SECTION 231113 - FACILITY FUEL-OIL PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes diesel-fuel-oil distribution systems and the following:

1. Pipes, tubes, and fittings.
2. Piping and tubing joining materials.
3. Piping specialties.
4. Valves.

1.3 DEFINITIONS

A. AST: Aboveground storage tank.

B. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, and dimensions of individual components and profiles. Also include, where applicable, rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1. Piping specialties.
2. Valves: Include pressure rating, capacity, settings, and electrical connection data of selected models.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuel-oil equipment and accessories to include in emergency, operation, and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Lift and support fuel-oil storage tanks only at designated lifting or supporting points, as shown on Shop Drawings. Do not move or lift tanks unless empty.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store pipes and tubes with protective PE coating to avoid damaging the coating and to protect from direct sunlight.

D. Store PE pipes and valves protected from direct sunlight.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M, for butt and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

a. Material Group: 1.1.
b. End Connections: Threaded or butt welding to match pipe.
c. Lapped Face: Not permitted underground.
d. Gasket Materials: Asbestos free, ASME B16.20 metallic, or ASME B16.21 nonmetallic, gaskets compatible with fuel oil.
e. Bolts and Nuts: ASME B18.2.1, cadmium-plated steel.

2.2 DOUBLE-CONTAINMENT PIPE AND FITTINGS

A. Flexible, Double-Containment Piping: Comply with UL 971.

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

a. Environ Products, Inc.

b. OPW.

2. Pipe Materials: PVDF complying with ASTM D 3222 for carrier pipe with mechanical couplings to seal carrier, and PE pipe complying with ASTM D 4976 for containment piping.
3. Watertight sump entry boots, pipe adapters with test ports and tubes, coaxial fittings, and couplings.
4. Minimum Operating Pressure Rating: 10 psig (69 kPa).
5. Plastic to Steel Pipe Transition Fittings: Factory-fabricated fittings with plastic end matching or compatible with carrier piping, and steel pipe end complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

2.3 PIPING SPECIALTIES

A. Flexible Connectors: Comply with UL 567.

1. Metallic Connectors:

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

1) FLEX-ING, Inc.
2) Hose Master, Inc.
3) Metraflex Company (The).

b. Listed and labeled for aboveground and underground applications by an NRTL acceptable to authorities having jurisdiction.
c. Stainless-steel bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
d. Minimum Operating Pressure: 150 psig (1035 kPa).
e. End Connections: Socket, flanged, or threaded end to match connected piping.
f. Maximum Length: 30 inches (762 mm.)

B. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (860 kPa).

C. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/8 (DN 6).
6. CWP Rating: 150 psig (1035 kPa).

7. Maximum Operating Temperature: 225 deg F (107 deg C).

2.4 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for fuel oil.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 MANUAL FUEL-OIL SHUTOFF VALVES

A. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller for Liquid Service: Comply with UL 842.

1. CWP Rating: 125 psig (860 kPa).
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in the valve schedule.
5. Service Mark: Initials "WOG" shall be permanently marked on valve body.

B. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with UL 842.

1. CWP Rating: 125 psig (860 kPa).
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in the valve schedule.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

C. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

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

    a. Conbraco Industries, Inc.; Apollo Div.
    b. Lyall, R. W. & Company, Inc.
    c. McDonald, A. Y. Mfg. Co.
    d. Perfection Corporation; A Subsidiary of American Meter Company.

2. Body: Bronze, complying with ASTM B 584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket as indicated in the valve schedule.
8. CWP Rating: 600 psig (4140 kPa).
9. Service Mark: Initials "WOG" shall be permanently marked on valve body.

2.6 SPECIALTY VALVES

A. Pressure Relief Valves: Comply with UL 842.

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

    a. Anderson Greenwood; Division of Tyco Flow Control.
    b. Fulflo Specialties, Inc.
    c. Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.

2. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
3. Body: Brass, bronze, or cast steel.
4. Springs: Stainless steel, interchangeable.
5. Seat and Seal: Nitrile rubber.
6. Orifice: Stainless steel, interchangeable.
7. Factory-Applied Finish: Baked enamel.
8. Maximum Inlet Pressure: 150 psig (1035 kPa).
9. Relief Pressure Setting: 60 psig (414 kPa).

B. Oil Safety Valves: Comply with UL 842.

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

    a. Anderson Greenwood; Division of Tyco Flow Control.
    b. Suntec Industries Incorporated.
    c. Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.

2. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
3. Body: Brass, bronze, or cast steel.
4. Springs: Stainless steel.
5. Seat and Diaphragm: Nitrile rubber.
6. Orifice: Stainless steel, interchangeable.
7. Factory-Applied Finish: Baked enamel.
8. Manual override port.
9. Maximum Inlet Pressure: 60 psig (414 kPa)
10. Maximum Outlet Pressure: 3 psig (21 kPa)

2.7 FUEL OIL

A. Diesel Fuel Oil: ASTM D 975, Grade No. 2-D, general-purpose, high volatility.

2.8 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (152 mm) wide and 4

mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (762 mm) deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for fuel-oil piping system to verify actual locations of piping connections before equipment installation.

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

3.2 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.3 PREPARATION

A. Close equipment shutoff valves before turning off fuel oil to premises or piping section.

B. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

3.4 OUTDOOR PIPING INSTALLATION

A. Install underground fuel-oil piping buried at least 18 inches (457 mm) below finished grade.

1. If fuel-oil piping is installed with less than 12 inches (305 mm) of cover to finished grade, install in containment piping.

B. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining, to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer. Review protective coating damage with Architect prior to repair.
3. Replace pipe having damaged PE coating with new pipe.

C. Install double-containment, fuel-oil pipe at a minimum slope of 1 percent downward toward fuel-oil storage tank sump.

D. Install vent pipe at a minimum slope of 2 percent downward toward fuel-oil storage tank sump.

E. Assemble and install entry boots for pipe penetrations through sump sidewalls for liquid-tight joints.

F. Install metal pipes and tubes, fittings, valves, and flexible connectors at piping connections to AST and UST.

G. Install fittings for changes in direction in rigid pipe.

H. Install system components with pressure rating equal to or greater than system operating pressure.

3.5 VALVE INSTALLATION

A. Install manual fuel-oil shutoff valves on branch connections to fuel-oil appliance.

B. Install valves in accessible locations.

C. Protect valves from physical damage.

D. Install metal tag attached with metal chain indicating fuel-oil piping systems.

E. Install oil safety valves at inlet of each oil-fired appliance.

F. Install pressure relief valves in distribution piping between the supply and return lines.

G. Install one-piece, bronze ball valve with hose end connection at low points in fuel-oil piping.

H. Install manual air vents at high points in fuel-oil piping.

I. Install emergency shutoff valves at dispensers.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Bevel plain ends of steel pipe.

2. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness for service application. Install gasket concentrically positioned.

G. Flared Joints: Comply with SAE J513. Tighten finger tight, then use wrench according to fitting manufacturer's written recommendations. Do not overtighten.

H. Fiberglass-Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.7 FUEL-OIL AST INSTALLATION

A. Install tank bases and supports.

B. Connect piping and vent fittings.

C. Install ground connections.

D. Install tank leak-detection and monitoring devices.

E. Install steel ASTs according to STI R912.

F. Install insulated and concrete-vaulted, steel ASTs according to STI R942.

G. Fill storage tanks with fuel oil.

3.8 HANGER AND SUPPORT INSTALLATION

A. Pipe hanger and support and equipment support materials and installation requirements are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1-1/4 (DN 32) and Smaller: Maximum span, 84 inches (2130 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1-1/2 (DN 40): Maximum span, 108 inches (2740 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 1/2 inch (13 mm).
5. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).
6. NPS 4 (DN 100): Maximum span, 13 feet (4 m); minimum rod size, 5/8 inch (16 mm).

C. Support vertical steel pipe at each floor and at spacing not greater than 15 feet (4.5 m).

3.9 CONNECTIONS

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

B. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment having threaded pipe connection.

C. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.

D. Connect piping to equipment with ball valve and union. Install union between valve and equipment.

E. Install flexible piping connectors at final connection to burners or oil-fired appliances that must be moved for maintenance access.

3.10 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on or near each service regulator, service meter, and earthquake valve.

B. Install detectable warning tape directly above fuel-oil piping, 12 inches (304 mm) below finished grade, except below subgrade under pavements and slabs. Terminate tracer wire in an accessible area, and identify as "tracer wire" for future use with plastic-laminate sign.

1. Piping: Over underground fuel-oil distribution piping.
2. Fuel-Oil Storage Tanks: Over edges of each UST.

3.11 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Piping: Minimum hydrostatic or pneumatic test-pressures measured at highest point in system:

a. Fuel-Oil Distribution Piping: Minimum 5 psig (34.5 kPa) for minimum 30 minutes.
b. Fuel-Oil, Double-Containment Piping:

1) Carrier Pipe: Minimum 5 psig (34.5 kPa) for minimum 30 minutes.
2) Containment Conduit: Minimum 5 psig (34.5 kPa) for minimum 60 minutes.

2. Inspect and test fuel-oil piping according to NFPA 31, "Tests of Piping" Paragraph; and according to requirements of authorities having jurisdiction.
3. Test leak-detection and monitoring system for accuracy by manually operating sensors and checking against alarm panel indication.
4. Start fuel-oil transfer pumps to verify for proper operation of pump and check for leaks.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
6. Bleed air from fuel-oil piping using manual air vents.

C. Fuel-oil piping and equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain.

3.13 OUTDOOR PIPING SCHEDULE

A. Aboveground fuel-oil piping shall be **one of** the following:

1. NPS 2 (DN 50) and Smaller: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints.
2. NPS 2-1/2 (DN 65) and Larger: Steel pipe, steel welding fittings, and welded joints.

3.14 ABOVEGROUND MANUAL FUEL-OIL SHUTOFF VALVE SCHEDULE

A. Distribution piping valves for pipe NPS 2 (DN 50) and smaller shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.

B. Distribution piping valves for pipe NPS 2-1/2 (DN 65) and larger shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.

C. Valves in branch piping for single appliance shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.

2. Two-piece, full-port, bronze ball valves with bronze trim.

END OF SECTION 231113

SECTION 231300 - FACILITY FUEL-STORAGE TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Aboveground fuel storage tanks.

B. Related Documents:

1. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and the other sections of this Division.
2. Other sections of this Division, and of other Divisions, may contain requirements that relate to this section.

1.2 REFERENCES

A. American Petroleum Institute:

1. API 650 - Welded Steel Tanks for Oil Storage.
2. API 2000 - Venting Atmospheric and Low-Pressure Storage Tanks: Nonrefrigerated and Refrigerated.

B. National Electrical Manufacturers Association:

1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

C. National Fire Protection Association:

1. NFPA 30 - Flammable and Combustible Liquids Code.
2. NFPA 31 - Standard for the Installation of Oil-Burning Equipment.

D. Underwriters Laboratories Inc.:

1. UL 142 - Steel Aboveground Tanks for Flammable and Combustible Liquids.
2. UL 567 - Pipe Connectors for Flammable Liquids and Combustible Liquids and LP-Gas.
3. UL 913 - Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous Locations.
4. UL 2085 - Standard for Safety for Insulated Aboveground Tanks Flammable and Combustible Liquids.

1.3 SYSTEM DESCRIPTION

A. Provide aboveground tank of double wall of welded steel construction.

1.4 SUBMITTALS

A. Shop Drawings:

1. Tanks: Indicate for fuel oil tanks dimensions; number, size, and location of openings; number, size, and location of manholes; number and location of hold down straps, and accessories. Indicate dimensions, reinforcing steel size, and reinforcing steel location of foundations.

B. Product Data:

1. Tanks: Submit manufacturer’s catalog information including capacity.

C. Test Reports: Submit written test results for tank pressure test.

D. Manufacturer's Installation Instructions: Submit tanks, and leak detection system data.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of manholes, tanks, and leak detection system.

B. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with NFPA 30 and NFPA 31.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing Work of this section with minimum three years documented experience approved by manufacturer.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Do not install tank foundations when bedding is wet or frozen.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.10 WARRANTY

A. Furnish 30 year limited manufacturer warranty for tanks.

PART 2 - PRODUCTS

2.1 ABOVEGROUND FUEL STORAGE TANKS

A. Manufacturers:

1. Highland Tank
2. Containment Solutions

B. Double Wall Fire-Rated

1. Product Description: Tank rated for multiple hazards and constructed of multiple layers consisting of inner steel tank surrounded by insulating concrete and outer steel tank providing multi-hazard rating including 2 hour fire resistance to meet requirements of UL 2085.
2. Tank Configuration: Horizontal cylindrical.
3. Primary Tank: Single wall steel tank constructed in accordance with UL 142 not less than 1/4 inch thick.
4. Insulation: Lightweight insulating concrete furnishing thermal protection located between the inner and outer tanks. No metal-to-metal connections of inner tank and outer tank are allowed except at tank nozzles.
5. Outer Tank: Single wall steel tank constructed in accordance with UL 142 not less than 3/16 inch (5 mm) inch thick.
6. Finish: Factory painted with industrial epoxy and urethane coating with dry film thickness of 4 mils (0.1 mm). Color: white.
7. Fill Connection: Furnish stainless steel remote fill containment assembly. Furnish with hinged locking cover, stainless steel hinges, handle, and lock hasp.
8. Normal Vent: Furnish each primary tank and with 2 inch (50 mm) updraft venting device. Size vent in accordance with NFPA 30.
9. Emergency Vent: Furnish for the primary tank the interstitial tank with emergency vent sized in accordance with NFPA 30.
10. Monitor Port: Minimum 2 inch (50 mm) steel pipe to be used for detecting leaks between primary and outer tanks.
11. Accessories:

    a. Level Gage: Mechanical float activated level gage capable of indicating approximate fluid level in tank reading in feet and inches. Open 200, TG-ENG-AST. Include an OPW TGTA-0400 bung fitting.
    b. Tank Decals: Furnish warning and tank identification signs located prominently on tank following local fire code requirements.
    c. 2” overfill protection valve in tank fill connection.

d. Single channel remote mounting liquid level high level tank alarm with 36" liquid level float switch subassembly. Intrinsically safe.
e. Provide a Veer-Root TLS-300C fuel management system with leak detection sensor, tank fuel level sensor, and network interface card to interface with the Plant SCADA System.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify excavations are to required grade, dry, and not over-excavated.

B. Verify tank foundation is ready for tank installation.

3.2 INSTALLATION - ABOVEGROUND TANKS

A. Install aboveground tanks in accordance with NFPA 30, and NFPA 31.

B. Check factory installed equipment and accessories for loosening during transit.

C. Clean and flush tanks prior to delivery to site. Seal until pipe connections are made.

D. Install aboveground tanks on concrete foundation.

E. Install grounding for aboveground tanks in accordance with Division 26.

F. Protect aboveground tanks by installing pipe bollards spaced as indicated on Drawings.

G. Install piping connections to tanks.

H. Tank Accessories:

1. Install tank accessories shipped loose with tank.
2. Install tank accessories as indicated on Drawings.

3.3 FIELD QUALITY CONTROL

A. Pressure test aboveground tanks in accordance with NFPA 30.

END OF SECTION 231300

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 GENERAL CONDITIONS:

A. The General Conditions, Supplementary General Conditions, General Requirements, and Special Conditions shall be and are hereby made a part of this Section of the specifications.

B. In case of conflicts between the electrical drawings and Division 26 of these specifications, the more stringent requirements shall govern. In all cases, notify the Engineer for direction.

C. The requirements of COMMON WORK RESULTS FOR ELECTRICAL establish minimum requirements, apply to, and are hereby made a part of all sections of Division 26 of this specification.

D. The Contractor shall be responsible for excavation of all earth, soil, and rock conditions at the site. Review the elevations and soil boring logs and include all associated costs.

1.2 DESCRIPTION:

A. The electrical work shall include all labor, materials, tools, transportation, equipment, services and facilities, required for the complete, proper and substantial installation of all electrical work shown on the plans, and/or outlined in these specifications. The installation shall include all materials, appliances, and apparatus not specifically mentioned herein or noted on the drawings but which are necessary to make a complete working installation of all electrical systems.

B. All of the electrical related work required for this project (unless specified otherwise) is a part of the Electrical Contract price but is not necessarily specified under this division of the specifications or shown on the electrical drawings. Therefore, all divisions of the specifications and all drawings shall be consulted.

C. The floor plan drawings are schematic only and are not intended to show the exact routing of raceway systems unless dimensions are noted on the drawings. Final routing will be governed by field conditions (structural members, mechanical equipment, ductwork, etc.) and shall be determined by the Contractor and approved by the Architect. Any changes in routing shall not change the design of the raceway system.

D. The floor plan drawings showing device and equipment locations are schematic only and are not intended to show exact locations unless dimensions are noted on the drawings. The Contractor shall review all contract drawings that may affect the location of devices and equipment to avoid possible interference and permit

full coordination of all work. The right to make any reasonable change in location within 6'-0", is reserved by the Architect up until the time of rough-in at no extra cost.

E. Furnish and install electrical wiring, systems, equipment and accessories in accordance with the specifications and drawings. Capacities and ratings of transformers, cable, switchgear, panelboards, motor control, and other items, arrangement for specified items in general are shown on drawings.

F. Electrical service entrance equipment (arrangements for temporary and permanent connections to the power company's system) shall conform to the power company's requirements. Coordinate fuses, circuit breakers and relays with the power company's system, and obtain power company approval. Provide all required temporary building power and lighting. Remove when finished. Installation of temporary power and lighting shall comply with N.E.C. and OSHA requirements.

G. Ampacities specified or shown on the drawings are based on copper conductors, with the conduit and raceways accordingly sized.

1.3 MINIMUM REQUIREMENTS:

A. Codes Rules and Regulations: Execute all work under ADA, the latest rules and regulations of the National Electrical Code Standard of the National Board of Fire Underwriters, the National Fire Protection Association, and with all laws, regulations and ordinances of the County, State, City, and the Utility Company.

B. Codes shall govern in case of any direct conflict between codes, plans and specifications; except when plans and specifications require higher standards than those required by code. Variance from the plan and specifications made to comply with code must be approved by the Architect. If approved they shall be made with no increased cost to the Owner.

1.4 STANDARDS:

A. All material and equipment shall be listed, labeled or certified by Underwriters Laboratories, Inc., where such standards have been established. Equipment and material which are not covered by UL Standards will be accepted provided equipment and material is listed, labeled, certified or otherwise determined to meet safety requirements of a nationally recognized testing laboratory. Equipment of a class which no nationally recognized testing laboratory accepts, certifies, lists, labels, or determines to be safe, will be considered if inspected or tested in accordance with national industrial standards, such as NEMA, or ANSI. Evidence of compliance shall include certified test reports and definitive shop drawings.

B. Definitions:

1. Certified: Equipment is "certified" if:

a. Equipment has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards, or to be safe for use in a specified manner.
b. Production is periodically inspected by a nationally recognized testing laboratory.
c. It bears a label, tag, or other record of certification.

2. Nationally recognized testing laboratory: A testing laboratory which is approved, in accordance with OSHA regulations, by the Secretary of Labor.

1.5 QUALIFICATIONS (PRODUCTS AND SERVICES):

A. Manufacturers Qualifications: The manufacturer shall regularly and presently produce, as one of the manufacturer's principal products, the equipment and material specified for this project, and shall have manufactured the item for at least three years.

B. Product Qualification:

1. Manufacturer's product shall have been in satisfactory operation, on three installations of similar size and type as this project, for approximately three years.
2. The Engineer reserves the right to require the Contractor to submit a list of installations where the products have been in operation before approval.

C. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will respond within three hours of receipt of notification that service is needed. Submit name and address of service organization.

1.6 MANUFACTURED PRODUCTS:

A. Materials and equipment furnished shall be new, of best quality and design, free from defects, of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts should be available. All items used on this project shall be free of asbestos, PCB, and mercury material.

B. When more than one unit of the same class of equipment is required, such units shall be the product of a single manufacturer.

C. Equipment Assemblies and Components:

1. Components of an assembled unit need not be products of the same manufacturer unless indicated otherwise.
2. Manufacturers of equipment assemblies, which include components made by others, shall be completely responsible for the final assembled unit.
3. Components shall be compatible with each other and with the total assembly for the intended service.
4. Constituent parts which are similar shall be the product of a single manufacturer.

D. Factory and Field wiring shall be identified on the equipment being furnished and on all wiring diagrams.

E. When Factory Testing is Specified:

1. The Engineer shall have the option of witnessing factory tests. The Contractor shall notify the Engineer a minimum of 15 working days prior to the manufacturer making the factory tests.
2. Four copies of certified test reports containing all test data shall be furnished to the Engineer prior to final inspection and not more than 90 days after completion of the tests.
3. When equipment fails to meet factory test and reinspection is required, the Contractor shall be liable for all additional expenses, including expenses of the Engineer.

1.7 EQUIPMENT PROTECTION:

A. Equipment and material shall be protected during shipment and storage against physical damage, dirt, moisture, cold and rain.

B. During installation, equipment, controls, controllers, circuit protective devices, and other like items, shall be protected against entry of foreign matter and be vacuum cleaned both inside and outside before testing, operating and painting.

C. Damaged equipment shall be, as determined by the Engineer, placed in satisfactory operating condition or be returned to the source of supply for repair or replacement.

D. Painted surfaces shall be protected with factory installed removable heavy Kraft paper, sheet vinyl or equal.

E. Damaged paint on equipment and materials shall be restored to the original quality of paint and workmanship as used by the manufacturer so repaired area is not obvious.

1.8 GENERAL WORK REQUIREMENTS:

A. Arrange, phase and perform work to assure electrical service both temporary and permanent for buildings at all times.

B. Coordinate location of equipment and conduit with other trades to minimize interferences.

C. Examination of Site:

1. Visit the site, inspect the existing conditions and check the drawings and specifications so as to be fully informed of the requirements for completion of the work.
2. Lack of such information shall not justify an extra to the contract price.

D. Permits:

1. Obtain and pay for all licenses and permits, fees, inspection and certificates required for the execution of this work.
2. Pay fees and charges for connection to outside services and use of property.
3. Deliver permits and certificates to the Architect to be transmitted to the Owner.

E. Services:

1. This Contractor shall pay for all expenses, deposits, reimbursements, etc., required by the local rules and codes for the service to the buildings, complete and ready for use. See plot plan.
2. Consult Power Company for their requirements and for coordinating with their installation. Contractor shall provide any work thus required beyond that indicated by the drawings and specifications. He shall bear all expense involved for the complete installation of the electrical service (both temporary and permanent) to the building ready for operation, including utility service charges, except as specifically excluded on the plans.
3. This Contractor shall consult all local departments to verify requirements and bid installation of service in accordance with local codes and Utility company rules and regulations.
4. This Contractor shall bear all expense involved for the complete telephone service conduit installation and pull wire ready for cable installation. Verify complete installation with the local telephone company and bid installation to comply with their requirements.

F. Responsibility:

1. This Contractor will be held responsible for any and all damage to any part of the building or to the work of other contractors, as may be caused through this contractor’s operation.
2. Any mutilation of building finishes or equipment initiated by electrical construction shall be properly corrected by the respective finishing contractor and paid for by the Electrical Contractor.

3. The operation of the temporary power and the permanent electrical system shall be the responsibility of this Contractor until acceptance of the building by the Owner.

G. Work to be done by General Contractor:

1. Build in all openings, sleeves, chases, etc., for conduit and equipment as established, furnished and set by this Contractor. The General Contractor shall seal or grout all openings after this Contractor has installed the conduits.
2. Build in bolts, brackets, hangers etc., for work established, furnished and set by this Contractor.
3. All concrete work required for equipment furnished and set by this Contractor including clean up pads under electrical gear, fixture bases, transformer bases, etc.
4. Painting: All painting of electrical equipment installed in finished areas shall be done by the General Contractor. Painting will not be required on receptacles, switches, circuit breakers etc. All fixtures and exterior poles specified to be factory-primed shall be painted by General Contractor. Paint all wiremold, exposed conduit and equipment, etc., to match final wall colors.
5. Provide fireproofing above fixtures located in fire rated ceilings per U.L. requirements.
6. Pay all utility costs for operation of electrical system during construction until acceptance of building by the Owner.

H. Work done by the Mechanical Contractor:

1. The Mechanical Contractor shall furnish wiring diagrams and temperature control drawings of all equipment furnished to the Electrical Contractor. (Catalog information is unacceptable, provide point to point drawings.)
2. The Mechanical Contractor shall furnish and install all control equipment requiring connections to air, water, steam, etc., such as pneumatic electric relays, remote bulb temperature controls, solenoid valves, aquastats and pressure controls.
3. The Mechanical Contractor shall reimburse the Electrical Contractor for any changes in system design i.e.; control or equipment which affects the Electrical Contractor. Also refer to equipment connections, controls and instrumentation in 260500.

I. Workmanship and Coordination:

1. Make installation substantially as shown on the plans.
2. Make alterations in location of apparatus or conduit as may be required to conform to building construction without extra charge.

3. Mechanical equipment service clearances and electrical apparatus service clearances as specified in their respective manufacturer's product data shall be maintained free from conduit.
4. Cooperate with other trades in their installation of work.
5. Complete the installation in a workmanlike manner, completely connected and ready to give proper and continuous service.
6. Use only experienced licensed electricians.

J. Cutting and Patching:

1. Notify the General Contractor in ample time, of the location of all chases, sleeves, and other openings required in connection with the work of this contract.
2. Cutting and patching made necessary because of failure to comply with the above shall be done by the General Contractor at the expense of the Electrical Contractor.
3. When it is necessary for the Electrical Contractor to cut building materials, it shall be done in a neat and workmanlike manner meeting with the approval of the Architect.
4. Holes through concrete shall be carefully drilled with a "Concrete Termite" drill. A Star Drill or Air Hammer will not be permitted. Structural members shall not be cut without approval from the Architect.
5. Any penetrations thru the roof shall be made with "Stoneman" 900 Series flashing connections as manufactured by Elmdor/Stoneman, City of Industry, California, or as approved by the Architect.
6. Any penetrations made in exterior or basement foundation walls shall be sealed with Thunderline "Link-Seal" connections, as manufactured by Thunderline Corporation, Wayne, Michigan.

K. Manufacturer’s Instructions:

1. Apply, install, connect, erect, use, clean, and condition articles, materials and equipment as directed by the manufacturer.

1.9 EQUIPMENT INSTALLATION AND REQUIREMENTS:

A. Equipment location shall be as close as practical to locations shown on the drawings.

B. Working spaces shall not be less than specified in the National Electrical Code for all voltages specified.

C. Inaccessible Equipment:

1. Where the Engineer determines that the Contractor has installed equipment without proper clearances or not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled as directed at no additional cost to the Owner.

a. Install access panels as approved by the Architect to provide access to all equipment, J-boxes and outlets located in non-accessible spaces. Panels shall be flush locking type with a fire rating equal to the ceiling system.

2. "Conveniently accessible" is defined as being capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, pumps, belt guards, transformers, piping, and ductwork. Outlet and box covers shall be removable by using regular length (8") screw drivers.

D. Distribution Equipment:

1. All items of Electrical Distribution Equipment (switchboards - panelboards - disconnects) shall be of one manufacturer, unless specifically noted on the drawings, in the specifications, or approved by the Engineer. Intermixing of distribution equipment by different manufacturers will not be permitted.
2. Equipment layouts on the drawings are based on one manufacturer. Verify all actual equipment sizes with equipment manufacturer prior to bidding.
3. If layout changes are required due to differing electrical manufacturer's equipment size, they must be submitted to and approved by the Engineer. National Electric Code working clearances must be maintained at all times. Extra remuneration will not be allowed for layout changes that differ from those shown.
4. Provide and install all steel supports as required for mounting of electrical equipment.
5. Anchor all free standing electrical equipment including switchboards, switchgear, substations, motor control centers, paralleling gear, transfer switches, transformers, etc. to the floor with plated, 1/2" diameter minimum, anchor bolts or as recommended by the manufacturer.

1.10 EQUIPMENT CONNECTIONS, CONTROLS AND INSTRUMENTATION:

A. General: The following applies to all electrical power and control connections for all equipment requiring electrical installation work provided by others.

B. Electrical Contractor shall install and connect the following items for equipment requiring electrical power that is either furnished or specified by other Contractors and/or the Owner. Where these required items are not furnished with the equipment being connected, it shall be the Electrical Contractors responsibility to provide the necessary items including conduit, boxes and wiring.

1. Disconnecting Devices
2. Overcurrent Devices
3. Short Circuit Protective Devices
4. Voltage Transformation Equipment

5. Control Devices (Local and Remote)
6. Equipment Mounting Structures
7. Additional Miscellaneous Devices

C. In general, all major equipment will be specified to be factory prewired with only service and interconnecting wiring required at the site by the electrical contractor; however, the Electrical Contractor shall check all divisions of the specification to verify if the equipment is specified factory prewired and if not, then it shall be the responsibility of the Electrical Contractor to provide the complete wiring of the equipment in accordance with wiring diagrams provided by other contractors and/or Owner to the Electrical Contractor. All interconnecting of equipment shall be by the Electrical Contractor.

D. All line and low voltage wiring and connections required to control the equipment are a part of this section. All wiring shall be in conduit. All conduit and wiring, and terminations shall be provided by the Electrical Contractor. Systems Integrator to make all low voltage terminations.

E. The Electrical Contractor shall provide 120 volt control power supply; #12 Ga. CU. THHN/THWN in 1/2"C. minimum at all points required by controls, instrumentation and sprinkler risers. Circuit as shown on the plans or to the nearest 120 volt panel if no circuiting is indicated. Use spare 20 Amp. breakers. Each control panel shall be on a separate circuit unless otherwise indicated. If the controlled equipment is fed from the emergency system, then the control power supply must feed from the emergency system.

F. The Contractor shall become familiar with the equipment to be furnished by the other Contractors and/or the Owner in connection with this work and include provisions for such connections and work in the Contractor's price. Extra remuneration will not be allowed for such work.

G. Connections to all equipment have been designed from units as specified on the drawings or in the specifications. In the event equipment or control differs on approved shop drawings it shall be the responsibility of the Supplying Contractor to coordinate electrical connections to the units and reimburse Electrical Contractor for any changes in system design. These changes shall not involve additional cost to the Owner.

H. Review all plans and specifications to verify all equipment connections that are required by mechanical and/or other contractors. Although the electrical drawings will show equipment connection requirements, it is the Electrical Contractor's responsibility to connect all equipment furnished by other Contractor's at no extra cost to the Owner, even if this equipment connection is not shown on the electrical drawings. Coordinate all required connections not shown on the electrical drawings with the Engineer.

1.11 NAMEPLATES:

A. General: The following items shall be equipped with nameplates:

1. Disconnect switches (fused or nonfused), transformers, switchgear and switchboards (including branch circuit breakers/switches), panelboards, separately mounted circuit breakers, starters, contactors, relays, junction boxes and pull boxes.

B. Inscription: Nameplates shall adequately describe the function or use of the particular equipment involved. Nameplates for panelboards and switchboards shall include the panel designation, voltage, and phase, A.I.C. rating of the supply (see schedules, one-line diagram, and color coding). For example, "Panel A" 120/208 V, 3-Phase, 4-Wire, 10,000 A.I.C. or “50,000 AIC with 22 KA Breakers, Series with class ‘J’ Fuses”:

1. Phase A - Black
2. Phase B - Red
3. Phase C - Blue
4. Neutral - White
5. Ground - Green

C. The name used for a machine nameplate shall be the same as the one used on the machine's motor starter, disconnect and P.B. station nameplates. Nameplates for fused switches and panels shall also indicate fuse type and size. .

D. Construction: Nameplates shall be laminated phenolic plastic white front and back with black core. Nameplates for emergency system panelboards and transfer switch shall be laminated phenolic plastic red front and back with white core. Lettering shall be engraved through front layer to form 1/4" black characters. Nameplates shall be securely fastened to the equipment to be identified, with No. 4 Phillips, round head, cadmium plated, steel self tapping screws or nickel plated brass bolts. Motor nameplate may be nonferrous metal not less than 0.03 inches thick, die stamped. In lieu of separate plastic nameplates, engraving directly on device plates is acceptable. Letters engraved thus, shall be filled with contrasting enamel. All nameplates and their installation are part of this work. Free hand lettering or dymo label marker will not be acceptable.

1.12 MATERIALS OF APPROVED EQUAL:

A. Where items of equipment and/or materials are specifically identified herein by a manufacturer's name, model or catalog number, and only such specific items may be used in the base bid, except as hereinafter provided.

B. Unless requests for changes in base bid specifications are received, approved and noted by written addendum prior to the opening of bids, the successful contractor will be held to furnish specified items.

C. After contract is awarded, changes in specifications shall be made only as defined under "Substitution of Equipment".

1.13 SUBSTITUTION OF EQUIPMENT:

A. After execution of the contract, substitution of equipment of makes other than those specifically named in the contract documents, may be approved by the Engineer, only if the equipment named in the specifications cannot be delivered to the job in time to complete the work in proper sequence and due to conditions beyond control of the Contractor. Provide documentary proof in writing from the manufacturer that the specified equipment will not be available in time. If the Contractor is responsible for the delay, the substitution will not be approved.

B. Requests for substitutions must be accompanied by documentary proof of equality or difference in price and delivery, if any, in form of certified quotations from suppliers of both specified and proposed equipment.

1.14 SUBMITTALS: In Accordance with Section SAMPLES AND SHOP DRAWINGS, furnish the following:

A. The Engineer's approval shall be obtained for all equipment and material before delivery to the job site. Delivery, storage or installation of equipment or material which has not had prior approval will not be permitted at the job site.

B. All submittals shall include adequate descriptive literature, catalog cuts, shop drawings and other data necessary for the Engineer to ascertain that the proposed equipment and materials comply with specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify equipment being submitted.

C. Submittals shall be complete and submitted together for each section. Individual systems and equipment assemblies which consist of more than one item or component shall be made for the system or assemble as a whole. Partial submittals will not be considered for approval.

1. Mark the submittals, "SUBMITTED UNDER SECTION_____". Mark out all statements on sheets that do not apply otherwise. The Engineer may select options and equipment not originally specified. All options that are not marked out will be assumed that the Contractor will furnish the same.
2. Submittals shall be marked to show specification reference including the section and paragraph numbers.
3. Submit each section separately.
4. Mark catalog cuts to indicate equipment, capacities, finishes, sizes, etc. Each individual item shall have its own sheet provided for approval. (Example: Separate sheets for each panelboard.)

D. The submittals shall include the following:

1. Information that confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, pictures, nameplate data and test reports as required.
2. Elementary and interconnection wiring diagrams for communication and signal systems, control system and equipment assemblies. All terminal points and wiring shall be identified on wiring diagrams.
3. Parts list which shall include those replacement parts recommended by the equipment manufacturer, quantity of parts, current price and availability of each part.
4. Quantities of materials will not be verified by the Architect or Engineer. Approval stamp on shop drawings does not constitute approval of quantities listed on shop drawings.
5. Shop drawings:

    a. All shop drawings shall be checked and signed by this contractor and general contractor prior to submittal to the Architect/Engineer.
    b. Shop drawings submitted without Contractor’s signatures or approval and verification will not be approved.
    c. Shop drawings shall be submitted on wire, cables, devices, lighting fixtures (including distribution curves), motor starters, panelboards, disconnects, substations, transformers, switchgear, switchboards, raceway systems, all systems, etc.

6. Each sheet shall be either 8 1/2" x 11"; 8 1/2" x 13"; or 11" x 17" bond with a 5" x 3" clear area for engineer’s stamp. (This area shall not be used by this contractor or the general contractor’s stamp.) Larger drawings shall be able to be blue printed.
7. Submittals for all systems (fire alarm, security, PA, controls, sound, clock, nurses’ call, intercom, etc.) shall include complete riser diagrams showing all conductors and conduit sizes.

E. Engineer’s acceptance of Compliance Submittals will not relieve the Contractor from his responsibility for any deviations from the requirements of the contract documents, unless Contractor has in writing called Engineer's attention to such deviation at the time of submission and the Engineer has given written approval to the specific deviation; nor shall any acceptance by Engineer relieve Contractor from responsibility for errors or omissions in Compliance Submittals.

F. Quantity of Submittals: See the general specification sections.

1.15 ELECTRICAL WORK COMPLETION:

A. Before requesting final inspection the following work must be completed.

B. Operating Instructions:

1. The Contractor shall submit along with the shop drawings of the equipment, three (3) copies of operating instructions for all items. Instructions shall be prepared by the manufacturer of the equipment.
2. After the operating instructions have been approved by the Engineer, the Contractor shall include the three (3) copies in maintenance instructions brochures.
3. The Contractor shall also obtain all manufacturers' instructions, manuals, and one complete set of drawings and turn these over to the Architect at the completion of the project.
4. The Contractor shall keep in a safe place; all keys and special wrenches furnished with equipment under this contract and shall give same to the Architect at the completion of the project.
5. The Contractor shall prepare a complete brochure, in triplicate, covering all systems and equipment furnished and installed under his contract. Brochures shall be submitted to the Architect-Engineer for approval and delivery to the Owner. The cost of this brochure shall be included in the contract cost. Brochures shall contain the following:

    a. Certified equipment drawings and/or catalog data clearly marked for equipment furnished as required for approval submission under detailed section of the specifications.
    b. Complete operating and maintenance instructions for each item of equipment.
    c. Complete part list for each equipment item.
    d. Any special emergency operating instructions or a list of service organizations (including addresses and telephone numbers) capable of rendering emergency service to the various parts of the system.

6. Brochures shall be bound in hard backed three ring binders with an index, sub dividers and reinforced sheets.

    a. Project name and address.
    b. Section of work covered by brochure, i.e., "Electrical Work".
    c. Name and address of Architect.
    d. Name and address of Engineer.
    e. Name and address of Contractor.
    f. Telephone number of Contractor, including night or emergency number.

7. In addition to these written instructions, each respective Contractor shall fully and carefully instruct the Owner, or Owner's selected representatives, as to the proper operation, care and maintenance of each system and its equipment.

1.16 TESTING AND ADJUSTMENT:

A. Record loads on each phase of all panelboards, distribution panels, switchboards, transformers and submit final readings to the Architect for records. This Contractor shall adjust equipment, instruments, gages, meters etc., as required to test and adjust these systems.

B. Check, test, and adjust the mechanisms of all electrical equipment and adjustable parts of lighting fixtures as required for optimum performance.

C. Perform tests for insulation resistance in accordance with the requirements of the National Electrical Code and insure that all circuits are free from short circuits.

D. Keep a calibrated voltmeter and ammeter available at all times and provides service for test readings when and as required, up until the project is accepted by the Owner.

E. Electrical Testing and Verification: Refer to the following specification sections (as applicable) for required tests and verifications:

1. 260513 – Cables, Medium Voltage (Above 600 Volts)
2. 260519 – Low Voltage Electrical Power Conductors and Cables
3. 260526 – Grounding and Bonding for Electrical Systems
4. 261201 – Transformers, Padmounted
5. 262200 – Low Voltage Transformers
6. 262416 – Panelboards
7. 262726 – Wiring Devices
8. 263213 – Gensets and Accessory Equipment
9. 263600 – Automatic Transfer Switches

1.17 AS-BUILT DRAWINGS:

A. Show on black or blue line prints in red ink all changes from original plans made during the installation. Return two (2) sets of red marked drawings, specifications and addenda, as set forth in the General Conditions, to the Architect upon completion of the project.

1.18 FINAL INSPECTION:

A. Final inspection will be made upon written request from the General contractor after the project is completed; in accordance with the Supplementary General Conditions.

B. Furnish a workman familiar with this project to accompany the Engineer on final inspection and have available ladders, drop cords, and other equipment as required to gain access to any portion of this system.

C. This Contractor and his principal subcontractors shall be represented at the inspection by a person of authority responsible to demonstrate to the engineer that his work conforms to the intent of the plans and specifications.

D. Extra inspections made necessary by the Electrical Contractor's failure to comply with the conditions as set forth above shall be charged to the Contractor for the Inspector's time both on the job and spent in travel between the office and the project site.

1.19 GUARANTEE:

A. Guarantee all work, material and equipment for a period of one year after date of substantial completion.

B. During the one year guarantee period the Electrical Contractor shall be responsible for any defects which develop in the electrical systems. Upon notification of a defect by the General Contractor the Electrical Contractor shall make immediate effort to correct it and shall notify the Architect when this work is completed. This guarantee does not include ordinary lamp failure.

C. Repairs and/or replacements shall be made with no cost to Owner.

D. Provide as part of the work of this contract, in addition to the first year's guarantee on equipment and materials, the following routine maintenance and inspection. (The one year time period will not start until each item is completed in accordance with plans and specifications and accepted by the Owner). Correct and adjust all emergency systems, controls, fire alarm, transformer, etc. This service to be provided throughout the guarantee period.

1.20 SINGULAR NUMBER:

A. Where any device or part of equipment is referred to in these specifications in the singular number (such as "the switch"), such reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

1.21 SPECIAL SYSTEMS:

A. Equipment and wiring for special systems shall be as shown in the following schedule:

SYSTEM	EQUPMENT FURNISHED BY	EQUIPMENT INSTALLED BY	WIRING FURNISHED AND INSTALLED BY
Veeder Root	Equipment Supplier	Equipment Supplier	Contractor

B. Power wiring for all systems shall be furnished and installed by the contractor as shown on the drawings and as required by the equipment manufacturer.

C. All systems shall be completely installed in separate conduit systems. All cable for these systems shall be in conduit and shall not be combined with any other system cable. Conduits systems shall be furnished and installed by the Electrical Contractor.

D. Conduits shall be sized as required by the number and type of conductors applied and/or as noted on plans (minimum 1") and shall be not smaller than sizes recommended by the equipment manufacturer. All conduits shall be labeled to identify which system it is to be used for i.e.: Nurse Call, Code Blue, P.A. etc.

E. Low voltage wire and cable shall be specifically designed to function with equipment supplied. Cable shall be color coded for ease of installation and service, twisted, shielded, and grounded for control of voice circuits and covered with wear-resistant moisture proof protective insulation. Wire shall bear manufacturer's trademark either embossed or printed on cable.

F. All systems shall be provided with a minimum of 20% spare capacity upon completion of the project unless otherwise noted.

END OF SECTION 260500

SECTION 260513 - CABLES, MEDIUM VOLTAGE (ABOVE 600 VOLTS)

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This section includes the furnishing, installation and connection of the medium voltage cables.

B. Samples:

1. When requested by the Engineer, furnish a 12-inch length of each type and size of wire and cable along with the tag from the coils or reels from which the samples were taken. The sample shall contain the manufacturer's markings.

C. Standards:

1. The cable shall meet or exceed the latest editions of the following industry specifications:

a. REA Spec U-1 dated 12/87.
b. AEIC CS-8 2007 (Assoc. of Edison Illuminating Co.).
c. ICEA S-93-639 (Insulated Cable Engineers Assoc.).
d. ASTM B-231, B-233, and B-609.

D. Certifications:

1. Factory test reports:

a. Prior to installation of the cables, deliver four copies of the manufacturers certified IPCEA standard factory test reports for representative cables to the Engineer.
b. Certified test reports shall include the following:

1) AC and DC voltage withstand test results per AEIC CS-8.
2) Partial discharge (or corona) test results showing no discharge higher than 5 picocoulombs at three times the operating voltage of the cable. If any reel chart shows discharge higher than 5 picocoulombs, reel shall be rejected.

2. Field test reports: After testing, submit four certified copies of each of the graphs, specified under field testing, to the Engineer. Adequate information shall be included identifying the cable locations, types, voltage rating and sizes.
3. Splices and terminations:

a. After the splices and terminations have been installed and tested, deliver four copies of a certificate by the Contractor to the Engineer which includes the following:

1) A statement that the materials, detailed drawings and printed instructions used was those contained in the kits approved for this contract.
2) A statement that each splice and each termination was completely installed without any overnight interruption.
3) A statement that field made splices and terminations conform to the following requirements:

a) Pencil the cable insulation precisely.
b) Connector installations:

(1) Use tools which are designed for the connectors being installed.
(2) Round and smooth the installed connectors to minimize localized voltage stressing of the insulating materials.

c) Remove contaminants from all surfaces within the splices and terminations before installing the insulating materials.
d) Solder block throughout stranded grounding wires which will penetrate the splicing and terminating materials.
e) Use mirrors to observe the installation of materials on the back sides of the splices and terminations.
f) Eliminate air voids throughout the splices and terminations.
g) Stretch each layer of tape properly during installation.

4) List all of the materials purchased and installed for the splices and terminations for this contract including the material descriptions, manufacturer's names, catalog numbers and total quantities.

E. Installer Approval:

1. Employees who install the splices and terminations shall have not less than three years of experience splicing and terminating cables which are equal to those being spliced and terminated, including experience with the materials in the kits. Furnish satisfactory proof of such experience for each employee who splices or terminates the cables.

F. Warranty:

1. The manufacturer shall provide a written warranty guaranteeing the cable for 40 years against dielectric failure or poor workmanship.

PART 2 - PRODUCTS

2.1 MATERIAL, MEDIUM VOLTAGE CABLE:

A. Medium voltage cable shall be in accordance with the NEC, IPCEA and UL. Manufacturers shall be: Southwire, Kerite or Okonite.

B. Conductor:

1. Shall be single conductor compact stranded copper.
2. Cable shall be rated for 15kV.

C. Conductor Screen:

1. Extruded semi-conducting ethylene propylene rubber (EPR), meeting or exceeding the requirements of ICEA S-93-639, and AEIC CS-8. The conductor screen shall be free of any voids, contaminants, or protrusions and shall be firmly bonded to the insulation yet free stripping from the conductor.

D. Insulation: Insulation level shall be 133%, extruded ethylene propylene rubber (EPR) meeting or exceeding the requirements of ICEA S-93-639 and AEIC CS-8. The EPR shall not contain any polyethylene in the compound formula. The EPR insulation must have a field experience record of over 15 years.

E. Insulation Screen:

1. Extruded semi-conducting ethylene propylene rubber (EPR) meeting or exceeding the requirements of AEIC CS-8 and ICEA S-93-639. The semi-conducting screen must have a strip tension between 6 and 24 lbs. per square inch consistently throughout each length of cable.
2. The conductor screen, insulation, and insulation screen shall be applied via the triple tandem extrusion method to avoid any voids and contaminants between insulation and semiconductor.

F. Shielding: Shall be a 5 mil copper tape shield with a 12.5% overlap.

G. Jacket:

1. Black PVC. The jacket shall be extruded directly over copper tape shield. The minimum average thickness of the jacket shall be 80 mils.

H. Cable temperature ratings for continuous operation, emergency overload operation and short circuit operation shall be not less than the ICEA Standard for the respective cable.

I. Manufacturer's name and other pertinent information shall be marked or molded clearly on the overall outside surface of the jackets, or incorporated on marker tapes within the cables at reasonable intervals.

2.2 MATERIAL, SPLICES AND TERMINATIONS:

A. The materials shall be compatible with the conductors, insulation's and protective jackets on the cables and wires.

B. The splices shall insulate and protect the conductors not less than the insulation and protective jackets on the cables and wires which protect the conductors. In locations where moisture might be present, the splices shall be watertight. In manholes and handholes the splices shall be submersible.

C. Splicing and Terminating Fittings:

1. Shall be heavy duty, pressure type fittings, which will assure satisfactory performance of the connections under conditions of temperature cycling and magnetic forces from available short circuit currents.
2. The fittings shall be suitable designed and the proper size for the cables and wires being spliced and terminated. Terminations to bus shall be with two hole lugs.
3. Where the engineer determines that unsatisfactory fittings have been installed, remove the unsatisfactory installations and install approved fittings at no additional cost to the Owner.

D. Splicing and Terminating Kits:

1. General;

a. Shall be assembled by the manufacturer or supplier of the materials and shall be packaged for individual splices and terminations or for groups of splices and terminations.
b. Shall consist of materials designed for the cables being spliced and terminated and shall be suitable for the prevailing environmental conditions.
c. Shall include detailed drawings and printed instructions for each type of splice and termination being installed, as prepared by the manufacturers of the materials in the kits.
d. Detail drawings, and printed instructions shall indicate the cable type, voltage rating, manufacturer's name and catalog numbers for the materials indicated.

e. Voltage ratings for the splices and terminations shall be not less than the voltage ratings for the cables on which they are being installed.
f. Shall include shielding and stress cone materials.

2. Taped splices and terminations:

a. Insulating and semi-conducting rubber tapes shall withstand 200 percent elongation without cracking, rupturing or reducing their electrical and self-bonding characteristics by more than 5 percent.

3. Epoxy resin kits shall be as follows:

a. Compatible with the cable insulation's and jackets and make the splices watertight and submersible.*
b. Thermosetting and generate its own heat so that external fire or heat will not be required.
c. Set solid and cure in approximately 60 minutes in 70 degree F ambient temperature.
d. Not deteriorate when subjected to oil, water, gases, salt water, sewage and fungus.
e. Furnished in pre-measured quantities, sized for each splice and each termination, with two resin components in an easy mixing plastic bag which will permit mixing the resin without entrapping air or contaminants. Other methods of packaging and mixing the epoxy resin components will be considered for approval provided they include adequate safeguards to assure precise proportioning of the resin components and to prevent entrapping air and contaminants.
f. Use snap-together, longitudinally-split, interlocking seam, transplant mold bodies or taped frameworks, injection fittings and injection gun or pouring equipment. Completely fill voids within the splices and terminations.

E. Premolded Rubber Splices and Terminations:

1. Splices and terminations shall be in accordance with IEEE 48, 386, 404 and 592.
2. Premolded rubber devices shall have a minimum of 0.125-inch semi-conductive shield material covering the entire housing. Test each rubber part prior to shipment from the factory.
3. Grounding of metallic shields shall be accomplished by a solderless connector enclosed in a watertight rubber housing covering the entire assembly. The grounding device and splice or terminator shall be of same manufacturer to insure electrical integrity of the shielded parts.
4. The premolded parts shall be suitable for indoor, outdoor, submersible, or direct-burial applications.

2.3 MATERIAL, FIREPROOFING TAPE:

A. The tape shall consist of a flexible, conformable fabric of organic composition coated one side with flame-retardant elastomer.

B. The tape shall be self-extinguishing and shall not support combustion. It shall be arcproof and fireproof.

C. The tape shall not deteriorate when subjected to water, gases, salt water, sewage, or fungus. It shall be resistant to sunlight and ultraviolet light.

D. The finished application shall withstand a 1000 ampere arc for not less than 30 seconds.

E. Securing tape: Shall be glass cloth electrical tape not less than 7 mils thick, and 3/4-inch wide.

2.4 CABLE FAULT INDICATORS:

A. Provide/install cable fault indicators, flag type as manufactured by Cooper or approved equal on all terminations for loop feed systems.

2.5 CABLE PULLING LUBRICANT:

A. The cable pulling lubricant shall be compatible with all cable jackets. The lubricant shall be UL (or CSA) listed. The lubricant shall contain no waxes, greases, silicones, or polyalkylene glycol oils or waxes.

B. A 200-gram sample of the lubricant, when placed in an one-foot, split metal conduit and fully dried for 24 hours at 105 degrees C, shall not spread a flame more than three inches beyond a point of ignition at a continued heat flux of 40 kW/m^2. Total time of test shall be one-half hour.

C. Approved Lubricant is:

1. Polywater J from American Polywater Corporation
2. Quick Slip from Buchanan
3. CCR Wire Pulling Lube from CRC
4. Poly-X from American Colloid.

PART 3 - EXECUTION

3.1 INSTALLATION, MEDIUM VOLTAGE CABLE:

A. Installation shall be in accordance with the NEC, and as shown on the drawings.

B. Use the specified lubricating compounds on the cables and wires to prevent damage to them during pulling-in. Provide compounds that are not injurious to the cable and wire jackets.

C. Splice the cables and wires only in manholes and accessible junction boxes.

D. In manholes, trenches and vaults:

1. Install the cables on suitable porcelain insulators with steel cables racks.

E. In manholes, underground raceways and other outdoor locations:

1. Seal the cable ends prior to pulling them in to prevent the entry of moisture.
2. For ethylene propylene rubber and polyethylene insulated cables, use bags of epoxy resin which are not less than 1/4-inch larger in diameter than the overall diameter of the cable. Clean each end of each cable before installing the epoxy resin over it.

3.2 INSTALLATION, SPLICES AND TERMINATIONS:

A. Install the materials as recommended by their manufacturer including special precautions pertaining to air temperature during installation.

B. Ethylene Propylene Rubber and Polyethylene Insulated Cables:

1. Cables rated 8000 volts or less: Install epoxy resin splices and terminations, or premolded rubber splices and terminations.
2. Cables rated more than 8000 volts: Install taped splices and terminations, or premolded rubber splices and terminations.

C. Installation shall be accomplished by qualified personnel trained to accomplish medium voltage equipment installations. All instructions of the manufacturer shall be followed in detail.

3.3 INSTALLATION, FIREPROOFING:

A. Cover all power cables located in manholes, handholes, and junction boxes with arcproof and fireproof tape.

B. Apply the tape in a single layer, one-half lapped or as recommended by the manufacturer. Install the tape with the coated side towards the cable and extend it not less than one inch into each duct.

C. Secure the tape in place by a random wrap of glass cloth tape.

3.4 FEEDER IDENTIFICATION:

A. In each manhole and pullbox install permanent tags on each circuit's cables and wires to clearly designate their circuit identification and voltage. In manholes the tags shall be the embossed brass type and shall also show the cable type and voltage rating. Position the tags so they will be easy to read after the fireproofing is installed.

3.5 FIELD TESTS FOR MEDIUM VOLTAGE CABLE:

A. New Cable:

1. Acceptance tests shall be performed on new cable.
2. Test new cable after installation, splices, and terminations have been made, but before connection to equipment and existing cable.

B. High Potential Test:

1. Leakage current test shall be by high potential dc step voltage method.
2. Prior to high potential test, test the cable and shields for continuity, shorts, and grounds.
3. High potential test shall measure the leakage current from each conductor to the insulation shield. Use corona shields, guard rings, taping, mason jars, or plastic bags to prevent corona current from influencing the readings. Unprepared cable shield ends shall be trimmed back one inch or more for each 10kV of test voltage.

C. Safety Precautions:

1. Exercise suitable and adequate safety measures prior to, during, and after the high potential tests, including placing warning signs and preventing people and equipment from being exposed to the test voltages.

D. Test Voltages:

1. New shielded EPR cable dc test voltages shall be as follows:

		Test Voltage kV	
Rated Circuit Voltage Phase-to-Phase Volts	Wire Size AWG or MCM	100 percent Insulation Level	133 percent Insulation Level
2001-5000	8-1000	25	25
5001-8000	6-1000	35	35
8001-15000	2-1000	55	65
15001-25000	1-1000	80	100
25001-28000	1-1000	85	
28001-35000	1/0-1000	100	

E. High Potential Test Method:

1. Apply voltage in approximately 8 to 10 equal steps.
2. Raise the voltage slowly between steps.
3. At the end of each step, allow the charging currents to decay, and time the interval of decay.
4. Read the leakage current and plot a curve of leakage current versus test voltage on graph paper as the test progresses. Read the leakage current at the same time interval for each voltage step.
5. Stop the test if leakage currents increase excessively or a "knee" appears in the curve before maximum test voltage is reached.

a. For new cable, repair or replace the cable and repeat the test.
b. For existing cable interconnected to new cable, notify the Engineer for further instructions.

6. Upon reaching maximum test voltage, hold the voltage for five minutes. Read the leakage current at 30 second intervals and plot a curve of leakage current versus time on the same graph paper as the step voltage curve.

   a. Stop the test if leakage current starts to rise, or decreases and again starts to rise. Leakage current should decrease and stabilize for good cable.

7. Terminate test and allow sufficient discharge time before testing the next conductor.

END OF SECTION 260513

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

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

1.2 SUMMARY:

A. Section includes:

1. Building wires and cables rated 600 VAC and less.
2. Connectors, splices, and terminations rated 600 VAC and less.
3. Wire lubricating compound.
4. Control wiring.
5. Communication and signal wiring.
6. Fireproofing tape.

1.3 SUBMITTALS

A. Product Data (Where indicated in Section “Common Work Results for Electrical”, provide the following information): For each type of product indicated.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended use.

B. Comply with NFPA 70.

C. Comply with NEMA WC 70.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES (POWER AND LIGHTING):

A. Conductors and Cables: NEMA WC 70, except as hereinafter specified.

1. All conductors shown on plans are sized for copper.
2. UL label required.

B. Single Conductor:

1. Soft annealed copper.
2. Stranded for sizes No. 8 and larger. Solid or stranded for sizes No. 10 and smaller, except that conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3, shall be stranded unless specifically indicated otherwise.
3. Minimum size No. 12, except where larger sizes are shown. (Size No. 14 minimum for controls).

C. Stranding:

1. Conductors between stationary and moving devices, such as hinged doors or panels, shall have Class H or Class K stranding. All other conductors shall have Class B or Class C stranding.

D. Insulation:

1. THHN-THWN, XHHW - Sizes No. 12 and larger.

2.2 SPLICES AND JOINTS:

A. In accordance with UL 486 A, B, D and NEC.

B. Split-bolt type connectors are not allowed.

C. Branch circuits (No. 10 and smaller):

1. Connectors: Solderless, screw-on, reusable pressure cable type, 600 volt, 105 degree C. with integral insulation, approved for copper and aluminum conductors.
2. The integral insulator shall have a skirt to completely cover the stripped wires.
3. The number, size, and combination of conductors, as listed on the manufacturer's packaging shall be strictly complied with.

D. Branch Circuits (No. 8 and No. 6):

1. Connectors: Pre-insulated, mechanical, reusable cable type, 600 volt, 90 degree C. with integral insulation, approved for copper and aluminum conductors, cold temperature rated to -45 degree C. Connectors shall be equal to those manufactured by Polaris Connectors.
2. Provide connectors rated for the location where installed.
3. The number, size, and combination of conductors, as listed on the manufacturer's packaging shall be strictly complied with.

E. Feeder Circuits:

1. All feeder conductors shall be the same size and type and be continuous from the overcurrent device to the panel or equipment the feeder terminates at.
2. Connectors shall be indent type, UL listed for use with the size and type of wire installed of high conductivity and corrosion-resistant material. Do not install more than one conductor per connector unless the connector is UL listed for use with the number of conductors installed.
3. Power distribution blocks shall be provided for splices or where quantity or size of conductors exceeds the terminal rating of the device to be connected. Power distribution blocks shall be equal to Square D by Schneider Electric Class 9080 Type LB or Ferraz Shawmut 62000-69000 Series. Provide with covers. Power distribution blocks shall be securely mounted in a code sized enclosure.
4. Field installed compression connectors for cable sizes 250 kcmil and larger shall have not less than two clamping elements or compression indents per wire.
5. Insulate splices and joints with materials approved for the particular use, location, voltage, and temperature. Insulation rating shall be not less than that of the conductor that is being joined.
6. Plastic electrical insulating tape: Flame retardant, cold and weather resistant.

2.3 CONTROL WIRING:

A. Unless otherwise specified in other sections of these specifications, size control wiring as specified for power and lighting wiring, except the minimum size shall be not less than No. 14, 90 degrees C. insulation. Where stranded conductors are used, provide with spade type insulated copper terminals.

B. Size wire large enough so that the voltage drop under inrush conditions does not adversely affect operation of the controls.

2.4 COMMUNICATION AND SIGNAL WIRING:

A. Shall conform to the recommendations of the manufacturers of the communication and signal systems; however, not less than what is shown.

B. Wiring shown is for typical systems. Provide wiring as recommended by the manufacturer for the systems being furnished.

C. Multi-conductor cables shall have the conductors color coded.

2.5 WIRE LUBRICATING COMPOUND:

A. The cable pulling lubricant shall be compatible with all cable jackets. The lubricant shall be UL (or CSA) listed. The lubricant shall contain no waxes, greases, silicones, or polyalkylene glycol oils or waxes.

B. A 200-gram sample of the lubricant, when placed in an one-foot, split metal conduit and fully dried for 24 hours at 105 degrees C, shall not spread a flame more than three-inches beyond a point of ignition at a continued heat flux of 40 kW/m^2. Total time of test shall be one-half hour.

C. Approved Lubricant is:

1. Polywater J from American Polywater Corporation

2.6 FIREPROOFING TAPE:

A. The tape shall consist of a flexible, conformable fabric of organic composition coated one side with flame-retardant elastomer.

B. The tape shall be self-extinguishing and shall not support combustion. It shall be arcproof and fireproof.

C. The tape shall not deteriorate when subjected to water, gases, salt water, sewage, or fungus and be resistant to sunlight and ultraviolet light.

D. The finished application shall withstand a 200 ampere arc for not less than 30 seconds.

E. Securing tape: Glass cloth electrical tape not less than 7 mils thick, and 3/4-inch wide.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERALLY:

A. Install in accordance with the NEC, and as specified.

B. Install all wiring in raceway systems.

C. Where No. 10 or No. 12 stranded conductors terminate at receptacles, toggle switches, or other devices with a screw-type connection, provide a solid conductor pigtail or spade-type connector listed for use with the appropriate class of stranded wire.

D. Install a ground wire sized per NEC 250.122 in each conduit containing phase conductors.

E. Color Code:

1. All conductors shall be identified by circuit number and color coding at all termination points and splices. All conductors shall be identified in all pull and junction boxes by the following method of color coding. Means of identification shall be permanently posted at each branch circuit panel with a nameplate identifying color coding system used in that panelboard.

Phase	208/120V
A	Black
B	Red
C	Blue
Neutral	White
Ground	Green
Iso. Grd	Green w/Yellow

2. Use solid color compound or solid color coating for No. 6 and smaller branch circuit conductors and neutral sizes.
3. Phase conductors No. 4 and larger color code using one of the following:

   a. Solid color compound or solid color coating.
   b. Colored as specified using 3/4-inch wide tape. Apply tape in half overlapping turns for a minimum of three-inches for terminal points, and in junction boxes, pull boxes, troughs, manholes, and handholes. Apply the last two laps of tape with no tension to prevent possible unwinding. Where cable markings are covered by tape, apply tags to cable stating size and insulation type.
   c. Yellow stripe on isolated ground may be 1/4-inch wide yellow tape on top of green.

4. Where neutrals are located in the same raceway, junction box or enclosure, neutrals shall be marked or labeled to indicate which circuit conductor (phase conductor) they are associated with. Neutrals (with stripes matching the associated phase conductor color) meeting the requirements of NEC Section 200.6 are acceptable for this purpose.
5. For modifications and additions to existing wiring systems, color coding shall conform to the existing wiring system.
6. Provide plastic engraved color code legend on each panelboard and switchboard per NEC Section 210.5 (C).
7. All improperly color coded conductors will be completely replaced at no additional cost to Owner.

F. All cable and wiring shall be continuous between electrical equipment. Splices shall not be added except as required for taps in branch circuits or as approved by the engineer.

G. Splice cables and wires only in outlet boxes, junction boxes, pull boxes, manholes, or handholes. Do not splice cables in panelboards, switchboards, disconnects, etc.

H. Install cable supports for all vertical feeders in accordance with the NEC. Provide split wedge type which firmly clamps each individual cable and tightens due to cable weight.

I. For panelboards, cabinets, wireways, switches, and equipment assemblies, neatly form, and tie all cables.

J. Seal cable and wire entering a building from underground between the wire and conduit, where the cable exits the conduit, with a non-hardening approved compound.

K. Wire Pulling:

1. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling of cables.
2. Use ropes made of nonmetallic material for pulling feeders.
3. Attach pulling lines for feeders by means of either woven basket grips or pulling eyes attached directly to the conductors, as approved by the Engineer.
4. Pull multiple cables into a single conduit with a single continuous pull.
5. Use wire lubricant per this specification when recommended by the cable manufacturer or as required to prevent damage to cables during installation.

L. Individual neutrals shall be provided for each circuit. Multi-wire branch circuits (i.e. Two or more phase sharing a neutral conductor) shall not be allowed, unless specifically noted or shown on the plans. Where multi-wire branch circuits are shown or noted on the plans, provide a disconnecting means that will simultaneously disconnect all phase conductors at the panel where the branch circuit originates.

3.2 INSTALLATION IN MANHOLES:

A. Install and support cables in manholes on the steel racks with porcelain or equal insulators. Train the cables around the manhole walls, but do not bend to a radius less than six times the overall cable diameter.

3.3 SPLICE INSTALLATION:

A. Splices and terminations shall be mechanically and electrically secure.

B. Where the Engineer determines that unsatisfactory splices or terminations have been installed, remove the devices and install approved devices at no additional cost to the Owner.

3.4 CONTROL, COMMUNICATION, AND SIGNAL WIRING INSTALLATION:

A. Unless otherwise specified in other sections of these specifications, install wiring as described below. Wiring shall be connected to perform the functions shown and specified in other sections of this specification.

B. Except where otherwise required, install a separate power supply circuit for each system, or control equipment, or control power. Circuit to nearest 120 volt panel or nearest emergency panel if equipment controlled is connected to emergency system. Use spare 20 Amp breakers in panels where none are designated. Verify all requirements with actual equipment supplied in field.

C. Install a breaker lock-on clip on the handle of the branch circuit breaker for the power supply circuit for each system to prevent accidental de-energizing of the systems. Lock-on clips for circuit breakers serving fire alarm systems shall be painted red.

D. System voltages shall not exceed 120 volts and shall be lower voltages where shown on the drawings or required by the NEC.

E. Wire and cable identification:

1. Install a permanent wire marker on each wire at each termination, outlet box, junction box, panel, and device. Markers shall be typed or handwritten and shall be clearly legible.
2. Identifying numbers and letters on the wire markers shall correspond to those on the wiring diagrams used for installing the systems.
3. Wire markers shall retain their markings after cleaning.
4. In each manhole and handhole, install permanent, waterproof tags to identify the cable type/system and the building or area served.

3.5 FEEDER IDENTIFICATION:

A. In each, interior pullbox and junction box, identify each phase, neutral and/or ground conductor by conductor color coding or tape based on system voltage.

B. In manholes and handholes, install permanent, waterproof tags to identify the cable type. Identify each phase, neutral, and/or ground conductor by conductor color coding or tape based on system voltage.

3.6 FIELD TESTING:

A. Feeders and branch circuits shall have their insulation tested after installation and before connection to utilization devices such as fixtures, motors, or appliances.

B. Test shall be performed by megger and conductors shall test free from short-circuits and grounds.

C. Test conductors' phase-to-phase and phase-to-ground.

D. Megger motors after installation but before start-up and test free from grounds.

E. The Contractor shall furnish the instruments, materials, and labor for these tests.

3.7 FIRE RATED CABLE

A. Install per the manufacturer's Installation Manual and the UL "Electrical Circuit Protective Listing" requirements.

B. Install in minimum 1/2" metallic conduit. Maximum support spacing shall be 5 feet.

C. Seal conduit to prevent smoke from entering electrical equipment enclosures per the manufacturer's directions.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

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

1.2 SUMMARY:

A. This section includes grounding and bonding systems and equipment, plus the following special applications:

1. Foundation steel electrodes.
2. Ground bonding common with lightning protection system.
3. Underground distribution grounding.

1.3 SUBMITTALS:

A. Product Data (Where indicated in Section "Common Work Results for Electrical", provide the following information): For each type of product indicated.

B. As-Built Data: Plans showing dimensioned as-built locations of grounding features, including the following:

1. Ground rods.
2. Grounding arrangements and connections for separately derived systems.
3. Test wells.
4. Ground rings.

C. Test Records: Submit the following test records to the Engineer for review and approval, and include in the operational and maintenance manuals:

1. Grounding system tests per paragraph FIELD QUALITY CONTROL in Part 3 of this Section.

1.4 QUALITY ASSURANCE:

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS:

A. Insulated General Purpose: UL and NFPA 70 approved types, copper, with THW, XHHW or dual rated THHN-THWN insulation color identified green.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B3.
2. Stranded Conductors: ASTM B8.

C. Size conductors not less than what is shown on the drawings and not less than required by the NFPA 70.

2.2 GROUND BUS:

A. Pre-drilled rectangular bars of annealed copper, 1/4 by 4 inches in cross-section with 9/32 inch holes spaced 1-1/8 inches apart. Stand-off insulators shall comply with UL 891 for use in switchboards, 600V and shall be Lexan or PVC, impulse tested at 5000V.

2.3 GROUND RODS:

A. Copper-clad steel, sectional type, 3/4-inch diameter by 20 feet long.

2.4 CONNECTORS:

A. Listed and labeled by a NRTL acceptable to the authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connections:

1. Exothermic welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
2. For structural steel, steel grounding stud for compression connector.

D. Compression Connectors: Hydraulic crimped, irreversible compression type kits. Connectors shall be factory filled with oxide inhibitor. All crimps shall be made with a hydraulic tool that embosses the index number on the outside of the connector.

E. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long barrel, two-bolt connection to ground bus bar.

F. All splices and grounding electrode connections shall be made with exothermic welds or with hydraulic compression fittings.

2.5 INTERSYSTEM GROUND BAR:

A. Complies with UL 467.

B. Base and cover shall be impact resistant and UV rated.

C. Shall be rated for copper and aluminum conductors.

D. Shall have provisions for one main grounding electrode conductor and a minimum of four bonding conductors.

PART 3 - EXECUTION

3.1 APPLICATIONS:

A. Conductors: Install solid or stranded conductors for #10 AWG and smaller and stranded conductors for #8 AWG and larger unless otherwise indicated.

B. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.

C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors or hydraulic compression connectors except as otherwise indicated.
3. Connections to Structural Steel: Welded connectors.
4. Aboveground Connections to Ground Rods: Bolted connectors.
5. Connections to Ground Rods at Test Wells: Bolted connectors.

3.2 INSTALLATION, GENERALLY:

A. Ground in accordance with the NFPA 70 as shown, and as hereinafter specified. All equipment ground conductors shall be terminated on a ground bus or ground lug attached to equipment can.

B. Service Grounding:

1. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus.
2. Install a main bonding jumper between the neutral and ground buses.

C. System Grounding:

1. Secondary service neutrals shall be grounded at the supply side of the secondary disconnecting means and at the related transformers.
2. Separately derived systems (transformers downstream from the service entrance) ground the secondary neutral.
3. Individual Buildings: Bond Main Disconnect ground bus to building steel, 20 foot re-bar in foundation, water pipe, driven ground, and ground ring.

D. Equipment Grounding:

1. Metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits shall be grounded for personnel safety and to provide a low impedance path for possible ground fault currents.

E. Generator Grounding:

1. Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.3 PRIMARY EQUIPMENT AND CIRCUITS:

A. Comply with IEEE C2 (National Electrical Safety Code) grounding requirements.

B. Switchgear: Provide a bare grounding electrode conductor from the switchgear ground bus to the grounding electrode system.

C. Duct Banks and Manholes:

1. Provide a bare equipment grounding conductor in each duct bank containing medium or high voltage cables. Connect the grounding conductors to the switchgear ground bus, to all manhole hardware, to the cable shielding of medium or high voltage cable splices and terminations, and equipment enclosures.
2. Provide a grounding conductor having at least 50 percent ampacity of the largest phase conductor in the duct bank.
3. Provide a ground rod at each manhole. Seal floor opening with waterproof, nonshrink grout
4. Connect the equipment grounding conductor to the ground rod.

D. Pad Mounted Transformers:

1. Provide a driven ground rod and connect with a grounding electrode conductor to the grounding terminals at the transformer.
2. Ground the secondary neutral.
3. Connect lightning arrester grounds to the pad ground per NFPA 70.

E. Lightning Arresters: Connect lightning arrester grounds to the equipment ground bus, or ground rods as applicable.

F. Metallic Conduit: Metallic conduits which terminate without mechanical connection to housing of electrical equipment by means of locknut and bushings or adapters, provided with grounding bushings. Connect bushings with a bare grounding conductor to the equipment ground box.

3.4 SECONDARY EQUIPMENT AND CIRCUITS:

A. Main Bonding Jumper: Connect the secondary service neutral to the ground bus in the service equipment.

B. Service Disconnect: Provide a ground bar bolted to the enclosure with lugs for connecting the various grounding conductors. Connect the neutral to the ground bus (main bonding jumper).

C. Switchgear, Switchboards, and Unit Substations:

1. Connect the various feeder green grounding conductors to the ground bus in the enclosure with suitable pressure connectors.
2. Connect the grounding electrode conductor to the ground bus.
3. Connect metallic conduits, which terminate without mechanical connection to the housing, by grounding bushings and ground wire to the ground bus.

D. Transformers:

1. Exterior: Exterior transformers supplying interior service equipment shall also have the neutral grounded at the transformer secondary. Provide a grounding electrode at the transformer.
2. Separately derived systems (transformers downstream from service equipment): Ground the secondary neutral at the transformer. Provide a grounding electrode conductor from the transformer to the nearest cold water pipe and the nearest structural steel that are effectively grounded. If neither of these are available, provide a driven ground rod or other code approved grounding electrode.

E. Conduit Systems:

1. Ground all metallic conduit systems.
2. Non-metallic conduit systems shall contain a grounding conductor.
3. Conduit provided for mechanical protection containing only a grounding conductor, bond to that conductor at the entrance and exit from the conduit via grounding bushings.

F. Feeders and Branch Circuits: Install green grounding conductors with feeders and branch circuits in all feeders and branch circuits and in any raceway containing a phase conductor.

G. Boxes, Cabinets, Enclosures, and Panelboards:

1. Bond the grounding wires to each pullbox, junction box, outlet box, cabinets, and other enclosures through which the ground wires pass (except for special grounding systems for intensive care units and other critical units shown.).
2. Make ground wire connections to ground bus in motor control centers, panelboards, etc.

H. Receptacles and toggle switches are not approved for grounding through their mounting screws. Ground with a ground wire from green ground terminal on the device to the outlet box ground screw.

I. Ground lighting fixtures to the green grounding conductor of the wiring system when the green ground is provided; otherwise, ground the fixtures through the conduit systems. Fixture connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.

J. Fixed electrical appliances and equipment shall have a ground lug installed for termination of the green ground conductor.

3.5 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS:

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set top of rod 4 inches above finished floor. Seal floor opening with waterproof, non-shrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, puling irons, ladders, and cable shields within each manhole to ground rod or grounding conductor. Make connections with #4 AWG minimum, stranded, hard drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and non-current carrying metal items to underground cable and grounding electrodes.

3.6 CONDUCTIVE PIPING:

A. Bond all conductive piping systems in the building to the electrical system ground. Bonding connections shall be made as close as practical to the water pipe ground or service equipment ground bus.

3.7 SPLICES:

A. All splices and grounding electrode connections shall be made with exothermic welds or with hydraulic compression fittings.

3.8 GROUNDING RESISTANCE:

A. Grounding system ground resistance must not exceed 2.5 ohms. Final tests shall assure that this requirement is met.

B. Where permanent ground connections are required, make the connections by the exothermic process or hydraulic compression method to form solid metal joints.

C. Where rock prevents the driving of vertical ground rods, install grounding electrodes in horizontal trenches to achieve the specified resistance.

D. Where more than one ground rod is required to meet the specified resistance, they shall be located at least 10 feet apart. Interconnect with grounding electrode conductor below grade and as otherwise indicated.

3.9 INSTALLATION:

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where subject to strain, impact, or damage.

B. Grounding electrode conductors shall be continuous.

C. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to the service entrance (where more than one ground rod has been installed). Set top of test well flush with finished grade or floor.

D. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor same size as system grounding electrode conductor.

3.10 FIELD QUALITY CONTROL:

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation. Inspect compression type connections for proper die index number embossment.

B. Perform the following testing:

1. After installing grounding system, but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system as each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at ground rods. Make tests at ground rods before any conductors are connected.

a. Measure ground resistance no fewer than two full days after the last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
b. Perform tests by fall-of-potential method according to IEEE 81. Submit test results to the Engineer.
c. Excessive Ground Resistance: If resistance to ground exceeds specified values, promptly notify Engineer and include recommendations for reducing ground resistance.

END OF SECTION 260526

SECTION 260533 – RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Description:

1. This section includes the furnishing, installation, and connection of raceways, fittings, and boxes to form complete, coordinated, grounded raceway systems. Raceways are required for all wiring unless shown or specified otherwise.
2. The term conduit, as used in this specification, shall mean any or all of the raceway types specified.

B. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Non-metallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Non-metallic wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes and enclosures.
7. Handholes and boxes for exterior underground cabling.

C. Related Requirements:

1. Section 260543 “Underground Electrical Construction” for exterior ductbanks and manholes.

1.3 DEFINITIONS:

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

D. RGS: Rigid galvanized steel.

1.4 ACTION SUBMITTALS:

A. Product Data (Where indicated in Section "Common Work Results for Electrical", provide the following information): For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings (Where indicated in Section "Common Work Results for Electrical", provide the following information): For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

PART 2 - PRODUCTS

2.1 CONDUIT:

A. Raceway Size: In accordance with the NFPA 70 but not less than 1/2-inch unless otherwise shown. Where permitted by the NFPA 70, 1/2-inch flexible conduit may be used for connections to recessed lighting fixtures.

B. Raceway Supports:

1. Parts and hardware: Zinc-coat or provide equivalent corrosion protection.
2. Pipe Straps: Fed. Spec. FF-S-760, Type I, Style A or B.
3. Individual Raceway Hangers: Designed for the purpose, having a pre-assembled closure bolt and nut, and provisions for receiving a hanger rod.
4. Multiple Raceway (trapeze) hangers: Not less than 1-1/2 by 1-1/2 inch, 12 gauge steel, cold formed, lipped channels; with not less than 3/8-inch diameter steel hanger rods.
5. Solid Masonry and Concrete Anchors: Fed. Spec. FF-S-325; Group III self-drilling expansion shields, or machine bolt expansion anchors Group II, Type 2 or 4, or Group VIII.

C. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.

2.2 RACEWAYS:

A. Install raceway types as shown on drawings and as listed below.

B. Metal Conduit:

1. Rigid steel: UL 6 and ANSI C80.1.
2. Rigid aluminum: UL 6A and ANSI C80.5.
3. Rigid intermediate steel conduit (IMC): UL 1242 and ANSI C80.6.
4. Electrical metallic tubing (EMT): U.L. 797 and ANSI C80.3. Maximum size 5-inch. Permitted only with cable rated 600 volts or less.
5. Flexible steel conduit (commercial Greenfield): UL 1, zinc-coated steel.

6. Liquid-tight flexible metal conduit: UL 360 flexible galvanized steel tubing covered with extruded liquid-tight jacket of polyvinyl chloride (PVC). Provide conduit with a continuous copper bonding conductor spiral between the convolutions.
7. PVC Coated Rigid Steel: NEMA RN 1. Conduit and fittings shall be as manufactured by Robroy Industries; Plasti-Bond, Perma-Cote, and KorKap or Thomas & Betts; Ocal. Any deviation will require approval of the specifying Engineer or Owner.

    a. Shall be UL listed.
    b. All male threads on conduit, elbows and nipples shall be protected by application of a urethane coating.
    c. All female threads on fittings or conduit couplings shall be protected by application of a urethane coating.

C. Conduit Fittings for Metal Conduit:

1. Comply with NEMA FB 1 and UL 514B.
2. Rigid steel and IMC conduit fittings:

    a. Standard threaded couplings, locknuts, bushings, and elbows: Fed. Spec. W-F-408, except only material of steel or malleable iron is acceptable. Integral retractable type IMC couplings are acceptable also.
    b. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure
    c. Bushings: Metallic insulating type, consisting of an insulating insert molded or locked into the metallic body of the fitting. Bushings made entirely of metal or nonmetallic material are not permitted. Bushings for conduit smaller than 1-1/4-inch shall have flared bottom with ribbed sides.
    d. Erickson (union-type) and set screw type couplings: Approved for use in concrete are permitted for use to complete a conduit run where conduit is installed in concrete. Use set screws of case hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.
    e. Sealing fittings: Threaded cast iron type. Use continuous drain type sealing fittings to prevent passage of water vapor. In concealed work, install fittings in flush steel boxes with blank coverplates having the same finishes as that of other electrical plates in the room.
    f. In trade sizes 2-1/2 inches to 4-inches for rigid steel raceway or intermediate metal raceway, contractor may use Allied 'Kwik-Couple' fittings in lieu of individual steel couplings. 'Kwik-Couple' fittings shall not be used in hazardous locations.

Where 'Kwik-Couple' fittings are used exterior for vertical risers, install fitting with taper end up.

3. Rigid aluminum conduit fittings:

   a. Standard threaded couplings, locknuts, bushings, and elbows: Malleable iron, steel or aluminum alloy materials. Zinc or cadmium plate iron or steel fittings. Aluminum fittings containing more than 0.4 percent copper are prohibited.
   b. Locknuts and bushings: As specified for rigid steel and IMC raceways.
   c. Set screw fittings: Not permitted for use with aluminum raceway.

4. Electrical metallic tubing fittings:

   a. Fed. Spec. W-F-408, except only material of steel for compression type. Steel or die-cast is acceptable for set screw type. Die-cast compression is not acceptable.
   b. Couplings and connectors: Concrete tight and rain tight, with connectors having flared throats. Use gland and ring compression type or set screw type couplings and connectors. Set screw type couplings for conduit 2 inches and larger shall be four set screws each. Use set screws of case-hardened steel with hex head and cup point to firmly seat in wall of conduit for positive grounding.
   c. Indenter type connectors or couplings are prohibited.

5. Flexible steel conduit (greenfield) fittings:

   a. Fed. Spec. W-F-406 and UL 5, except only steel or malleable iron material is acceptable.
   b. Clamp type, with insulated throat.

6. Liquid-tight flexible metal conduit fittings:

   a. Fed. Spec. W-F-406, except only steel or malleable iron material is acceptable.
   b. Type incorporating a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening. Connectors shall have insulated throats.

7. Expansion and deflection couplings:

   a. UL 467 and UL 514.
   b. Accommodate, 1.9 cm (0.75”) deflection, expansion, or contraction in any direction, and allow 30 degree angular deflections.
   c. Include internal flexible metal braid sized to guarantee conduit ground continuity and fault currents in accordance with UL 467,

NFPA 70 Section 250.98, and the NFPA 70 code tables for ground conductors.

d. Shall be watertight, seismically qualified, corrosion-resistant, threaded for and compatible with rigid or intermediate metal conduit.

e. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat resistant molded rubber material with stainless steel jacket clamps.

f. Expansion fittings shall accommodate a minimum of 4-inches of movement.

D. Nonmetallic Conduit:

1. PVC Conduit: NEMA TC 2 and UL 651 Schedule 40, conduit size is 3/4-inch minimum.

E. Conduit Fittings for Non-Metallic Conduits:

1. PVC Conduit: Comply with NEMA TC 3; match to conduit type and material.

2.3 OUTLET BOXES:

A. UL-50, UL514A and NEMA OS 1.

B. Cast metal where required by NFPA 70 or shown, and equipped with rustproof boxes; NEMA FB 1.

C. Sheet metal boxes: 4-inch square, galvanized steel, except where otherwise shown.

D. Boxes installed in concrete or masonry and boxes larger than two gang shall be masonry type.

E. Box extensions used to accommodate building finishes shall be of the same material as the recessed box.

F. Boxes for use with IMC or RGS raceways shall be cast ‘F’ type or stainless steel unless noted otherwise on the drawings.

G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of lumenaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

H. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.

2.4 WIREWAYS AND AUXILIARY GUTTERS:

A. Sized according to NFPA 70.

B. Equip with hinged covers, except where removable covers are shown. Wireways shall only be permitted as indicated on the drawings or approved by the Engineer.

C. Fittings and accessories: Include covers, couplings, offsets, elbows expansion joints, adapters, hold down straps, end caps, and other fittings to match and mate with wireways as required for a complete system.

D. Metal Wireways:

1. Sheet metal complying with UL 870 and NEMA 250.
2. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70 and shall be marked for intended location and application.

2.5 PULL AND JUNCTION BOXES:

A. Small boxes shall comply with NEMA OS 1.

B. Larger boxes shall comply with UL 50 and NEMA 250.

C. Pull and junction boxes shall be code gauge steel boxes with hinged, bolted or screwed covers. Boxes shall be flush or surface mounted as shown or required.

D. Junction and pull box shall be installed where shown on drawings and additional boxes shall be installed if required for pulling of wire provided location and installation is approved by the Architect. All boxes shall be code construction with screw type cover and shall be installed in accessible locations.

E. Pull and junction boxes for use with IMC or RGS raceways shall be cast ‘FS’ type or stainless steel unless noted otherwise on the drawings. Comply with NEMA FB 1 and UL 1773 with gasketed cover.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.

B. Comply with SCTE 77.

C. Configuration: Designed for flush burial with open bottom unless otherwise indicated.

D. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.

E. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

F. Cover Legend: Molded lettering shall be “ELECTRIC” for power handholes and “COMMUNICATIONS” or “CONTROLS” as applicable for low voltage handholes.

G. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

H. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

I. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete.

PART 3 - EXECUTION

3.1 RACEWAY:

A. Minimum 1/2-inch above grade, 3/4-inch below grade, and 1-inch on site, unless otherwise noted.

B. A ground wire, sized per NFPA 70 Section 250.122 shall be installed in all conduits containing phase conductor(s).

C. RGS or IMC must be used at all times when exposed to weather or physical abuse and in all NFPA 70 classified hazardous locations. EMT may not be used in direct contact with earth, or in concrete slabs on grade.

D. U.L. approved Schedule 40 P.V.C. conduit may be used where feeders or branch circuits are to be run in earth or slabs (3/4" minimum).

1. Use PVC coated RGS ells and risers approved for underground use. All conduit risers through concrete floors shall be RGS from below the top of the floor slab. Use conduit adapters when converting from PVC to steel conduit.
2. Use plastic spacers when more than one conduit is installed together. See Drawings for areas requiring concrete encasement.

E. All nonmetallic (PVC and fiberglass) conduits shall be provided with separate ground conductor sized per NFPA 70.

3.2 PENETRATIONS:

A. Cutting or Holes:

1. Locate holes in advance where they are proposed in the structural sections such as ribs or beams. Obtain the approval of the Structural Engineer prior to drilling through structural sections.
2. Cut holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw. Pneumatic hammer, impact electric, hand or manual hammer type drills are not allowed, except where permitted by the Structural Engineer as required by limited working space.

B. Fire Stop:

1. Where conduits, wireways, and other electrical raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases, and maintains specified fire rating. Completely fill and seal clearances between raceways and openings with the fire stop material. See Section "Common Work Results for Low Voltage Systems Cabling" for firestopping requirements for low voltage cabling sleeves.

C. Fire Barrier Penetration Seals:

1. Manufacturer: Subject to compliance with requirements, provide fire barrier penetration seals of one of the following:

   a. Electro Products Div./3M
   b. Nelson; Unit of General Signal.

2. Provide seals for any opening through fire-rated walls, floors, ceilings, or assemblies used as passage for components such as conduits or cables.
3. Cracks, voids or holes up to 4-inch diameter: Use putty or caulking, one-piece intumescent elastomer, non-corrosive to metal, compatible with synthetic cable jackets, and capable of expanding 10 times when exposed to flame or heat and UL-listed.
4. Openings greater than 4-inch diameter and raceway sleeves thru floors at telephone terminal boards: Use sealing system capable of passing 3-hour fire test in accordance with ASTM E-814, consisting of wall wrap or liner, partitions, and end caps capable of expanding when exposed to temperatures of 250 degrees to 350 degrees F (121 to 177·C), that is UL-listed. KBS "Sealbags" manufactured by P-W Industries will be acceptable.
5. Execution: Fill entire opening with sealing compound. Adhere to manufacturer's installation instructions. All fire barrier seals shall meet the rating of the wall.

D. Waterproofing:

1. Install sleeves and sleeve seals at exterior floor, exterior wall, and roof conduit penetrations and completely seal clearances around the conduit and sleeve and make watertight as specified in Section, SEALING AND CAULKING.

3.3 CONDUIT SYSTEMS INSTALLATION, GENERAL:

A. Installation: In accordance with UL, NFPA 70, as shown, and as hereinafter specified.

1. Where non-metallic (PVC or fiberglass) conduits are used, a ground wire sized per NFPA 70 Section 250.122 shall be provided if not already specified.

B. All branches of the emergency system shall be installed entirely independent of other raceway systems. Common supports and hangers may be used.

C. Raceway Burial Depths: (Underground work)

1. 18” minimum, 30” maximum cover to grade or bottom of floor slab.
2. 24” minimum under streets, highways, roads, alleys, driveways and parking lots.
3. 2” minimum below concrete slab inside a building.
4. Prior to any underground work, contractor shall verify and locate all existing underground utilities. All existing utilities may not be shown on the drawings. Verify in field with owner and with utility locating services. The contractor shall exercise extreme caution when trenching or boring, hand digging at all crossings and where in close proximity of existing utilities. Repair existing parking lots, streets, roads, alleys, driveways, etc. to its original condition in a timely manner prior to substantial completion. Contractor shall be responsible for any damage to underground utilities.
5. Underground conduits shall be installed in a sand bed and in an organized manner.
6. Conduit ductbanks of more than 3 conduits (2” and larger) shall be installed with spacers and encased with flowable fill.

D. Install raceways as follows:

1. Comply with NECA 1, comply with NECA 101 for metal conduit and NECA 102 for aluminum conduit except where requirements on drawings or this article are stricter.
2. In complete runs before pulling in cables or wires.
3. Flattened, dented, or deformed raceways are not permitted. Remove and replace the damaged raceways with new undamaged material.
4. Assure raceway installation does not encroach into the ceiling height head room, walkways, or doorways.
5. Cut square with a hacksaw, ream, remove burrs, and draw up tight.
6. Mechanically and electrically continuous.
7. Independently support raceway. Do not use other supports i.e., (suspended ceilings, suspended ceiling supporting members, lighting fixtures, mechanical piping, or mechanical ducts.). Group raceways with common supports where possible. Conduit shall be supported within 12-inches of connectors.
8. Close ends of empty raceway with plugs or caps at the rough-in stage to prevent entry of debris, until wires are pulled in.
9. Raceway installations under fume and vent hoods are prohibited.

10. Secure raceways to cabinets, junction boxes, pull boxes and outlet boxes with bonding type locknuts. For RGS and IMC raceway installations, provide a locknut on the inside of the enclosure, made up wrench tight. Do not make raceway connections to junction box covers.
11. Flashing of penetrations of the roof membrane is specified in Section, FLASHING AND SHEET METAL.
12. Raceways shall not be used as a support.
13. Use thread compounds that are UL approved conductive type to insure low resistance ground continuity through the raceways.
14. Tightening set screws with pliers is prohibited.
15. Keep raceways a minimum of 6 inches away from parallel runs of flues and steam or hot-water pipes.

E. Raceway Bends:

1. Make bends with standard raceway bending machines.
2. Raceway hickey may be used for slight offsets, and for straightening stubbed out raceways.
3. Bending of raceways with a pipe tee or vise is prohibited.

F. Raceways Installed Under Metal - Corrugated Sheet Roof Decking

1. Where rigid metal conduit or intermediate metal conduit is not used, raceways shall be installed and supported so the nearest outside surface of the raceway is not less than 1.5 inches from the nearest surface of the roof decking.

G. PVC coated RGS:

1. Use only fittings listed for use with this type of conduit.
2. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduit and fittings. Use sealant recommended by conduit manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameter of the coated conduit.
4. All clamping, cutting, threading, bending, and assembly instructions listed in the manufacturer’s installation guide should be vigorously followed. Installer certification, before installation, is required.

3.4 CONCEALED WORK INSTALLATION:

A. General:

1. Raceway and Outlet Boxes Installation: All raceway systems work and outlet boxes shall be installed concealed in walls, floor and roof construction or concealed within furred spaces or above ceilings. In

equipment or mechanical rooms exposed work shall include feeders and connections to equipment unless noted otherwise.

B. In Concrete:

1. Raceway: RGS, IMC, PVC or EMT; except do not install EMT in concrete slabs that are in contact with soil, gravel or vapor barriers.
2. Align and run raceways in direct lines.
3. Install raceways through concrete beams only when the following occurs:

   a. Where shown on the structural drawings.
   b. As approved by the Structural Engineer prior to construction, and after submittal of drawing showing location, size, and position of each penetration.

4. Installation of raceways in concrete that is less than three inches thick is prohibited. All raceways installed in concrete shall be approved by the Structural Engineer.

   a. Raceway outside diameter larger than one-third of the slab thickness is prohibited.
   b. Space between raceways in slabs: Approximately six conduit diameters apart, except one conduit diameter at conduit crossings.
   c. Install raceways approximately in the center of the slab so that there will be a minimum of 3/4-inch of concrete around the raceways.

5. Make couplings and connections watertight.

C. Above Furred or Suspended Ceilings and in Walls:

1. Raceways for conductors 600 volts and below:

   a. RGS, IMC, rigid aluminum, or EMT. Types mixed indiscriminately in the same system are prohibited.
   b. Do not use aluminum in wet locations or in contact with concrete.

2. Raceways for conductors above 600 volts:

   a. RGS or rigid aluminum. Do not use aluminum in wet locations or in contact with concrete.
   b. Aluminum conduit mixed indiscriminately with other types in the same system is prohibited.

3. Align and run raceways parallel or perpendicular to the building lines.
4. Connect recessed or lay-in lighting fixtures and all other devices installed in a lay-in ceiling to raceway runs with flexible metal conduit extending

from a junction box to the fixture. Provide a ground wire in all flexible conduits.

5. Tightening set screws with pliers is prohibited.

3.5 EXPOSED WORK INSTALLATION:

A. Raceways for Conductors 600 volts and below:

1. RGS, IMC, rigid aluminum, or EMT. Types mixed indiscriminately in the system are prohibited.
2. Do not use aluminum in wet locations or in contact with concrete.
3. All raceways exposed to physical abuse and in all industrial pump, treatment plant locations shall be RGS, or IMC.

B. Raceways for conductors above 600 volts:

1. RGS or rigid aluminum. Do not use aluminum in wet locations.
2. Aluminum mixed indiscriminately with other types in the same system is prohibited.

C. Align and run raceways parallel or perpendicular to the building lines.

D. Install horizontal runs close to the ceiling or beams and secure with raceway straps.

E. Surface metallic raceways:

1. Surface metallic raceway shall only be used where shown on the drawings, and in remodels and modifications to existing where wall and ceiling voids do not permit concealed installation but shall not be used at any other location unless called for on the drawings.
2. All surface raceway and outlets must be painted to match the surface it is attached to.
3. Install a ground wire sized per NFPA 70 Section 250.122 for the largest circuit in the raceway if not already specified.

F. Painting:

1. Paint exposed raceways as specified in Section, PAINTING.
2. Paint raceways containing cables rated over 600 volts safety orange as specified in Section, PAINTING. In addition, paint legends, using 2-inch high black numerals and letters, showing the cable voltage rating. Provide legends where raceways pass through walls and floors and at maximum 20-foot intervals in between.

3.6 WET OR DAMP LOCATIONS:

A. Unless otherwise shown, use raceways of RGS or IMC above grade. Use PVC conduit below grade, except RGS ells and risers shall be used.

B. Provide sealing fittings, to prevent passage of water vapor, where raceways pass from warm to cold locations, i.e., (refrigerated spaces, constant temperature rooms, air conditioned spaces) or similar spaces.

C. When RGS ells and risers are used below grade or when RGS or IMC conduit or RGS ells and risers are used below concrete building slabs in contact with soil, gravel, or vapor barriers, conduit shall be PVC coated RGS or PVC coated IMC.

3.7 CORROSIVE LOCATIONS:

A. Conduit shall be PVC coated RGS.

3.8 MOTORS AND VIBRATING EQUIPMENT:

A. Use flexible metal conduit (Type FMC) for connections to motors and other electrical equipment subject to movement, vibration, misalignment, cramped quarters, or noise transmission. Provide liquid-tight flexible metal conduit Type (LFMC) for installation in exterior locations, kitchens, moisture or humidity laden atmosphere, corrosive atmosphere, water or spray wash-down operations, treatment plants, pump stations, and locations subject to seepage or dripping of oil, grease or water. Provide a green ground wire with all flexible metal conduit.

3.9 EXPANSION JOINTS:

A. Expansion fittings shall be used wherever the change in length of PVC conduit due to temperature variation exceeds 0.25-inches per NEC Section 352.44.

B. All conduits routed outdoors or in non-conditioned spaces (i.e., attics, non-insulated plenums, etc.) shall have expansion fittings per the following:

1. Steel: One expansion fitting in runs longer than 40 feet. Provide additional expansion fittings every 200 feet.
2. Aluminum: One expansion fitting in runs longer than 20 feet. Provide additional expansion fittings every 100 feet.
3. PVC: One expansion fitting in runs longer than 20 feet. Provide additional expansion fittings every 50 feet.

C. Equip raceways 3-inches and larger, that are rigidly secured to the building structure on opposite sides of a building expansion joint, with expansion and deflection couplings. Install the couplings in accordance with the manufacturer’s recommendations.

D. Equip raceways smaller than 3-inches, that are rigidly secured to the building structure on opposite sides of a building expansion joint, with junction boxes located 12-inches either side of the expansion joint. Connect junction boxes with 24-inches of flexible conduit that is slack (to allow for movement). Flexible conduit shall have an insulated copper bonding jumper installed. In lieu of this flexible conduit, expansion and deflection couplings as specified above for 3-inches and larger conduits are acceptable.

3.10 RACEWAY SUPPORTS, INSTALLATION:

A. All raceways shall have supports at maximum spacing of 10-feet and within 3-feet of a fitting, elbow, change of direction, box outlet or enclosure. Safe working load shall not exceed 1/4 of proof test load of fastening devices. This shall apply to both vertical and horizontal conduit runs.

B. Use pipe straps or individual raceway hangers for supporting individual conduits.

C. Support multiple raceway runs with trapeze hangers. Use trapeze hangers that are designed to support a load equal to or greater than the sum of the weights of the raceways, wires, hanger itself, and 200 pounds. Attach each raceway with U-bolts or other approved fasteners.

D. Support raceways independently of junction boxes; pull boxes, fixtures, suspended ceiling T-bars, angle supports, and similar items.

E. Fasteners and Supports in Solid Masonry and Concrete:

1. New Construction: Use steel or malleable iron concrete inserts set in place prior to placing the concrete.
2. Existing Construction:

a. Steel expansion anchors not less than 1/4-inch bolt size and not less than 1-1/8 inch embedment.
b. Power set fasteners not less than 1/4-inch diameter with depth of penetration not less than 3-inches.
c. Use vibration and shock resistant anchors and fasteners for attaching to concrete ceilings.

F. Hollow Masonry: Toggle bolts are permitted. Bolts supported only by plaster are not acceptable.

G. Metal Structures: Use machine screw fasteners or other devices specifically designed and approved for the application.

H. Attachment by wood plugs, rawl plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.

I. Chair, wire, or perforated strap shall not be used to support or fasten conduit.

J. Spring steel type supports "caddy clips" that are listed for the intended use are acceptable in appropriate locations.

K. Vertical Supports: Vertical raceway runs shall have riser clamps and supports in accordance with NFPA 70 and as shown. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.

3.11 BOX INSTALLATION:

A. Boxes for Concealed Raceways:

1. Mount flush. Boxes protruding from the finished wall surface or with more than 1/8-inch gap between the wall or outlet mounted in the box will be changed out with all wall reconstruction expense paid by the Electrical Contractor.
2. Provide raised covers for boxes to suit the wall or ceiling, construction and finish.

B. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling in operations.

C. Remove only knockouts as required and plug unused openings. Use threaded plugs for cast metal boxes and snap-in metal covers for sheet metal boxes.

D. Outlet boxes in the same wall mounted back-to-back are prohibited.

E. Minimum size of outlet boxes for ground fault interrupter (GFI) receptacles is 4-inches square by 2-1/8 inches deep, with device covers for the wall material and thickness involved.

F. Where lighting fixtures and appliance outlets are to be mounted in concrete or in plaster finish on concrete, outlet boxes shall be installed in forms at exact dimensions from bench marks, columns, walls or floors.

G. Where lighting fixtures and appliances outlets are to be mounted on masonry walls and/or plastered furring or other finish, outlet boxes shall be roughed in to general location before installation of wall and furring and shall be reset to exact dimensions before walls and furring are constructed.

H. All outlet boxes shall be set true to horizontal and vertical lines parallel to walls, floors and ceilings and true to finish lines. All boxes shall be secured to ceilings or walls so all installations are solidly mounted.

I. Boxes mounted to wall studs shall be secured to a horizontal box mounting bracket equal to B-Line Series #BB2 or Caddy Series #SGB. B-Line Series #BB4, Caddy Series #H23 or equal one piece support brackets may be used for mounting light switch boxes only. However, metal stud clips with far side box supports are not acceptable.

J. Boxes for exterior exposed work (where approved by the engineer) shall be Appleton or Pyle National Type FS or FSC for shallow devices and Type FD or FDC for deep devices. Boxes for ceiling mounted light fixtures shall have approved no-bolt fixture studs. Boxes used as junction boxes shall have beveled edge flat steel blank cover.

K. Where outlet boxes are mounted exposed in unfinished areas, (where approved by the engineer) surface mounted boxes shall be 4-inches square, have rounded corners and 1/2-inch raised steel cover plates.

L. Location of outlets on small drawings is approximate and exact dimensions for locations of outlets shall be as taken from large scale plans and details on drawings or as directed by the Architect/Engineer.

1. Outlets shall be located generally from column centers and finished wall lines or to center of wall or joints between wall panels. Ceiling outlets shall be installed at elevation of suspended ceiling connected to outlets in ceiling or slab above. Where necessary to fit and center with panel or ceilings and wall spaces, the contractor must, at no expense the Owner, shift the lighting outlets or other outlets as required by the Architect.

M. Clock outlets shall be mounted 7-inches below ceiling height unless otherwise noted on the drawings. All other outlets shall be mounted at heights above floor as called for on drawings or as directed.

N. Bracket lights over mirrors shall be centered on mirrors with 2-inch fixture clearance above mirror.

O. Boxes for switches and receptacles installed in columns shall be located off center to allow for future partitions.

P. Boxes for switches at or near door shall be installed on the side opposite the hinge. Verify door swing direction prior to rough-in.

Q. To prevent sound from traveling through walls, electrical devices from different rooms shall not be mounted in the same stud place. Through-wall boxes shall not be used. In fire rated walls or partitions, outlet boxes on opposite sides of walls or partitions shall be separated by a horizontal distance of 24-inches. Outlet boxes larger than 4-inch square shall not be installed in fire rated walls or partitions. Verify location of fire rated walls or partitions with Architectural drawings prior to rough-in.

R. Mark all junction boxes and pull boxes and/or the conduit where it enters the box with panel designation and circuit number in permanent, black marker. Mark on the outside where located in unfinished spaces and mark on the inside in finished spaces.

S. Verify exact location of floor boxes and poke-throughs with Architect prior to rough-in.

3.12 TELEPHONE, CABLE TV, COMMUNICATIONS, SECURITY AND OTHER SYSTEMS CONDUIT:

A. These specifications include the furnishing of all labor and materials necessary for the complete installation of a system of conduits, outlets, and boards for use by the system suppliers.

B. This installation must be done according to the requirements of the system suppliers and the general specifications covering "Light and Power" herewith.

C. Provide and install pull boxes at all locations as required by the system suppliers. Mark all pull boxes and/or the conduit where it enters the box with type of system in permanent, black marker. Mark on the outside where located in unfinished spaces and mark on the inside in finished spaces.

D. Provide and install conduit sleeves thru floors and walls as required by the system suppliers.

E. The systems shall be provided with main service conduit sized as indicated on drawings. Each phone, data or TV location requires 1-inch empty conduit with pull rope unless noted otherwise. Conduits shall be routed to nearest associated telephone or data terminal board or above lay-in ceiling. If ceiling is an air return plenum, cables shall be routed completely in conduit or must be rated for use in air return plenum. Verify conditions of job prior to rough-in.

F. Outlets:

1. All wall outlets shall be installed with standard square box, plates furnished by system suppliers, or as directed. All outlets to be located as directed. Outlet boxes not used shall be provided with blank covers.

3.13 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES:

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from ½-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finish grade. Set covers of other enclosures 1 inch above finished grade.

D. Install handholes with bottom below frost line.

E. Where conduits enter side of enclosures, field-cut openings for conduits according to manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

END OF SECTION 260533

SECTION 260543 - UNDERGROUND ELECTRICAL CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This section includes the furnishing, construction and installation of duct lines to form a complete underground raceway system.

PART 2 - PRODUCTS

2.1 MATERIALS:

A. Concrete: ACI-318. Concrete shall have 3000 psi minimum 28 day compressive strength. Steel reinforcement shall be provided.

B. Duct Lines:

1. Size: Except where otherwise shown on the drawings, ducts and conduits shall be not less than 4-inch trade size.
2. Ducts (direct burial):

a. Plastic duct:

1) NEMA TC2 and TC3, EPC-40-PVC, Type II and III.
2) UL 651, heavy wall PVC or PE.
3) Duct shall be suitable for use with 75 degree C rated cable.

b. Rigid metal conduit: UL 6 rigid galvanized steel.

1) Where metal conduit is shown on drawings, or hereinafter specified, conduit shall have a coating of 20 mil bonded PVC, or shall be coated with bituminous asphaltic compound.

C. Ground Rods: Shall be copperclad steel, 3/4-inch diameter, and 20 feet long. Sectional ground rods (10'-0" min.) are permitted.

D. Ground Wire: Shall be stranded bare copper No. 6 AWG minimum.

E. Marker Tape: Shall be 6" wide, minimum, and equal to Thomas and Betts #NA0700 Series "Electric Line".

PART 3 - EXECUTION

3.1 TRENCHING:

A. General:

1. See Section, EARTHWORK for excavating, shoring, sheeting, bracing, and backfilling.
2. Work with extreme care near existing ducts, conduits, cables, and other utilities to avoid damaging them.
3. Cut the trenches neatly and uniformly.
4. Contractor shall include the removal of any rock encountered in the excavation. Verify with the soil borings. No additional cost will be paid by the Owner.

B. For Reinforced Concrete Encased Ducts:

1. After excavation of the trench, stakes shall be driven in the bottom of the trench at four foot intervals to establish the grade and route of the duct bank.
2. Pitch the trenches uniformly towards manholes or both ways from high points between manholes for the required duct line drainage. Avoid pitching the ducts towards buildings wherever possible.
3. The walls of the trench may be used to form the side walls of the duct bank provided that the soil is self-supporting and that concrete envelope can be poured without soil inclusions. Forms are required where the soil is not self-supporting.
4. After the concrete encased duct has sufficiently cured, the trench shall be backfilled to grade with earth.

3.2 DUCT LINE INSTALLATION:

A. General:

1. Duct lines shall be in accordance with the NEC, as shown on the drawings, and as specified.
2. Duct shall be sloped to drain towards manholes and handholes, and away from building and equipment entrances. Pitch shall be not less than four inches in 100 feet. Curved sections in duct lines shall consist of long sweep bends with a minimum radius of 50 feet in the horizontal and vertical directions. The use of manufactured bends is limited to building entrances and stub-ups to equipment.
3. Upon completion of the duct bank installation, a standard flexible mandrel shall be pulled through each duct to loosen particles of earth, sand, or foreign material left in the line. The mandrel shall be not less than 12 inches long, and shall have a diameter 1/2-inch less than the inside diameter of the duct. A brush with stiff bristles shall then be pulled through each duct to remove the loosened particles. The diameter of the brush shall be the same as, or slightly larger than, the diameter of the duct.
4. Seal the ducts and conduits at building entrances, and at outdoor terminations for equipment, with a suitable non-hardening compound to prevent the entrance of moisture and gases.
5. Raceway Burial Depths:

a. 18" minimum, 30" maximum cover to grade or bottom of floor slab.
b. 24" minimum under streets, highways, roads, alleys, driveways and parking lots.
c. 2” minimum below concrete slab inside a building.

B. Reinforced Concrete Encased Ducts:

1. Install reinforced concrete encased ducts for both medium and low voltage systems when shown on the drawings.
2. Duct lines shall consist of single or multiple duct assemblies encased in reinforced concrete. Ducts shall be uniform in size and material throughout the installation, unless otherwise shown or specified.
3. Rigid, unplasticized, polyvinyl chloride spacers shall securely support and maintain uniform spacing of the duct assembly a minimum of three inches above bottom of trench during the concrete pour. Spacers shall be placed at intervals per NEC Table 352.30.
4. Clearances between individual ducts:

   a. For like services: Not less than three inches.
   b. For power and signal services: Not less than 12 inches.
   c. For medium voltage to signal/communication/control: Not less than 18".
   d. Provide plastic spacers to maintain clearances.
   e. Provide nonferrous tie wires to prevent displacement of the ducts during pouring of concrete. Tie wires shall not act as substitute for spacers.

5. Duct lines shall terminate at window openings in manhole walls as shown on the drawings. All ducts shall be fitted with end bells.
6. Couple the ducts with proper couplings. Couplings shall be staggered in rows and layers to insure maximum strength and rigidity of the duct bank.
7. The reinforced concrete envelope encasing the ducts shall extend not less than three inches beyond the outside walls of the outer ducts and conduits.
8. Ducts shall be kept clean of earth, sand, or gravel during construction, and sealed with tapered plugs upon completion of each portion of the work.
9. Where new ducts, conduits, and concrete envelopes are to be joined to existing manholes, handholes, ducts, conduits, and concrete envelopes, make the joints with the proper fittings and fabricate the concrete envelopes to insure smooth durable transitions.
10. Where ducts turn up above grade, elbows, risers and fittings shall be PVC coated RGS.

END OF SECTION 260543

SECTION 260573 - ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY:

A. This Section includes computer-based, short-circuit and protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study.

B. The studies shall be prepared for the electrical overcurrent devices to be installed under this project to assure proper equipment and personnel protection.

C. The studies shall be prepared for the electrical overcurrent devices for the emergency system to be installed under this project as required by N.E.C. Section 700.27 to assure proper equipment and personnel protection. The “Emergency System” shall be defined as both normal and emergency line side feeds to automatic transfer switches (ATS) and all devices on the load side of the ATS(s).

D. The protective device coordination study shall present an organized time-current analysis of each protective device in series from the branch circuit panelboard back to the Utility Company substation and generator mounted circuit breaker(s). The study shall reflect the operation of each device during normal and abnormal current conditions.

E. Obtain all required information from the Utility Company. If published minimum values are available from the Utility Company, they shall be used for short circuit calculations.

F. The Contractor is responsible for providing all pertinent information required by the preparers to complete the study, including information on any devices that are part of an existing distribution system.

1.3 REFERENCES:

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

1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
2. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings

3. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
4. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
5. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations

B. National Fire Protection Association (NFPA):

1. NFPA 70 – National Electrical Code
2. NFPA 70E – Standard for Electrical Safety in the Workplace

1.4 ACTION SUBMITTALS:

A. Submit equipment shop drawings simultaneously with the protective device study based. The device study shall be based on equipment submitted as part of the equipment shop drawings.

B. Report shall include the following:

1. Executive Summary including Introduction, Scope of Work, and Results/Recommendations.
2. Short-Circuit Methodology Analysis Results and Recommendations.
3. Short-Circuit Device Evaluation Table.
4. Protective Device Coordination Methodology Analysis Results and Recommendations.
5. Protective Device Settings Table.
6. Time-Current Coordination Graphs and Recommendations.
7. Arc Flash Labeling showing types of labels to be provided. Include descriptive information as well as typical label images.
8. One-line system diagram shall be computer generated and shall clearly identify:

a. Individual equipment buses
b. Bus numbers used in the short-circuit analysis
c. Cable and bus connections between the equipment
d. Calculated maximum short-circuit current at each bus location
e. Device numbers used in the time-current coordination analysis
f. Other pertinent information

C. Certification: Two weeks prior to final inspection, deliver to the Engineer one copy of the following certifications:

1. Certification by the Contractor that the protective devices have been adjusted and set in accordance with the approved protective device coordination study.

1.5 QUALITY ASSURANCE:

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified herein. Manual calculations are not acceptable.

B. The Contractor shall have the coordination study prepared by a qualified Registered Professional Engineer, licensed in the state where the Project is located. The Registered Professional Engineer shall be an employee of the electrical equipment manufacturer or an approved consultant.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

1.6 REQUIREMENTS:

A. The studies shall be calculated by a computer software program capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

PART 2 - PRODUCTS

2.1 STUDIES:

A. The complete study shall include a system one-line system diagram, short-circuit analysis, ground fault analysis, and protective coordination plots.

B. Include calculation methods and assumptions.

C. Selected base per unit quantities.

D. Shall include input circuit data including electric utility system characteristics, source impedance data, conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions, and other information as related to the calculations.

E. Include notes regarding adequacy or inadequacy of equipment ratings.

F. Include discussion section evaluating the adequacy or inadequacy of the equipment and include recommendations as appropriate for improvements to the system.

2.2 DATA:

A. The Contractor shall furnish all data as required for the electrical system studies.

B. Source combination may include proposed, existing, and future motors and generators.

C. Load data may include proposed, existing, and future loads obtained from the Contract Documents, provided by the Owner and/or Contractor.

D. If applicable, the study shall include fault contribution from existing motors.

2.3 ONE-LINE DIAGRAM:

A. Show, on the one-line diagram, all electrical equipment and wiring to be protected by the overcurrent devices installed under this project. Clearly show, on the one-line, the schematic wiring of the electrical distribution system.

B. Also show on the one-line diagram the following specific information:

1. Calculated fault impedance, X/R ratios, and short circuit values at each bus.
2. Circuit breaker and fuse current ratings and types.
3. Transformer KVA, primary and secondary voltage ratings, percent impedance, X/R ratios, and wiring connections.
4. Voltage at each bus.
5. Identification of each bus.
6. Conduit material, conductor sizes, conductor material, insulation, length, and X/R ratios.
7. Busway ampacity and impedance.
8. Motor horsepower and code letter designation according to NEMA MG 1.
9. Generator kVA, size, voltage, and source impedance.

2.4 SHORT-CIRCUIT ANALYSIS:

A. Prepare short-circuit study for each protective device in series from the branch-circuit panelboard to the Utility Company substation and generator mounted circuit breaker(s).

B. Fault-Current Study:

1. Systematically calculate the maximum available short-circuit current in amperes rms symmetrical at each bus. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit.

C. Ground Fault Study:

1. Systematically calculate the fault impedance to determine the ground fault currents at each bus.

D. Present the data determined by each study in a table format. Include the following:

1. Device identification.
2. Operating voltage.
3. Protective device.
4. Device rating.
5. Short circuit current.

2.5 PROTECTIVE DEVICE TIME-CURRENT COORDINATION ANALYSIS:

A. Prepare the coordination curves to determine the required settings of protective devices to assure selective coordination to 0.10 seconds. Graphically illustrate on a log-log graph that adequate time separation exists between series devices, including the Utility Company upstream device and generator mounted circuit breaker(s). Plot the specific time-current characteristics of each protective device in such a manner that all upstream devices will be clearly depicted on one sheet.

B. The following specific information shall also be shown on the coordination curves:

1. Device identification.
2. Voltage and current ratio for curves.
3. 3-phase and 1-phase ANSI damage points for each transformer.
4. No-damage, melting, and clearing curves for fuses.
5. Cable damage curves.
6. Transformer inrush points.
7. Maximum short circuit cutoff point.

C. Develop a table to summarize the settings selected for the protective devices. Include in the table the following:

1. Device identification.
2. Relay CT ratios, tap, time dial, and instantaneous pickup.
3. Circuit breaker sensor rating, long-time, short-time, and instantaneous settings, and time bands.
4. Fuse rating and type.
5. Ground fault pickup and time delay.

PART 3 - EXECUTION

3.1 FIELD ADJUSTMENTS, SETTINGS, AND MODIFICATIONS:

A. Contractor shall adjust relay and protective device settings according to the recommended settings table provided by the protective device coordination study without additional cost to the Owner.

B. Contractor and equipment supplier shall make necessary minor modifications to equipment as required to accomplish conformance with short-circuit and protective device coordination studies without additional cost to the Owner.

C. The Engineer shall be informed immediately if major equipment or distribution system modifications are required to comply with the protective device coordination study.

END OF SECTION 260573

SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

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

1.2 SUMMARY:

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. General purpose distribution transformers.

1.3 SUBMITTALS:

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer to be provided.

B. Operation and Maintenance Data: Include operation and maintenance data for all transformers in the operation and maintenance manuals.

C. Test Records: Submit the following test records to the Engineer for review and include in the operational and maintenance manuals:

1. Recorded output voltages and tap settings per paragraph ADJUSTING in Part 3 of this Section.

1.4 QUALITY ASSURANCE:

A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended use.

C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.5 COORDINATION:

A. Coordinate size and location of concrete bases with actual transformer provided.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. ACME Electric Corporation; Power Distribution Products Division.
2. Eaton Electrical Inc.; Cutler-Hammer Products.
3. General Electric Company.
4. Siemens Infrastructure and Cities (Siemens IC)
5. Square D by Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS:

A. Description: Factory assembled and tested designed 60-Hz service.

B. Core and coil assemblies:

1. Shall be rigidly braced to withstand the stresses caused by short circuit currents and rough handling during shipment.
2. Cores shall be grain-oriented, non-aging silicon steel with high magnetic permeability.
3. Coils shall have continuous windings without splices except for taps.
4. Primary, secondary, and tap connections shall be brazed or pressure type.
5. Coil windings shall have end fillers or tie downs for maximum strength.
6. Coil material shall be aluminum or copper.
7. Core and coil assemblies shall be bonded to their enclosures by adequate flexible bonding straps.
8. Coils shall be impregnated with nonhygroscopic thermosetting varnish.
9. Cores shall be constructed with low hysteresis and eddy current losses.
10. Cores shall have a flux density well below the saturation point to prevent core overheating caused by harmonic voltage distortion.
11. Cores shall be of common core construction. Use of more than one core, or Scott-T connections, shall not be acceptable.

C. Ratings shown on the Drawings are for continuous duty without the use of cooling fans.

D. Sound Level Requirements: In accordance with NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

E. Enclosures:

1. Shall be of a type compatible with the environment in which the transformer is installed.
2. Shall be not less than code gauge steel.
3. Ventilation openings shall prevent accidental access to live components.

4. Shall be thoroughly cleaned and painted at the factory with manufacturer's prime coat and standard finish.

F. Wall-Mount Brackets or Ceiling-Mount Brackets: Manufacturer's standard brackets.

2.3 GENERAL PURPOSE DISTRIBUTION TRANSFORMERS:

A. In addition to the General Transformer Requirements above, General Purpose Distribution Transformers shall meet the following requirements:

B. Comply with NEMA ST 20 and list and label as complying with UL 1561.

C. Taps: All transformers rated 30 kVA and larger shall have two 2.5% full capacity taps above normal rated primary voltage, and four 2.5% full capacity taps below normal rated primary voltage.

D. Insulation Class: 220 deg C, UL-component-recognized insulation system. Transformer enclosure warm spot shall not exceed 35 degrees C rise above a 30 degrees C ambient condition. Transformer shall have the following maximum temperature rise above 40 degrees C ambient temperature:

1. Transformers 0-10 kVA: 115 degrees C
2. Transformers 15 kVA and larger: 150 degrees C

E. Energy Efficiency Standard for Transformers Rated 15 kVA and Larger:

1. Meet Class 1 Efficiency Levels for distribution transformers as specified in Table 4-2 of the 'Guide for Determining Energy Efficiency for Distribution Transformers' published by the National Electrical Manufacturers Association (NEMA TP-1-2002).
2. Test according to NEMA TP-2.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

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

3.2 INSTALLATION:

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.

B. For floor mounted transformers, construct 3.5” high concrete bases and anchor transformers according to manufacturer's written instructions.

C. All transformers shall be protected on the primary side by Class ‘L’ or ‘J’ time delay fuses or a circuit breaker. Manufacturer shall size and coordinate to allow for transformer inrush and protect transformer from damage.

1. 112.5 kVA and Larger Transformers: Where circuit breakers are used for primary protection, provide Adjustable Electronic Trip Molded Case Circuit Breakers.

3.3 IDENTIFICATION:

A. Label each transformer with an engraved nameplate.

3.4 CONNECTIONS:

A. Ground equipment according to Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section "Low-Voltage Electrical Power Conductors and Cables."

C. Use flexible metal conduit, maximum of 6 feet in length, for conduit connections to the transformer.

3.5 CLEANING:

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.6 ADJUSTING:

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recorded output voltages and tap settings as test results.

END OF SECTION 262200

SECTION 262313 - PARALLELING SWITCHGEAR AND LOAD TRANSFER SYSTEM

PART 1 - GENERAL PROVISIONS AND REQUIREMENTS

1.1 SYSTEM RESPONSIBILITY:

A. Provide complete new factory assembled paralleling equipment with digital electronic controls designed for fast, reliable operation and including the functions described herein.

B. The generator set manufacturer shall supply and warrant the paralleling equipment to provide a single source of responsibility for all products provided. Warranty documents shall be provided verifying this warranty. Technicians specifically trained to support the product and employed by the generator set supplier shall service the paralleling equipment. Submit names, qualifications, and locations of individuals who will service and support the equipment.

C. Warranty: See 263213:1.4.A

1.2 CODES AND STANDARDS

A. Equipment provided shall conform to the requirements of the following codes and standards to the extent that they are applicable:

1. ANSI/IEEE C37.20.2 - Standard for Metal-Clad Switchgear.
2. ANSI/IEEE C37.04 Standard Rating Structure for AC High-Voltage Circuit Breakers
3. ANSI/IEEE C37.06 - IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis--Preferred Ratings and Related Required Capabilities for Voltages Above 1000 V.
4. ANSI/IEEE C37.11 - Requirements for electrical control for AC High-Voltage Circuit Breakers rated on a symmetrical current basis or a total current basis.
5. ANSI/IEEE C37.09 - Standard Design and Production Testing.
6. CSA C22.2, No. 14 – M91 Industrial Control Equipment. CSA 282, Emergency Electrical Power Supply for Buildings
7. EN55011, Class B Radiated Emissions
8. EN55011, Class B Conducted Emissions
9. IEC 1000-4-4 (EN 61000-4-4) Fast Transients Immunity
10. EC 1000-4-2 (EN 61000-4-2) Electrostatic Discharge Immunity
11. IEC 1000-4-3 (EN 61000-4-3) Radiated Field Immunity
12. IEC 1000-4-6 Conducted Field Immunity
13. IEC 1000-4-11 Voltage Dip Immunity
14. NEMA SG4 - Alternating Current High Voltage Circuit Breakers.
15. NEMA SG5 - Power Switchgear Assemblies.
16. NFPA70 – National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 702.

17. NFPA110 – Emergency and Standby Power Systems. The transfer switch shall meet all requirements for Level 2 systems.
18. IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
19. UL891 – Switchboards and Controls. Control equipment provided in switchboard enclosures shall be listed and labeled under this standard.

B. The paralleling equipment manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

1.3 APPROVED MANUFACTURERS:

A. Only pre-approved bidders shall supply equipment provided under this contract. Equipment shall be Cummins or Caterpillar, and shall be supplied by the authorized local distributor of Cummins Power Generation or Caterpillar.

B. Manufacturers shall have completed a minimum of 10 medium voltage generator/switchgear projects during the past two years. Submit completed project list with references with proposal.

1.4 TRAINING

A. Provide 40 hours of operator training for the Owner in a classroom environment with DVD of all training.

1.5 SUBMITTAL REQUIREMENTS: Each bidder shall furnish with his submittal data the following information:

A. Proposals shall include a technical submittal including catalog information of all proposed equipment, technical description of the project and all technical information required to properly evaluate the proposals submitted.

B. Outline drawings of the equipment showing overall dimensions, power and control wiring entrance locations, breaker sizes and locations, lug sizes, and front panel drawings showing all devices to be provided, with each device referenced to a material list with a complete description for the device.

C. Interconnection detail drawing showing all related field control and power connections in the entire emergency system.

D. Literature describing in detail the equipment proposed, and all possible operating modes.

E. A complete review of this specification, noting for each paragraph whether or not proposed equipment complies with the project specifications, or deviates in some fashion. For each deviation, a justification for that deviation must be given.

F. Complete test specification detailing the testing procedure to be used to verify the performance of the equipment provided.

1.6 FACTORY TESTING:

A. The paralleling and load transfer control system will be tested with the specific gensets for this project at the manufacturer's facility at rated load and power factor, to demonstrate compliance with design specifications and assure reliable system performance. Manufacturer shall provide a detailed test specification with the submittal documents which covers both switchgear and gensets to be tested together as a complete system.

B. At the time of the test, the generator sets shall be labeled for proper connection into the system (unit # 1, unit #2, etc.) to match the paralleling control with which they were tested.

C. A certified test report shall be issued, confirming the results of this testing. (See genset specs for details of testing required for the gensets--units may be tested in parallel for these tests). Copies of test specifications and all performance test data shall be included in project submittals.

1. Site Testing: On completion of the installation and preparation of the gensets and paralleling equipment by the system supplier, a complete on site test shall be performed by the system supplier, duplicating the factory testing of the equipment.
2. Site system testing shall be supervised and witnessed by the consulting engineer for the project, as well as manufacturers' and suppliers' representatives.

1.7 DOCUMENTATION REQUIREMENTS:

A. On completion of on-site testing, a complete set of "as built" drawings shall be furnished for the complete emergency power system, consisting of the following:

1. Equipment outline, showing front and side plan views, electrical power one line diagram, and equipment ratings.
2. Schematic drawings.
3. Wiring diagrams.
4. Interconnection wiring diagram, showing all field interconnections between gensets, switchboards, and other remote devices (such as transfer switches, annunciators, and fuel tank).
5. Material list, cross referenced to schematics for component identification.
6. Narrative sequence of operation description, detailing all possible operating modes.
7. Ladder diagram and program listing for programmable controller with each logic rung’s purpose clearly defined, including identification of inputs and outputs.

B. All equipment drawings shall specifically show the interface between the paralleling controls and remote devices. Standard or typical drawings are not acceptable.

C. Operator's manuals shall be provided for the emergency power system which includes all the information noted above, plus troubleshooting guidelines, spare parts data, final test certificates and maintenance instructions. Operator's manuals shall be written specifically for this project. Standard or typical, pre-printed manuals will not be acceptable.

PART 2 - PARALLELING EQUIPMENT

2.1 EQUIPMENT RATINGS:

A. The paralleling/distribution power switchgear shall be configured as shown on the contract drawings, with emergency bus rated to carry the total capacity of the generator sets in the system at .8 power factor, and rated for operation at voltage and current levels as shown on the contract drawings. It shall contain devices and equipment as shown on the drawings, in addition to meeting the requirements of the specifications.

B. The paralleling switchgear shall be UL listed and labeled to the ratings specified herein.

2.2 EQUIPMENT CONSTRUCTION:

A. The paralleling power switchgear shall be designed, assembled, and tested in accordance to the latest applicable standards of ANSI, IEEE, and NEMA.

B. Metal-Clad Paralleling Switchgear Assembly

1. The metal-clad switchgear shall consist of an outdoor enclosure containing circuit breakers and the necessary accessory components all factory assembled (except for necessary shipping splits) and operationally checked. The assembly shall be self-supporting and designed for floor mounting on a level concrete pad. The integrated switchgear assembly shall withstand the effects of closing, carrying and interrupting currents up to the assigned maximum short circuit rating.
2. Nominal System Voltage: 12.47/7.2kV, 3 Phase, 3 Wire, Solidly Grounded Wye
3. Maximum Bus Continuous Current: 1200A
4. Maximum Short Circuit Current: 50kA (RMS Symmetrical)
5. Maximum Voltage: 15kV
6. One-Minute Withstand Voltage: 36kV RMS
7. Impulse Withstand Voltage (BIL): 95kV
8. Frequency: 60 Hertz
9. Momentary Current Ratings: Equal to the circuit breaker

C. The power system components will be enclosed in a rigid, freestanding metal-clad switchgear lineup. In each switchgear section the major components of the system (vacuum breakers, buswork, potential transformers, control power transformers, etc.) will be completely enclosed by grounded metal barriers. Full length removable lifting rails shall be provided. Enclosure shall be finished in light gray ANSI 61 enamel.

D. Breaker compartment shall be designed to house a 15kV, removable element, 2000A vacuum circuit breaker. Stationary contacts to be constructed of silver plated copper. Grounded metal safety shutters shall be provided to isolate primary connections in the compartment when the breaker is withdrawn.

E. Main system bus shall be copper, and rated 2000 amps, continuous, in accordance with ANSI temperature rise standards. Joints to be silver plated, with minimum of two bolts per joint. Bracing to withstand the magnetic stresses developed by currents equal to the main power circuit breaker close, carry and interrupt ratings. Bus shall be insulated. 1/4 by 2 inch ground bus shall extend through all sections of the equipment.

F. Switchgear wiring shall be composed of UL listed, 105 degree centigrade rated material, with all wiring labeled at each end.

G. Paralleling circuit breakers shall be rated for operation at 15kV, with continuous current rating of 1200 amps, and nominal interrupting rating of 1000MVA. Breakers to be operated by an electrically charged, mechanically and electrically trip free stored energy mechanism. Provisions for manual charging of the mechanism and interlocks to prevent withdrawal of the breaker unless it is open shall be included. Breaker shall be 120VAC charging, with DC capacitive trip system.

H. Individual control power transformer shall be provided for each breaker. The control power transformer for the generator breaker shall be connected on the generator side of the breaker. The control power transformer for the utility breaker shall be connected on the utility side of the breaker.

I. Current transformers as required for proper system operation, and metering as described herein shall be provided. Current ratios and relay and metering accuracy as required for function of the system. Transformers provided shall have a mechanical rating equal to the momentary rating of the circuit breakers, and insulated for the full voltage rating of the switchgear.

J. Potential transformers shall be drawout type, with current limiting fuses on the primary and secondary, and ratings and sizes as required for the functional use of the device.

K. Components

1. Stationary Structure

a. The switchgear shall be configured to include the number and type of devices as shown on the drawings to form a rigid self-supporting completely enclosed structure providing steel barriers between sections. The equipment provided shall be installed as shown on the drawings, and within the space allocated for the equipment.

b. The sections are divided by metal barriers into the following separate compartments; Circuit breaker, instrument, main bus, auxiliary device and cable. Each feeder section may have up to two circuit breaker compartments.

c. Construction: Each equipment bay shall be a separately constructed cubicle assembled to form a rigid free-standing unit. Minimum sheet metal thickness shall be 11-gauge steel on all exterior surfaces. Adjacent bays shall be securely bolted together to form an integrated rigid structure. The rear covers shall be removable to assist installation and maintenance of bus and cables. Each individual unit shall be braced to prevent distortion.

2. Circuit Breaker Compartment

a. Each circuit breaker compartment shall be designed to house a horizontal drawout metal-clad vacuum circuit breaker. The stationary primary disconnecting contacts are to be silver-plated copper and mounted within porcelain support bushings. The movable contacts and springs shall be mounted on the circuit breaker element for ease of inspection/maintenance.

b. Entrance to the stationary primary disconnecting contacts shall be automatically covered by metal shutters when the circuit breaker is withdrawn from the connected position to the test or disconnected position or removed from the circuit breaker compartment. Extend a ground bus into the circuit breaker compartment to automatically ground the breaker frame with high-current spring type grounding contacts located on the breaker chassis when in the test and connected positions. Guide rails for positioning the circuit breaker and all other necessary hardware are to be an integral part of the circuit breaker compartment. Blocking devices shall interlock breaker frame sizes to prevent installation of a lower ampere rating or interrupting capacity element into a compartment designed for one of a higher rating. It shall be possible with indoor switchgear to install a circuit breaker into a bottom compartment without use of a transport truck or lift device.

3. Cable Compartment/Ground Bus

a. Cable terminators shall be furnished to match installed cables. The ground bus shall extend through this compartment for the full

length of the switchgear. Auxiliary bus, if needed, and load bus support NEMA Class A-20 standoff insulators shall be epoxy.

4. Main Bus Compartment

   a. The main bus is to be rated as shown on the drawings and be fully insulated for its entire length with an epoxy coating by the fluidized bed process. The conductors are to be silver-plated copper and be of a bolted design. Access to this compartment is gained from the front or rear of the structure by removing a steel barrier. Provide standard provisions for future extension, as applicable.

5. Doors and Panels

   a. Relays, meters, control switches, etc., shall be mounted on a formed front-hinged panel for each circuit breaker compartment.

6. Circuit Breakers:

   a. The circuit breakers shall be rated for voltage and steady state current as shown on the drawings, with a maximum symmetrical interrupting rating of 50kA/1000MVA - 15 kV system. Furnish 3-pole circuit breakers with one vacuum interrupter per phase. Breakers of same type and rating shall be completely interchangeable. The circuit breaker shall be operated by means of a stored energy mechanism which is normally charged by a universal motor but can also be charged by the manual handle supplied on each breaker for manual emergency closing or testing. The closing speed of the moving contacts is to be independent of both the control voltage and the operator. Provide a full front shield on the breaker. Secondary control circuits shall be connected automatically with a self-aligning, self-engaging plug and receptacle arrangement when the circuit breaker is racked into the connected position. Provision shall be made for secondary control plug to be manually connected in test position. A minimum of 4 auxiliary contacts (2a 2b), shall be provided for external use. Provisions shall be made for 10 additional cell-mounted auxiliary contacts both MOC and TOC type for external use. The racking mechanism to move the breaker between positions shall be operable with the front door closed and position indication shall be visible with door closed.
   b. An interlocking system shall be provided to prevent racking a closed circuit breaker to or from any position. An additional interlock shall automatically discharge the stored-energy operating mechanism springs upon removal of the breaker out of the compartment.

c. The circuit breaker control voltage shall be: 120 volts ac - provide one capacitor trip unit for each circuit breaker. Trip voltage shall be 24VDC, and provided by the generator set starting batteries. A potential transformer located at the source side of each main or generator set breaker shall provide control power for that device.

7. Instrument Transformers

a. Current transformers: Each breaker compartment shall have provision for front-accessible mounting of up to four current transformers per phase* (ANSI standard relay accuracy), two on bus side and two on cable side of circuit breaker. The current transformer assembly shall be insulated for the full voltage rating of the switchgear. The current transformer wiring shall be Type SIS #12 AWG. Relaying and metering accuracy shall conform to ANSI Standards.

b. Voltage transformers are drawout mounted with primary current-limiting fuses and shall have ratios as indicated. The transformers shall have mechanical rating equal to the momentary rating of the circuit breakers and shall have metering accuracy per ANSI Standards.

8. Control Wiring: The switchgear shall be wired with type SIS #14 AWG, except where larger size wire is specified. The switchgear shall be provided with terminal blocks for outgoing control connections. Wire markers shall be provided for each end of all control wires.

9. Note space available and access requirements for the paralleling equipment, and provide equipment that will fit into the space allowed

10. AC control circuits in the switchboard shall be protected with properly sized fuses in safety fuse blocks, with visible blown fuse indication for each fuse. Potential transformers shall be protected on line and load side.

L. All CT installations shall include shorting type terminal blocks.

M. Protective Relaying:

1. Protective relaying for protection of the utility service to the facility, which is in compliance with the local utility requirements, shall be provided. The protective relaying shall be mounted in the power switchgear. A letter from the utility shall be provided with project submittals verifying that the equipment proposed meets the approval of the utility.

2. Each utility main breaker shall be provided with the following utility grade protective devices as minimum, in addition to meeting local utility requirements:

a. Phase sequence (47)
b. Over/under voltage relay (27/59).

c. High speed over and under frequency relay (81 o/u).
d. Lockout relay (86).
e. Directional power (32).
f. Sync check (25).
g. Over current (50/51).

3. Each generator breaker in the system shall be provided with utility grade relaying or protective devices for the following functions:

a. Overcurrent Relay (50/51).
b. Ground Overcurrent Relay (51G).
c. Differential Relay (87) The differential protection shall provide a zone of protection around the alternator only.
d. Directional power (32).
e. Lockout Relay (86).

4. The generator main (tie), and each feeder breaker shall be provided with the following protective devices:

a. Overcurrent Relay (50/51).
b. Lockout Relay (86).

5. The relaying shall be utility grade equipment, complete with test provisions. Multifunction Relays Are Acceptable. Generator set protection devices may be integrated into the genset controller when they meet all requirements of this section. The generator set overcurrent protection shall be coordinated with the alternator thermal damage curve.
6. All relays shall be sufficiently located/isolated from high voltage compartments to eliminate nuisance trips and alarms caused by interference with other components of the system.

N. The generator set paralleling breakers and utility main breaker shall be provided with voltage surge suppressors as are described elsewhere in these specifications.

O. The breaker transfer pairs each shall include a graphical operator panel on one of the breaker sections for use in manual control of the system. The operator panel shall include a complete set of AC metering (ammeter, voltmeter, frequency meter, kw, kVAR and power factor metering, monitoring all phases), a display indicating which of the sources to the transfer pair are available, and which are connected, provisions for setting all time delays associated with the transfer pair and bypassing them. The panel shall include an auto/manual switch and individual breaker control switches that allow manual operation in open transition mode when the primary control system has failed. Electrical interlocks shall be in place during manual mode to prevent utility paralleling across the transfer breaker pair.

P. Distribution Equipment:

1. Provide feeder distribution breakers of the number and size as shown on the project drawings.
2. The breakers shall be drawout vacuum power circuit breakers of the same manufacturer and model as the paralleling breakers.
3. The feeder distribution breakers shall be electrically operated and controlled from the system master control panel. Breakers shall be factory wired to provide operation sequence as described in sequence of operation, or as shown on the drawings.

Q. Controls shall be designed for future addition of future genset and feeder breaker, via industrial plug interface.

R. Note space available and access requirements for the paralleling equipment, and provide equipment which will fit into the space allowed.

2.3 CONTROL EQUIPMENT CONSTRUCTION

A. Construction

1. Control equipment shall be designed for front access only.
2. Each section of the paralleling control system shall be listed and labeled under the requirements of UL 891, including all covers, barriers, and supports. Individual control sections shall be isolated from each other by metal or insulating barriers.
3. All wiring shall be UL listed 105 degree C, 600 volt rated, and sized as required. Each wire, device or function shall be suitably identified by silk-screen or similar permanent identification.
4. The framework and all other sheet metal components of the system shall be primed with a rust-inhibiting primer, and finished with two coats of satin finish ANSI 61 gray enamel.
5. All door mounted control components shall be industrial type oil-tight devices with contact ratings a minimum of twice the maximum circuit ampacity they are controlling. Toggle switches and other light duty control devices are not acceptable. Indicator lamps shall be high intensity led type devices. Indicator lamp condition (on or off) shall be easily visible in bright room lighting conditions.
6. AC control circuits in the switchboard shall be protected with properly sized fuses in safety fuse blocks, with visible fuse blown indication for each fuse. Potential transformers shall be protected on line and load side.
7. All CT Installations shall include shorting type terminal blocks.
8. All field control interconnecting wiring shall be sized as specified by system manufacturer (wiring not designated by the system manufacturer shall be minimum 14 AWG copper). All control interconnect wiring shall be stranded.

B. System Control Power

1. Control power for the paralleling control system shall be derived from the generator set 24 VDC starting batteries. A solid state, no break "Best Battery" selector system shall be provided so that control voltage is available as long as any battery bank in the system is available, and that all battery banks are isolated to prevent the failure of one battery from disabling the system.
2. The Entire System including Generator Set Governing, Voltage Regulation, Load Sharing, Synchronizing, Protection, And transfer control Control Equipment Shall Be Capable Of Proper Operation With Battery Voltage Levels Down To 8vdc without external battery support. The control power for the breaker transfer pairs shall be derived from at least two different generator set battery banks.
3. A Redundant 24 VDC control power supply shall be provided for the System Master Control and touch screen, including batteries, Rack, and charger.
4. Paralleling breaker control power for breaker tripping shall be derived from the generator set starting batteries.

2.4 PARALLELING CONTROLS

A. The Control System shall communicate on a fully redundant communication network with hot bus standby/backup master controller or fully redundant and distributed master control.

B. Provide a paralleling control panel for each generator set in the emergency/standby power system. The paralleling control functions may be integrated with the generator set control functions (with duplicate functions eliminated). Each paralleling control panel shall contain the components and devices as described in this section.

C. Operator Panel. Each paralleling control panel shall be provided with a panel to allow the operator to view the status and control operation of the specific generator set being paralleled. The operator panel shall be provided with the following features and capabilities.

1. 1% accuracy generator set AC output instruments; Ammeter, Voltmeter, Frequency Meter, Wattmeter, KW-hour meter, Power Factor Meter. Selector switches to allow viewing of voltage and amperes for each phase shall be provided. For 3-phase/4-wire systems the voltmeter shall indicate line to line and line to neutral conditions. Voltmeter and frequency meter shall be analog instruments. Switches and/or other provisions shall be included to allow reading of bus voltage and frequency from this metering set.
2. Synchroscope and “generator set synchronized” indication. Indication may be synchronizing lamps, LED indication, or other provisions, but

must be located on the paralleling control panel, adjacent to the paralleling breaker control switches.

3. Run Time Meter, Start Counter
4. Generator Set Mode Selector Switch: Switch shall provide manual, off, and automatic functions for control of the generator set. Manual mode and associated pushbutton start switch causes the generator set to immediately start and accelerate to rated speed and voltage, but paralleling breaker does not automatically close. Off mode prevents generator set from starting, or immediately shuts down the generator set if it is running. Auto mode allows genset starting from a remote control system.
5. Breaker trip/close switch with breaker status indications. The switch shall be interlocked with the control system such that breaker closure is not possible unless the mode select switch is in the run position and the generator set is synchronized with the system bus.
6. Control Reset push-button switch with indicating lamp. Lamp shall flash to indicate that generator set is locked out due to a fault condition.
7. Lamp test provisions shall be provided by means of a lamp test push-button.
8. Emergency Stop switch. The emergency stop switch shall be a red, mushroom head switch which maintains its position until manually reset.
9. Precision voltage and frequency adjust raise/lower switches. Switches shall allow the generator set frequency and voltage to be adjusted plus or minus 5% when the generator set is operating independently of the system bus. Voltage and frequency adjustment switches shall be located adjacent to the generator set and bus metering, breaker control switches, synchroscope and manual paralleling panel, for ease of use by the operator.
10. Alarm and status indicating panel to indicate the following conditions (alarm horn shall be located on master control) :

Function	Lamp Color	Alarm Horn	Shutdown Unit
Low DC Voltage	Amber	*	
High DC Voltage	Amber	*	
Weak Battery	Amber	*	
Fail to Sync	Amber	*	
Low Oil Pressure Alarm	Amber	*	
Low Fuel	Amber	*	
Ground Fault	Amber	*	
High Engine Temp Alarm	Amber	*	
Overcurrent Alarm	Amber	*	
Breaker Failure	Red	*	*
Breaker Tripped	Red	*	*

Function	Lamp Color	Alarm Horn	Shutdown Unit
Not in Auto	Red	*	*
High Engine Temp	Red	*	*
Low Oil Pressure	Red	*	*
Overcurrent	Red	*	*
Short Circuit	Red	*	*
Loss of Excitation	Red	*	*
Reverse Power	Red	*	*
Overcrank	Red	*	*
Overspeed	Red	*	*
Under Frequency	Red	*	
Under Voltage	Red	*	*
Over Voltage	Red	*	*
Phase Rotation	Red	*	*
Low Coolant Level	Red	*	*
Automatic	Green		
Generator Running	Green		
Breaker Open	Green		
Breaker Closed	Green		
Demand Mode Standby	Green		
Timing for Start	Green		
Timing for Shutdown	Green		

11. Fuel system alarms, stations, and controls.

    a. Provide fuel level, low level warning, low level alarm, leak detection from main tank.

D. Internal Controls. The following internal control components or functions shall be provided for each generator set in the system.

1. Electronic isochronous kW load sharing control to operate the engine governors during synchronizing and to provide isochronous load sharing when paralleled. The control system shall allow sharing of real kW load between all generator sets in the system to within 1% of equal levels, without introduction of frequency droop into the system. The control system shall include all equipment required for kW load sharing with an infinite bus. The infinite bus governing controls shall allow the generator set to synchronize to an infinite bus, parallel, and ramp up to a preset load

level on the generator set. Additional controls shall be provided to cause the generator set to ramp up to a kW load level signaled by the system master control PLC. The isochronous load sharing module and engine governor shall be a coordinated system of a single manufacturer.

2. Load demand governing controls shall be provided to cause the generator set to ramp down to zero load when signaled to shut down in a load demand mode. On a signal to re-start, the load demand governing controls shall cause the generator set to synchronize to the system bus, close, and ramp up to its proportional share of the total bus load. The ramp rate of the generator set shall be operator-adjustable.
3. Electronic kVAR load sharing control to operate the alternator excitation system while the generator set is paralleled. The control system shall allow sharing of reactive load between all generator sets in the system to within 1% of equal levels, without introduction of voltage droop into the system. The control system shall include all equipment required for VAR load sharing with an infinite bus in either a constant VAR or constant power factor mode for future application flexibility. (Mode and adjustments selectable by the operator)
4. Equipment shall be provided to monitor the generator set as it is starting, and verify that it has reached at least 90% of nominal voltage and frequency before closing to the bus. The equipment provided shall positively prevent out-of-phase paralleling if two or more engine-generator sets reach operating conditions simultaneously by providing a lockout signal to disable breaker closure for generator set(s) in the system which have not been selected to be the first units to close to the bus. Controls to recognize the failure of the first breaker signaled to close, and allow system operation to proceed in spite of this failure shall also be provided (breaker failure alarm). Systems using dead bus relay schemes without a disable signal to positively prevent out-of-phase paralleling shall not be acceptable under this specification. System shall include an independent backup to automatically operate in the event that the primary system fails.
5. Synchronizer to electronically adjust the engine governor to match the voltage, frequency and phase angle of the bus. Synchronizer shall maintain the engine-generator voltage within 1% of bus voltage and phase angle within 20 electrical degrees of the bus for 0.5 seconds before circuit breaker closing. Each unit shall have its own synchronizer; systems using a switching scheme to utilize a single system synchronizer will not be approved. Synchronizers and systems which utilize a motor driven pot for control of AC voltage during the synchronizing process will not be accepted. The system shall be provided with a fail to synchronize time delay that is adjustable from 10-120 seconds. Control logic for fail to synchronize function shall allow field adjustment of function for either alarm or shutdown of the generator set on failure condition.
6. Controls shall include a permissive relay function to assure that the generator set does not attempt to close out of phase with the bus, due to errant operation of the synchronizer.

7. Controls shall include a permissive (sync check) function, to be used with "generator synchronized" indicator during manual paralleling, to prevent accidental closure of the breaker with the generator set out of phase with the bus. Provisions to allow manual closure of the first generator set to a de-energized bus shall be included.
8. Control equipment shall contain a system of diagnostic LED's to assist in analyzing proper system function.
9. Controls shall include three-phase sensing reverse power equipment, to prevent sustained reverse power flow into the generator set. The engine manufacturer shall approve the reverse power sensing equipment. When the reverse power condition exceeds 10% of the generator set kW for 3 seconds, the paralleling circuit breaker shall be tripped open and the generator shut down.
10. Controls shall be provided to verify generator set and bus phase rotation match prior to closing the paralleling breaker.
11. Electronic alternator overcurrent alarm and shutdown protection. This protection is required in addition to the overcurrent relaying on the paralleling breaker, and shall sense current flow at the generator set output terminals. The overcurrent alarm shall be indicated when the load current on the generator set is more than 110% of rated current for more than 60 seconds. The overcurrent shutdown shall be matched to the thermal damage curve of the generator set, and shall not have an instantaneous function.
12. Electronic alternator short circuit protection. This protection is in addition to the overcurrent trip on the paralleling breaker. The short circuit shall occur when the load current on the generator set is more than 175% of rated current and an aggregate time/current calculation indicates that the system is approaching the thermal damage point of the alternator. The equipment used shall not have an instantaneous function
13. Provide overcurrent and short circuit protection for the feeder connecting the generator set to the paralleling switchgear. This protection may be integrated with alternator protection but must be positively coordinated to prevent tripping of the paralleling breaker prior to the operation of the alternator protective equipment.
14. Controls shall be provided to sense loss of excitation of the alternator while paralleled to the system bus.
15. Generator set start contacts rated 10 amps at 32 VDC. A redundant network-based starting system shall also be provided.
16. Cool down time delay, adjustable: 0-600 seconds. The control panel shall indicate the time remaining in the time delay period when the generator set is timing for shutdown.
17. Start time delay, adjustable: 0-300 seconds. The control panel shall indicate the time remaining in the time delay period when the generator set is timing for start.
18. The control system shall monitor the paralleling breaker auxiliary contacts, and initiate a fault signal if the breaker fails to close within an adjustable time delay period after the control has signaled it to close (0.5-

15 seconds). Breaker failure alarm shall cause the paralleling breaker to trip open, and lock out until manually reset.

19. Controls shall be provided to initiate an alarm condition when generator set is at or below 90% of rated frequency for more than 20 seconds.
20. Controls shall be provided to shut down generator set and initiate alarm when the generator set is at less than 85% of nominal voltage for more than 15 seconds, more than 110% of nominal voltage for more than 10 seconds, or more than 130% of nominal.
21. Provide all other components required, such as properly sized current transformers, transducers, terminal blocks, etc., for reliable system operation, as described herein under "MODES OF OPERATION".

2.5 POWER TRANSFER CONTROLS

A. Provide an independent power transfer control system for each breaker transfer pair. Each power transfer control panel shall contain the components and devices as described in this section.

B. Operator Panel. Each paralleling control panel shall be provided with a panel to allow the operator to view the status and control operation of the specific transfer pair controlled. The operator panel shall be provided with the following features and capabilities.

1. 1% accuracy digital AC output instruments; Ammeter, Voltmeter, Frequency Meter, Wattmeter, KW-hour meter, Power Factor Meter, kVAR meter, KVA meter shall be provided for the utility supply service and the generator bus. AC metering shall provide total values and per phase values. Provide analog metering displays for each source indicating voltage, current, kW load, power factor, and frequency.
2. LED indication for utility parallel, lockout, warning, remote start, auto and manual modes.
3. Synchroscope and “systems synchronized” indication. Indication may be synchronizing lamps, LED indication, or other provisions.
4. Breaker open and close manual switch and LED indications, with auto manual switch as described in switchgear specification.
5. Alarm and status indicating panel to indicate the following conditions (alarm horn shall be located on master control) :

Function	Lamp Color	Alarm Horn	Shutdown Unit
Low DC Voltage	Amber	*	
High DC Voltage	Amber	*	
Weak Battery	Amber	*	
Fail to Sync	Amber	*	
Low Oil Pressure Alarm	Amber	*	

Function	Lamp Color	Alarm Horn	Shutdown Unit
Low Fuel	Amber	*	
Ground Fault	Amber	*	
High Engine Temp Alarm	Amber	*	
Overcurrent Alarm	Amber	*	
Breaker Failure	Red	*	*
Breaker Tripped	Red	*	*
Not in Auto	Red	*	*
High Engine Temp	Red	*	*
Low Oil Pressure	Red	*	*
Overcurrent	Red	*	*
Short Circuit	Red	*	*
Loss of Excitation	Red	*	*
Reverse Power	Red	*	*
Overcrank	Red	*	*
Overspeed	Red	*	*
Under Frequency	Red	*	
Under Voltage	Red	*	*
Over Voltage	Red	*	*
Phase Rotation	Red	*	*
Low Coolant Level	Red	*	*
Automatic	Green		
Generator Running	Green		
Breaker Open	Green		
Breaker Closed	Green		
Demand Mode Standby	Green		
Timing for Start	Green		
Timing for Shutdown	Green		

C. Internal Controls. The following internal control components or functions shall be provided for each generator set in the system.

1. The automatic power transfer control functions shall include source availability sensing, genset start/stop commands and transfer pair monitoring and control. The transfer/retransfer function shall be field configurable for open transition, fast closed transition (less than 100 mS

interconnect time), or soft closed transition (load ramping) sequences of operation. Utility source failure shall automatically start the genset and transfer load, retransferring when utility source returns. A Test function will start genset and transfer load if test with load is enabled. Sensors and timers include:

a. Under voltage sensor - 3 phase L-N or L-L under voltage sensing adjustable for pickup from 85 - 100% of nominal. Dropout adjustable from 75 - 98% of pickup. Dropout delay adjustable from 0.1 - 30 sec.
b. Over voltage sensor - 3 phase L-N or L-L over voltage sensing adjustable for pickup from 95 - 99% of dropout. Dropout adjustable from 105 - 135% of nominal. Dropout delay adjustable from 0.5 - 120 sec.
c. Over/under frequency sensor - Center frequency adjustable from 45 - 65 Hz. Dropout bandwidth adjustable from 0.3 - 5% of center frequency beyond pickup bandwidth. Pickup bandwidth adjustable from 0.3 - 20% of center frequency.
d. Loss of phase sensor - Detects out of range voltage phase angle relationship.
e. Phase rotation sensor: Checks for valid phase rotation of source.
f. Relay lockout tripped - If the input is active, the associated source will be considered as unavailable.
g. Control shall provide adjustable start delay from 0 - 3600 sec, stop delay from 0 – 3600 sec, transfer delay from 0 - 120 sec, retransfer delay from 0 – 1800 sec, programmed transition delay from 0 - 60 sec, and maximum parallel time from 0 - 1800 sec.
h. Reverse power sensor: 1 – 30 sec, Detects reverse power flow at the utility and generator connections.

2. The controls shall provide for opening and closing of the utility, tie and generator bus main breakers, including separate relays for opening and closing breaker, as well as inputs for both 'a' and 'b' breaker position contacts and tripped status. Breaker diagnostics shall include contact failure, fail to close, fail to open, fail to disconnect, and tripped. Upon breaker failure, appropriate control action shall be taken to maintain system integrity.
3. A master synchronizer shall be provided to electronically adjust the generator set engine governors simultaneously to match the voltage, frequency and phase angle of the bus. Synchronizer shall maintain the engine-generator voltage within 1% of bus voltage and phase angle within 10 electrical degrees of the bus for 0.5 seconds before circuit breaker closing. The system shall be provided with a fail to synchronize time delay that is adjustable from 10-120 seconds. The master synchronizer shall be capable of operating up to 16 generator sets simultaneously. The operation of the master synchronizers on the project shall be coordinated so that only one synchronizer will operate at any point in time.

4. Control equipment shall contain a system of diagnostic LED's to assist in analyzing proper system function.
5. Controls shall be provided to verify generator set and bus phase rotation match prior to closing the paralleling breaker.
6. Generator set start contacts rated 10 amps at 32 VDC. A redundant network-based starting system shall also be provided.
7. Provide all other components required, such as properly sized potential and current transformers, transducers, terminal blocks, etc., for reliable system operation, as described herein under "MODES OF OPERATION".

2.6 UTILITY MONITOR AND CONTROL PANEL:

A. Provide a utility monitor and control panel to monitor and control the utility service to the facility. The control panel shall contain the components described in this section.

1. The front panel of the utility control shall contain the following instruments and devices (monitoring utility conditions):

a. 4 1/2 inch, 1% accuracy instruments:

1) Ammeter
2) Voltmeter
3) Watt/Varmeter

b. Heavy duty meter control switches (Electroswitch series 24 or equal) for:

1) Voltmeter (4 position)
2) Ammeter
3) Watt/Varmeter

2.7 MASTER CONTROLLER

A. The following specification section is intended to set the scope and functionality of the HMI System only. The manufacturers shall comply with the intent for operating and functionality. Actual screens will be per the specific manufacturers systems.

B. Provide a master control system to monitor and control the operation of the entire paralleling system. The master control system shall contain the components described in this section, and shall be designed with all controls and provisions for two new and one future gensets.

C. Main Menu:

1. The Main Menu Screen shall be the primary navigational system for the HMI. It shall also include the security log-on system and a means for the user to view the current security level.
2. If the current user is logged on as "Engineer (level 2)", then all screens will be accessible.
3. If the current user is logged in as "Operator (level 1), then all screens except the Setup screen will be accessible.
4. Finally, If the current user is logged in as "Guest (level 0), then all screens except the Setup screen, System Control screen, and Utility Parallel screen will be accessible.

D. Genset One-Line Diagram:

1. The Gen One-Line Diagram shall give a graphical display of the power system components directly controlled by the Power Generation Paralleling System. System status is displayed by a combination of animation, changing screen color, text messages, and pop-up indicators. Conditions visible on the screen include:

    a. Generator set symbol - A generator set graphic symbol, designator and the % kW are displayed for each genset. Control, data, and performance summary screens are accessible through hot keys (links) located on or adjacent to the genset icon.
    b. Generator set mode (run/off/auto)
    c. Generator set status (normal/warning/shutdown/load demand stop).
    d. Breaker status. (open/closed/tripped/racked-in/racked-out) - Status and condition of customer supplied breakers and devices is optional.
    e. Bus condition (energized or de-energized)
    f. Gen Runtime display
    g. ATS symbol – A transfer switch graphic symbol is shown for each ATS associated with the system. At a minimum, ATS position (normal, emergency, shed) is shown along with indicator flags for "transfer inhibit" and "load shed

2. Touching the gen bus will launch the Gen Bus Metering screen. Touching any of the generator set "Summary" or "Control" buttons will launch the associated Genset Summary or Genset Manual Control screen.
3. "Main Menu" and "System Control" screen navigation buttons are included in the footer area of the screen.

E. Genset Status Summary:

1. The Genset Status Summary shall provide an analog and graphical display of critical generator set operating parameters. The screen includes

generator set state display (stopped, time delay start, idle speed state, rated volts/hz, synchronizing, load share, or load govern); analog AC metering for generator set, including 3-phase AC volts and current, frequency, kW, and power factor; and 3-phase AC bus voltage and frequency. The screen provides a complete display of engine and alternator data present in the generator set control. The screen also shows status of the bus and generator set breaker. Hot buttons are provided for quick access to similar data on all machines.

2. A "Help" screen is available via a screen navigation button in the footer area of the screen. "Main Menu", "Genset Oneline" and "Genset Meters" screen navigation buttons are also included in the footer area of the screen.

F. Genset Meters / Gauges:

1. Four predefined AC meters (kW, Amps, Volts, Frequency), and four predefined engine gauges (Oil Pressure, RPM, Coolant Temperature, and DC Volts) will be displayed for each genset in the paralleling system.
2. A "Genset Summary" screen navigation button is located in the footer area of the screen.

G. Generator Manual Control:

1. The Generator Manual Control shall allow manual operation of the gensets and paralleling circuit breakers. The control mode switch on this screen must be in the "manual" position for controls to be functional. Note that the system will not function in any automatic modes until the control mode switch is placed back into "automatic – open transition" mode or "automatic – closed transition" mode. The user must be logged-in as "Level 1 (Operator)" or higher to access this screen.
2. A "Genset One-Line" screen navigation button is located in the footer area of the screen.

H. System Control:

1. The System Control screen shall allow monitoring and control of "Load Demand" system. This screen will also contain the "System Test" function and a control mode selector. The user must be logged-in as "Level 1 (Operator)" or higher to access this screen.

    a. Load demand operation – Control / display the load demand mode (on or off). In addition, display and modify the load demand shutdown sequence, shutdown time delay, kW pickup and dropout setpoints.
    b. Test with or without Load - Initiate test with or without load, and display mode.
    c. Control Mode selector - Displays the transition mode ("Auto Open Transition" or "Manual") and allows the operator to change modes from "Manual" to "Auto Open Transition".

2. A "Help" screen is available via a screen navigation button in the footer area of the screen. "Main Menu" and "Genset One-line" screen navigation buttons are included in the footer area of the screen.

I. Load Control:

1. The Load Control Screen shall allow monitoring and control of the 2 (with 3rd future) load breakers. The following features and functions are included:

   a. Frequency Indicator Flag - When the bus frequency is normal, a green "Frequency OK" flag will be visible. If the bus frequency goes low, a red "Bus Overload" flag (with flashing text) will be visible.
   b. kW and Amp Displays - Digital displays will be provided for genbus capacity, genbus actual load, and spare capacity. Bar Graphs are provided for percent load (Amps and kW).

2. A "Help" screen is available via a screen navigation button in the footer area of the screen. A "Main Menu" screen navigation button is also included in the footer area of the screen.

J. System Metering:

1. The System Metering screen shall provide an analog and graphical display of AC metering data for the. Gen Bus. AC metering shall include 3-phase AC volts and current, frequency, kW, and power factor. In addition to this, volts, amps, frequency, kW, and power factor are shown in bar graph format.
2. "Main Menu" and "Back" screen navigation buttons are included in the footer area of the screen.

K. Real-Time Trending:

1. The Real Time Trending screen shall allow an operator to view the last 6 minutes of historical data. There are 4 variables available, namely Voltage (V) Current (A), Power (kW), and Frequency (Hz). The instantaneous values of these variables are also displayed in digital format, directly below the scales.
2. The tabs in the upper left corner of the screen can be used to navigate between the Real-Time Trending Screens, if applicable.
3. A "Help" screen is available via a screen navigation button in the footer area of the screen. A "Main Menu" screen navigation button is also included in the footer area of the screen.

L. Current Alarms:

1. The Current Alarms screen shall display the date, time, alarm description, and acknowledged date and time for genset and system alarms. Unacknowledged active alarms are shown in red, and unacknowledged inactive alarms are shown in blue.
2. Alarms can be acknowledged by touching the "Acknowledge All Alarms" pushbutton. Acknowledged alarms will turn green, and acknowledged inactive alarms will disappear.
3. The alarm horn can be silenced by touching the "System Alarm Reset" PB.
4. "Main Menu" and "Back" screen navigation buttons are included in the footer area of the screen.

M. Historical Alarms:

1. The Alarm History screen shall provide the operator with an ongoing history of System and Genset alarms. Included are fields for date, time, alarm description, and acknowledge date/time. Unacknowledged active alarms are shown with red text, acknowledged active alarms are shown with green text, and unacknowledged inactive alarms are shown with blue text.
2. The "page up" and "page down" buttons can be used to navigate up and down on the historical alarm list.
3. A "Help" screen is available via a screen navigation button in the footer area of the screen. A "Main Menu" screen navigation button is also included in the footer area of the screen.

N. Set-Up:

1. The Setup screen shall be used to enter the PLC program constants for the project. This screen is programmed for security level 2 (Engineer), so that unauthorized personnel can't get access. The project specific Genset Constants and System Constants must be entered on this screen in order for the PLC program to properly function. This is to be done at the factory during the static test.
2. A "Help" screen is available via a screen navigation button in the footer area of the screen. A "Main Menu" screen navigation button is also included in the footer area of the screen.

O. Web Serving:

1. All screens except for the help screens shall be available for web serving.
2. For security purposes, all "write" variables in the HMI database shall be disabled, so that there is no possibility of remote control via the web.
3. Remote monitoring can also be achieved through an Ethernet connection to the customer's PC and existing plant SCADA system.

P. Internal Components

1. System PLC:

a. Paralleling control functions (synchronizing, load sharing, etc.) are provided by the paralleling controls. System control logic such as load add and shed shall be performed by a programmable logic controller (PLC). A modular design with distributed I/O shall be utilized to the fullest extent. Main features of the PLC processor include:

1) Flash-Based Executive Memory
2) Memory Backup and protection
3) The CPU's store the application program in battery-backed RAM
4) On-Line Changes
5) The PLC may be interconnected to a personal computer and control sequences may be modified without shutting down the system.
6) LED Status Indicators. The PLC CPU and Input/Output (I/O) blocks include LED status indicators for use in viewing system status and diagnosis of failures.

2. Touchscreen Operator Panel:

a. A full color high-resolution 15 inch (diagonal) touchscreen operator interface panel (HMI) is provided to allow the operator to monitor and control the on-site power system.

1) Temp requirements (32F to 122F)
2) Windows CE operating system.
3) NEMA4 / IP65 compliance for front panel

b. All data will be configurable for display in US standard units only. Context sensitive help buttons shall be available as needed in the application.

3. Control Power System:

a. Control power for the system is derived from the generator set 24VDC starting batteries. A solid state no break "best battery" selector system is provided so that control voltage is available as long as any battery bank in the system is available. All battery banks are isolated to prevent the failure of one battery from disabling the entire system. A station battery and charger back up the generator set control power systems so that the master control has multiple redundant control power.

b. The control (on each generator set in the system) continually monitors the battery charging system for low and high DC voltage, and runs a battery load test every time the engine is started.
c. The master control station battery also includes battery and charger failure testing and indication. A station battery under voltage alarm is included.

4. SCADA Control System Interface:

a. Provide Modbus TCP/IP interface for communicating data to the plant SCADA system.
b. Utility elect meter KWH consumed and KW demand.
c. Generator set mode (run/off/auto) for three generators (one is future).
d. Generator set status (normal/warning/shutdown/load demand stop) for three generators.
e. Breaker status. (open/closed/tripped) for all breakers
f. Bus condition (energized or de-energized)
g. Fuel tank level.
h. Main fuel tank low fuel level warning (activates at 62% of tank capacity)
i. Main fuel tank critical low level warning (activates at 6% of tank capacity)
j. System alarm should automatically call the generator system web page for alarms

Q. Provide one (1) remote computer with full system monitoring and operation. Provide all software, programming, and licenses. Computer installation shall be by electrical contractor and systems integrator. Commissioning and testing shall be by vendor.

2.8 PARALLELING BREAKERS:

A. Electrically operated power circuit breaker.

B. Breaker shall be 1200 amp frame.

2.9 FEEDER BREAKERS:

A. Electrically operated power circuit breaker.

B. Breaker shall be 1200 amp frame.

2.10 TIE BREAKERS:

A. Electrically operated power circuit breaker.

B. Breaker shall be 1200 amp frame.

2.11 PROTECTIVE RELAYING

A. Provide relays as designated on the drawings.

B. Provide all PTs/CTs as required to implement the protective relaying scheme as indicated on the drawings and in these specifications.

PART 3 - LOAD TRANSFER SWITCHGEAR

3.1 MODES OF OPERATION:

A. Loss of normal power:

1. System continually monitors condition of the utility, and on sensing loss of both utility feeds, and immediately on power failure, the generator sets automatically and independently start, accelerate to rated frequency and build up to rated voltage. The start system monitors this process, and on finding a genset at 90% of rated voltage and frequency, automatically disables all other units from closing to the bus, and closes the ready unit to the bus. Loss of utility voltage relays shall be 3 phase sensing, adjustable (set at 85%) and with an adjustable time delay of 0-300 sec. (set at 120 sec.)
2. The system then senses emergency power available, opens the 15kV utility main breakers, and closes the 15kV generator bus main breaker. The system then closes the 15kV tie breakers one at a time.
3. After the first unit is closed to the bus, the control of the remaining unit is switched to the synchronizer in its paralleling control, which causes the genset to synchronize with the system bus, and then close to it at the proper time.
4. As each unit closes to the bus, the unit assumes its proportional share of the total load on the bus.
5. On closure of the second genset to the bus, the system begins operation in load control mode.

B. Load Control

1. The system shall continuously monitor the total load on the system bus. If the total load is less than 90% of system capacity, the system shall notify the operator that additional capacity exists to add loads.
2. When the system is running in emergency mode, controls shall continuously monitor the total load on the bus. If the total load on the bus falls below preset limits for a period of 15 minutes, the controller will automatically shut down gensets in an operator predetermined order, until the minimum number of generators required to safely handle the load remain on the bus. The purpose of this function is to allow the gensets to operate closer to their rated capacity, thereby decreasing fuel consumption, and reducing wear on the system.

3. On sensing that the available bus capacity is being approached, the standby units will automatically be restarted (in the reverse order of which they were shut down) and paralleled with the bus to assume their proportional share of system load.

C. Bus overload:

1. If a bus overload occurs for any reason, a load shed signal will be generated to notify the operator to shed loads.
2. If the bus does not return to proper frequency within a predetermined period of time, an additional load shed signal will be generated, until the system bus returns to normal frequency.
3. Once capacity exists, a signal will be generated to notify the operator that it is safe to re-add loads.

D. Failure of a unit to start or synchronize: If a unit fails to start, after the overcrank time delay (in the genset control) has expired, the unit will be shut down, and an alarm will sound. The priority control will prevent the lowest priority loads from being added to the system without manual intervention. The priority override key switches may be used by an operator to manually add low priority loads to the bus, if he determines that generator capacity is available to serve the loads. Bus overload monitoring shall protect the first priority loads in the event that the bus is inadvertently overloaded due to operator error.

1. If a unit fails to synchronize after a preset time delay, an alarm will sound, but the unit will continue to attempt to synchronize until signaled to stop by manual operation of system control switches by the operator.

E. Return of Normal Power (Closed Transition Mode): When the system senses that normal power has returned, and after a programmable time delay (1-30 minutes), the generator bus shall automatically synchronize with the first priority utility bus, and the 15kV utility main breaker shall be closed. After a 30 second time delay the 15kV tie breaker shall open. The generator bus shall then automatically synchronize with the second priority utility bus, and the 15kV utility main breaker shall be closed. After a 30 second time delay the 15kV tie breaker shall open. After an additional 30 second time delay, the generator paralleling breakers shall open, and the gensets shall run for a cool down period and then shut down. (Time period of cooldown shall be as recommended by engine supplier.)

F. Return of Normal Power (Open Transition Mode): When the system senses that normal power has returned, and after a 15 minute time delay, the operator shall be notified that utility power has been restored. Upon command by the operator, the 15kV tie breakers shall open. After a 30 second time delay, the utility main breakers shall be closed and the generator paralleling breakers shall open, and the gensets shall run for a cooldown period and shut down. (Time period of cooldown shall be as recommended by engine supplier.)

G. If a both utility feeds are lost during the cool down period, one generator set shall immediately close to the system bus and the second unit shall synchronize to it, as described in “Loss of Normal Power” above.

H. Test Mode: Operation of the test switch on the master/totalizing control shall simulate a loss of utility power in the system, and the system shall transfer to the generator bus as described above, except that if the transfer mode select switch is set to "closed", the system shall perform the transfer to the generator system without a loss of power to the system loads.

I. Provide all control power, wiring, relays, switches, etc. to operate complete system.

END OF SECTION 262313

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

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

1.2 SUMMARY:

A. Section includes:

1. Lighting and appliance branch-circuit panelboards.

1.3 SUBMITTALS:

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage surge suppressor, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment, include the following information:

1. Dimensional data.
2. Enclosure type, per NEMA 250.
3. Detailed bus configuration, including current and voltage ratings.
4. Short-circuit current rating of panelboard and overcurrent protective devices.

a. Where series ratings are permitted and utilized, submit evidence of series ratings for each selected combination of fuses and/or circuit breakers.

5. Evidence of NRTL listing for series rating of installed devices.
6. Detailed features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Layout or elevation of each panelboard showing the relative locations of all specified breakers, lugs, accessories, and features.
8. Wiring diagrams for power, signal, and control wiring.

C. Operation and Maintenance Data: Include operation and maintenance data for all panelboards and components in the operation and maintenance manuals. Data shall include, but not be limited to:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

2. Summary of final settings for all adjustable overcurrent protective devices.
3. Print or copy of all final panel schedules in 8.5” x 11” format.

D. Test Records: Submit the following test records to the Engineer for review and approval, and include in the operation and maintenance manuals:

1. Load Balancing: Submit records of load readings before and after load balancing, per paragraph ADJUSTING in Part 3 of this Section.

1.4 QUALITY ASSURANCE:

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories through one source from a single manufacturer.

B. Product Selection for Restricted Space: Drawings may indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with any indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NEMA PB 1 and NFPA 70.

1.5 COORDINATION:

A. Coordinate layout and installation of panelboards and components with other construction that penetrates wall or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and requires clearances for equipment access doors and panels.

B. Coordinate sizes and locations of any concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS:

A. All panelboard components shall be the product and assembly of the same manufacturer. All similar units of all panelboards shall be of the same manufacturer.

B. All panelboards shall be completely factory assembled with molded case circuit breakers or switches.

C. Panelboards shall have main breaker, main switch, or main lugs, voltage, bus sizing, and flush or surface mounting as indicated on the Drawings.

D. Enclosures: Flush or surface mounted as indicated on the Drawings

1. Rated for environmental conditions at installed location:

   a. Kitchens and Wash-Down Areas: NEMA 250, Type 4X Stainless Steel.

2. Cabinets:

   a. Finish shall be galvanized steel.
   b. Shall not have ventilation openings for panels with bus ratings of 225 amperes or less.
   c. Back and sides shall be fabricated from one piece of formed steel for lighting and appliance branch-circuit panelboards.
   d. Shall contain a minimum of four interior mounted studs and necessary hardware for “in” and “out” adjustment of panel interior.
   e. Gutter sizes for cabinets containing through-feeders shall be increased by the amount required for auxiliary gutters in the NEC.
   f. For multi-section flush-mounted panelboards, all cabinets shall be the same height.

3. Front Trim:

   a. Shall include frame and door with concealed hinges.
   b. Shall be secured to cabinet with screws. Trim clamps are not allowed.
   c. Shall be galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer’s standard two-coat, baked-on finish consisting of prime coat and thermosetting top coat.
   d. Shall be same width and height as cabinet for surface-mounted panels. Shall overlap cabinet by at least 0.75 inches for flush-mounted panels.
   e. Shall not have ventilation openings for panels with bus ratings of 225 amperes or less.
   f. Shall include a welded angle on the rear to support and align trim to cabinet.
   g. Shall be separate for each section of multi-section panelboards. For flush installations, trims and doors of all sections shall be the same height.
   h. All trims for circuit breaker panelboards with bus ratings of 600 amperes or less shall be hinged trim construction with a concealed piano hinge on the right side. Trim shall be able to be hinged open by operating a latch or removing no more than four (4) screws.

4. Doors:

   a. Shall be galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting top coat.
   b. Shall be provided with concealed butt hinges welded to the doors and trim.
   c. In making switching devices accessible, doors shall not uncover any live parts.
   d. Shall have metal directory card holder with transparent protective cover for card, permanently mounted to inside of door.

E. Phase, Neutral, and Ground Buses:

1. Material shall be plated copper or aluminum, with copper connection straps bolted together and rigidly supported on molded insulators.
2. Phase bus bars for panels with single pole branches shall be arranged for sequential phasing of branch circuit devices.
3. Phase bus bar connections for breakers with trip settings of 100 amperes and less shall be arranged so that a two-pole breaker may be substituted for two single-pole breakers, and a three-pole breaker may be substituted for three single-pole breakers, without any modifications to the bus bars or connecting straps.
4. Protective devices shall be able to be replaced without removing adjacent units or main bus connectors, and without drilling or tapping. Panel phase bus connections to protective devices shall be field removable by means of a screwdriver.
5. Neutral bus shall be full sized. Neutral bus shall be rated for 200 percent of phase bus ampacity for panels fed from K-Factor Rated transformers and as indicated on the Drawings.
6. Equipment ground bus shall be bonded to cabinet, and shall have adequate terminals and lugs for all branch circuit and feeder equipment grounding conductors.
7. Isolated ground bus shall be provided when indicated on the Drawings. It shall be insulated from the cabinet, and shall have adequate terminals and lugs for all branch circuit and feeder isolated grounding conductors.
8. In multi-section panelboards, the bussing in each section shall be full size. In all except the final section, provide sub-feed line-side lugs or feed-through load-side lugs for cable connections to the other sections. Sections with tapped bus or cross-over bus shall not be accepted.
9. Coordinate lug quantities and sizes with the feeders serving the panel, as scheduled on the Drawings.

F. Future Devices: Where designated on panel schedule or one-line diagram as "space" or "future", include all mounting brackets, bus connections, filler plates, and necessary appurtenances necessary for installation of devices.

G. Panelboard Short-Circuit Current Rating:

1. Refer to the Drawings for required A.I.C. ratings for each panelboard.
2. Panelboards shall bear a UL label indicating the integrated equipment rating.
3. Rating Options:

a. Fully rated panelboards and circuit breakers.
b. Series rated with line side Class-J or Class-L fuse.
c. Series rated with line side circuit breaker.

2.2 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS:

A. Shall comply with the GENERAL REQUIREMENTS FOR PANELBOARDS listed above.

B. 240 Volt Panelboards: Subject to compliance with requirements, provide product from one of the following list of manufacturers and types:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit: PRL1A
2. General Electric Company: AQ
3. Siemens Infrastructure and Cities (Siemens IC): P1
4. Square D by Schneider Electric: NQOD

C. Shall comply with NEMA PB 1, lighting and appliance branch-circuit type.

D. Branch Overcurrent Protective Devices: Shall be bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Shall have flush latch. For doors over 36" in height, provide two latches.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES:

A. Molded Case Circuit Breaker (MCCB):

1. Molded Case Circuit Breakers shall comply with the requirements specified in Section "Overcurrent Protective Devices".
2. Circuit breakers shall be factory-installed in the panelboards in the same numbered positions indicated on the Drawings.
3. Thermal-Magnetic or Non-Adjustable Electronic Trip Molded Case Circuit Breakers shall be provided for all panelboard circuit breakers less than 400 amperes, unless noted otherwise.

4. Adjustable Electronic Trip Molded Case Circuit Breakers shall be provided for all panelboard circuit breakers 400 amperes and larger, unless noted otherwise.
5. Where indicated on the drawings breaker shall be provided with a handle blocking clip, allowing the breaker to be blocked in the "ON" position.
6. Adjustable Electronic Trip Molded Case Circuit Breakers shall be provided for all panelboard circuit breakers feeding 112.5 kVA and larger low-voltage transformers.

B. Fused Switch:

1. Fused switches shall comply with requirements specified in Section "Enclosed Switches and Circuit Breakers".
2. Fuses shall comply with requirements specified in Section "Overcurrent Protective Devices".

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

B. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION:

A. Where indicated on the Drawings, install panelboards on concrete bases, in addition to attaching them to the vertical finished or structural surface behind the panelboard.

B. Install wall-mounted panelboards so that the maximum height of the highest circuit breaker or switch above the finished floor does not exceed 78 inches. The bottom of the cabinet shall not be less than 6 inches above the finished floor.

C. Mount panelboard cabinet plumb and rigid, without distortion of the box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

D. Arrange panelboard sections for easy removal without disturbing other sections. Locate sections so that present and future conduits can be conveniently connected. Coordinate sizes of cabinets with the designated installation space.

E. Where flush-mounted panelboards are specified, install one 3/4-inch empty conduit into an accessible ceiling space for every three single-pole spare breakers or breaker spaces, for future use.

F. Multi-section panelboards shall be coupled together by conduit nipples appropriately sized for all feeder wiring installed between the sections.

G. Where multi-section panelboards are flush-mounted, sections shall be arranged side by side and shall be 1.5 inches apart.

H. Arrange conductors in gutters into neat groups and bundle and wrap with nylon cable ties.

I. At the direction of the Architect or Engineer, where panelboards are installed in public areas, paint the exposed surfaces of the trims, doors, and cabinets to match surrounding wall finishes after the panelboards are installed.

3.3 IDENTIFICATION

A. Identify all field-installed conductors, interconnect wiring, and components.

B. Panelboard Nameplates: Label each panelboard with a nameplate as indicated on the Drawings and as specified elsewhere.

C. Create a type-written schedule of circuits in each panelboard, after approval of the Engineer, and install in the directory holder in each panelboard.

1. Circuit descriptions shall include final room numbers, room descriptions, and items or equipment served.
2. Spare breakers and breaker spaces shall be neatly marked in pencil, to allow for future updates of the schedule.
3. Schedules shall be typed on paper directory cards, or printed on card stock appropriately sized for the directory sleeves provided on the panel door.

3.4 ADJUSTING:

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Load Balancing: If the contractor modifies the circuiting arrangement from what is shown on the plans, the contractor shall be responsible for balancing the loads between phases. The maximum difference of load between phases shall not exceed 20%. Submit calculations to the engineer for review.

C. All adjustable trip circuit breakers shall be, as a default, set by the manufacturer to match as closely as possible the trip curve of a fuse of the same ampacity rating (Class J fuses for 600 amperes and less, Class L for over 600 amperes). Ground

fault default settings shall be minimum time delay and low pickup, and shall be field adjusted up as necessary to avoid nuisance tripping.

1. Contractor may use reduced settings during construction if desired.

D. Set final values for all field-adjustable circuit breaker trip ranges as directed by the Engineer.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY:

A. This section includes the furnishing, installation, and connection of wiring devices.

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Weather-resistant receptacles.

1.3 DEFINITIONS:

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. SPD: Surge Protective Device.

1.4 ADMINISTRATIVE REQUIREMENTS:

A. Coordination:

1. Receptacles for Owner Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS:

A. Product Data (Where indicated in Section “Common Work Results for Electrical”, provide the following information): For each type of product.

B. Shop Drawings (Where indicated in Section “Common Work Results for Electrical”, provide the following information): List of legends and description of materials and process used for premarking wall plates.

1.6 CLOSEOUT SUBMITTALS:

A. Operational and Maintenance Data: For wiring devices to include all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING DEVICE REQUIREMENTS:

A. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

B. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

2.2 RECEPTACLES:

A. Comply with NEMA WD 1, NEMA WD 6, and UL 498.

B. LIST OF ACCEPTABLE RECEPTACLE MANUFACTURERS

Manufacturer:	Hubbell / Kellems	Leviton	P&S	Bryant	Cooper Wiring Devices
1. Weather Resistant Ground Fault: 20 A. 125 V.	GFTR20	---	2095TRWR	---	WRVGF20
2. Weather Resistant: 20 A. 125 V.	HBL5362WR	---	---	BRY5362WR	---

C. Weatherproof duplex receptacles shall be weather resistant GFCI grounded duplex receptacles.

1. All receptacles shall be mounted with the same orientation (horizontal or vertical). When a different orientation is required or desired, obtain permission from the Architect/Engineer prior to rough-in.
2. Damp Locations: Provide with a single weatherproof coverplate.
3. Wet Locations: Provide "In-Use" extra-duty metallic weatherproof cover.

    a. Hubbell #WP26E (vertical) or #WP26EH (horizontal)
    b. Red Dot #CKMUV (vertical)

D. See plans for Special Outlet Schedule.

E. Receptacle body shall be formed of high-impact nylon faced thermoplastic or urea and receptacle contacts shall be Bronze. Hard use industrial specification grade receptacles shall have a one piece brass bridge with integral ground contacts.

F. When only one receptacle is connected to a 20 amp circuit by itself, that receptacle must be rated 20 Amp.

G. All receptacles shall be self-grounding with ground lug.

H. Install receptacles to clear all cabinets, equipment, etc.

I. Color of receptacles: Ivory. Color of receptacles on the emergency system: Red. Verify colors prior to ordering.

J. All 120V, 15 or 20A receptacles located, within kitchens, within 6 feet of a sink, exterior locations, elevator machine rooms, elevator pits, garages, per NFPA 70 and as located on the plans shall be ground fault circuit interrupters (GFCI) for personnel protection (Class A) with 5ma trip. Feed through GFCI receptacles or GFCI breakers may be used to protect other receptacles in the same room and on the same circuit if wired per the manufacturer's recommendations. Prior to final inspection, perform ground fault test on each protected receptacle and submit list of all receptacles tested with results to the Engineer. Label receptacles that are GFCI protected by another feed through GFCI receptacle or by GFCI breaker "GFCI protected".

K. Provide duplex receptacle on separate circuit beside each telephone terminal board location and other communications equipment requiring 120V, power.

L. All 15 and 20 amp, 125 or 250 volt non-locking receptacles in damp or wet locations should be listed as “weather resistant”.

2.3 PENDANT CORD-CONNECTOR DEVICES:

A. Description:

1. Matching plug and receptacle body connector.
2. Body: Nylon with screw-open, cable-gripping jaws and provisions for attaching external cable grip.
3. External Cable Grip: Woven wire mesh type made of high-strength, galvanized steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.4 CORD AND PLUG SETS:

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.

2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket, with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
3. Plug: Nylon body and integral cable clamping jaws. Match cord and receptacle type for connection.

2.5 TOGGLE SWITCHES:

A. Wall Switches: Wall switches in general, used to control lighting shall be quiet operating.

B. Comply with NEMA WD 1, UL 20, and FS W-S-896.

C. Switches shall be single pole, two-pole, three-way, four-way, keyed, and with pilot light as called for on the drawings. Groups of switches shall be under one gangplate. Where switches are in fire rated walls groups of switches shall be maximum of two (2) gangs under one cover plate.

D. Switches shall be as follows unless specified otherwise.

Single Pole	20 A. 120 V. / 277 V.
Two Pole	20 A. 120 V. / 277 V.
Three-Way	20 A. 120 V. / 277 V.
Four-Way	20 A. 120 V. / 277 V.
Pilot Light	20 A. 120 V. / 277 V.
Key Switch	20 A. 120 V. / 277 V.

E. When only one switch is connected to a 20 amp circuit by itself, it must be rated 20A.

F. All switches shall be self grounding w/ground lugs.

G. LIST OF ACCEPTABLE SWITCH MANUFACTURERS

Manufacturer:	P&S	Hubbell / Kellems	Leviton	Bryant	Cooper Wiring Devices
Specification Grade Switches	PS 20AC Series	HBL 1220 Series	1220 Series	4901	1220 Series

H. Color of switches: Ivory. Color of switches on the emergency system: Red. Verify colors prior to ordering.

2.6 WALL PLATES:

A. Wall plates in industrial areas, gymnasiums, maintenance areas, warehouses and other high abuse areas shall be stainless steel.

B. For receptacles or switches mounted adjacent to each other, wall plates shall be common for each group of receptacles or switches.

C. Provide plates for all telephone, cable TV, communication outlets.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Installation shall be in accordance with NFPA 70, and as shown on the drawings.

B. Comply with NECA 1.

C. Switches shall be located on the latch side of all doors. If switches must be located on the hinge side of a door, they shall be located so that they are not behind the door when it is open. All questionable locations shall be brought to the Engineers/Architects attention.

D. Verify all outlet locations on the job prior to rough-in. Locations may be altered up to 6'-0" in any direction without additional cost to the Owner.

E. When conductors larger than #12 AWG are used on 15A or 20A circuits, splice #12 AWG pigtails for device connections.

F. Install ground pin up on vertically mounted receptacles and install ground pin to the right on horizontally mounted receptacles.

3.2 FIELD QUALITY CONTROL:

A. Convenience Receptacles:

1. Verify ground continuity.
2. Verify correct polarity of hot and neutral conductors.

END OF SECTION 262726

SECTION 262810 - OVERCURRENT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

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

1.2 SUMMARY:

A. Section includes:

1. Plug fuses rated 125 VAC and less for use in enclosed switches and fuseholders.
2. Molded Case Circuit Breakers (MCCBs)

1.3 DEFINITIONS:

A. MCCB: Molded Case Circuit Breaker

1.4 SUBMITTALS:

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, and descriptions of individual components.

1. Dimensions and manufacturer's technical data on features, performance, and electrical characteristics.
2. Current and voltage ratings.
3. Short-circuit current ratings (both interrupting and withstand, as appropriate).
4. Evidence of UL listing for series rating of installed devices.

B. Operation and Maintenance Data:

1. Manufacturer's written instructions for testing, operating, and adjusting overcurrent protective devices.
2. Summary of final settings for all adjustable overcurrent protective devices.

1.5 QUALITY ASSURANCE:

A. Source Limitations: Obtain overcurrent protective devices, components, and accessories, within same product category, through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for the intended locations and application.

C. Comply with NFPA 70.

D. Comply with NEMA FU 1 for cartridge fuses.

E. Comply with UL 248-11 for plug fuses.

F. Comply with UL 489 for circuit breakers.

1.6 COORDINATION:

A. Coordinate overcurrent protective device ratings with utilization equipment nameplate limitations of maximum fuse and/or breaker size and with system short-circuit current levels.

B. Final fuse sizes for mechanical and other motor loads shall be selected by the fuse manufacturer to provide Type-2 “no damage” protection for equipment served. Contractor shall provide and install the selected fuses.

1.7 EXTRA MATERIALS:

A. Furnish extra materials that match products installed and that are packaged in protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity of installed fuses for each size and type but no fewer than three for each size and type.

PART 2 - PRODUCTS

2.1 FUSES:

A. Manufacturers: Subject to compliance with requirements, provide product from one of the following list of manufacturers:

1. Cooper Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.

B. Cartridge Fuses:

1. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
2. Fuse Classes:

a. Class-CC: UL 248-4, time-delay, rejection type

b. Class-J: UL 248-8, dual-element, time-delay
c. Class-L: UL 248-10, dual-element, time-delay

C. Plug Fuses:

1. Characteristics: UL 248-11, dual-element, time-delay, Edison base.

2.2 MOLDED-CASE CIRCUIT BREAKERS:

A. Shall be provided as factory installed components of panelboards or switchboards, or as separately enclosed units, as specified in other Sections or on the Drawings.

B. Manufacturers: Subject to compliance with requirements, provide product from one of the following list of manufacturers:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit
2. General Electric Company
3. Siemens Infrastructure and Cities (Siemens IC)
4. Square D by Schneider Electric

C. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

D. Standard Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Line connections shall be bolt-on.
3. Lugs: Mechanical type, suitable for the trip rating, number and size of conductors, and conductor material.
4. Multi-pole units shall be enclosed in a single housing or be factory-assembled to operate as a single unit. They shall have a trip element for each pole, a common trip bar for all poles, and a single operator.
5. Operating handle shall indicate ON, TRIPPED, and OFF positions.
6. Shall be 80% rated, unless 100% rating is shown on the Drawings or is otherwise specified.
7. Application Listing: Appropriate for application:

a. Type SWD for switching fluorescent lighting loads.
b. Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
c. Type HACR for feeding heating, air conditioning, and refrigeration equipment.

E. Optional Features and Accessories: Provide where indicated on the Drawings or otherwise specified.

1. Ground-Fault Protection: Relay and trip unit with push-to-test feature.
2. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
3. Handle Padlocking Device: Fixed attachment, for padlocking circuit-breaker handle in off position.
4. Shunt Trip: 120-Volt trip coil energized from separate circuit, set to trip when at least 75% of coil voltage is applied, with coil clearing contact.
5. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts; "b" contacts operate in reverse of circuit-breaker contacts.
6. Key Interlock Kit: Externally mounted to prohibit circuit breaker operation; key shall be removable only when circuit breaker is in off position.
7. Alarm Contacts: One SPDT switch with "a" and 'b" contacts; "a" contacts mimic circuit breaker contacts; "b" contacts operate in reverse of circuit breaker contacts.

F. Thermal-Magnetic (or Non-Adjustable Electronic Trip) Circuit Breakers:

1. Shall have inverse time element for low-level overloads.
2. Shall have instantaneous magnetic trip element for short circuits.
3. Shall have front-mounted, field-adjustable magnetic trip setting for circuit-breaker frame sizes 250 amperes and larger. Factory setting shall be LO, unless otherwise noted.

G. Adjustable Electronic Trip Circuit Breakers:

1. Shall have RMS sensing.
2. Shall have field replaceable rating plug and field replaceable electronic trip unit.
3. Shall have the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long-time delay and pickup levels.
    c. Short-time delay and pickup levels.
    d. Ground-fault pick-up level, time delay, and I2t response.

        1) Ground fault functions shall not be provided on systems operating at less than 150 volts to ground unless specifically noted otherwise.

4. Shall have a digital current ammeter.
5. Shall have a trip test button to provide a means to manually trip the breaker.
6. Shall have permanently installed provisions for padlocking the breaker in the open position.
7. Field adjustable settings shall be protected by a transparent cover.
8. Shall have communications interface.

9. For circuit breakers that require power or minimum power flow to the trip unit in order to make settings, provide portable battery power unit so settings can be made during no power or low power flow situations.

H. Each circuit breaker installed between an emergency generator and an automatic transfer switch, including generator-mounted circuit breakers, shall be provided with auxiliary and alarm contacts as specified above as required to monitor circuit breaker for open and tripped status. Contact status of all such breakers shall be monitored by the generator monitoring system and shall be annunciated at the generator and all remote annunciating panels as an alarm, with a flashing red light, reading “Open/Tripped Circuit Breaker”.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine overcurrent protective devices before installation. Reject units that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install overcurrent protective devices of sizes and with characteristics appropriate for each piece of equipment.

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

3.2 FUSE APPLICATIONS:

A. Cartridge Fuses:

1. Service Entrance: Class-J for up to 600 A; Class-L for over 600 A
2. Feeders: Class-J for up to 600 A; Class-L for over 600 A
3. Motor branch circuits: Class-J for up to 600 A; Class-L for over 600 A
4. Single-phase motor and other branch circuits where appropriate fuse holders are specified in other Sections: Class-CC

B. Plug Fuses:

1. Motor and other branch circuits: Edison-base type.

3.3 CIRCUIT BREAKER APPLICATIONS:

A. Refer to applicable Drawings and Specification Sections for information on types of circuit breakers to be installed in particular applications. Applicable Sections may include, but not be limited to, “Switchboards”, “Panelboards”, and “Enclosed Switches and Circuit Breakers”.

3.4 INSTALLATION:

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.5 IDENTIFICATION:

A. Install labels complying with requirements found on the Drawings and elsewhere in this Specification. Install labels at every fused switch and each fuse block, socket, or holder which indicate fuse replacement information

END OF SECTION 262810

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

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

1.2 SUMMARY:

A. Section includes:

1. Fusible Switches
2. Fustats
3. Enclosures

1.3 DEFINITIONS:

A. NC: Normally closed

B. NO: Normally open

1.4 SUBMITTALS:

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, factory setting, accessories, and finishes.

1. Enclosure types and details for types other that NEMA 250, Type 1.
2. Current and voltage ratings.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work. Include wiring diagrams for power, signal, and control wiring.

C. Operation and Maintenance Data: Include operation and maintenance data for all enclosed switches and circuit breakers in the operation and maintenance manuals. Data shall include, but not be limited to:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.5 QUALITY ASSURANCE:

A. Source Limitations: Obtain enclosed switches and circuit breakers, components, and accessories, within same product category, through one source from a single manufacturer.

B. Product Selection for Restricted Space: Drawings may indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for the intended locations and application.

D. Comply with NFPA 70.

1.6 COORDINATION:

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and requires clearances for equipment access doors and panels.

1.7 PROJECT CONDITIONS:

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager, Engineer, and Owner in writing, not fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of electric service without Construction Manager’s, Engineer’s and Owner’s written permission.
3. Comply with NFPA 70E.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES:

A. Manufacturers: Subject to compliance with requirements, provide product from one of the following list of manufacturers:

1. Allen-Bradley; Rockwell Automation
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit
3. Eaton Electrical Inc.; Pringle Business Unit
4. General Electric Company
5. Siemens Infrastructure and Cities (Siemens IC)

6. Square D by Schneider Electric

B. Type GD General Duty switches are not allowed, unless specifically noted otherwise.

C. Type HD, Heavy Duty, Single Throw, 1200 A and smaller: UL 98 and NEMA KS 1.

1. Shall be horsepower rated for the load served.
2. Shall have clips or bolt pads to accommodate the specified fuses, with rejection features to reject fuses other than those specified.

    a. Refer to Section "Overcurrent Protective Devices" for specified fuse types.

3. Shall have an external operating handle indicating ON and OFF positions, with provisions to padlock the switch in the OFF position.
4. Shall have a mechanical interlock to prevent the opening of the cover unless the handle is in the OFF position. This interlock shall be defeatable with a special tool to permit inspection.
5. Shall have an equipment ground kit. Equipment ground shall be internally mounted and labeled for copper and aluminum ground conductors.
6. Accessories: Provide where indicated on the Drawings or required to complete the intended design.

    a. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
    b. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
    c. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact arranged to activate before switch blades open.
    d. Hookstick Handle: Allows use of a hookstick to operate the handle.
    e. Service Entrance Rating: Labeled for use as service entrance equipment.

2.2 FUSTATS:

A. 120 V motor loads up to 0.5 horsepower: Shall be horsepower rated, and include an Edison-base fuse holder and integral toggle switch. Where located in damp or wet locations, provide weatherproof unit equal to Bussman #SSN.

B. 120 V motor loads, 0.75 horsepower: Shall consist of a horsepower rated Edison-base fuse holder, with a separate horsepower rated toggle switch mounted adjacent to fuse holder.

C. 120 V motor loads, 1 horsepower, or 277 V motor loads: Shall consist of a horsepower and voltage rated manual motor starter switch and a horsepower and voltage rated fuse holder designed to hold a time-delay Class CC rejection-type fuse.

1. Manual motor starter switch: NEMA ICS 2, general purpose, Class A, with quick-make, quick-break toggle action, marked to indicate ON, OFF, and TRIPPED. Shall include an ambient-compensated type overload relay with inverse-time characteristics and NEMA ICS 2, Class 10 tripping characteristics. Shall have heaters and sensors in each phase, matched to nameplate full-load current of specific motor it protects and appropriately adjusted for duty cycle.

2.3 ENCLOSURES:

A. Comply with NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50.

B. Enclosure Types: Shall be compatible with environmental conditions at installed locations, unless more stringent requirements are specified on the Drawings or elsewhere in the Specifications.

1. Kitchens, Wash-Down Areas, and Wet or Damp Non-Corrosive Locations: NEMA 250, Type 4X Stainless Steel.

C. Finished Spaces: In finished spaces, enclosures shall be flush mounted unless otherwise noted.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the work.

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

3.2 INSTALLATION:

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated. Maximum mounting height and required working clearances shall comply with NFPA 70.

B. Install fuses in fusible devices.

1. Where fuses serve utilization equipment or motors, coordinate final fuse sizes with equipment nameplates and comply with listed minimum and maximum sizes.

2. Plug fuses installed in fustats shall be sized for 125 percent of the nameplate full load amps or running load amps.

C. Comply with NECA 1.

3.3 IDENTIFICATION:

A. Identify field-installed conductors, interconnecting wiring, and components.

B. Label each enclosure with engraved nameplate.

3.4 ADJUSTING:

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit breaker trip ranges.

END OF SECTION 262816

SECTION 262900 - MOTORS

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This section applies to all motors that are not directly specified or when referenced by other sections.

PART 2 - PRODUCTS

2.1 MOTORS:

A. For alternating current, fractional and integral horsepower motors. Fed. Spec. CC-M-1807, NEMA Publications MG1 and MG2 shall apply.

B. Voltage ratings shall be as follows:

1. Single phase:

a. Motors connected to 120 volt systems: 115 volts.
b. Motors connected to 208 volt systems: 200 volts.
c. Motors connected to 240 volt or 480 volt systems: 230/460 volts, dual connection.

C. Number of phases shall be as follows:

1. Motors, 1/2 HP and less: Single phase, 120 volt.
2. Exceptions:

a. Hermetically sealed motors.
b. Motors for equipment assemblies, less than one HP, may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.

D. Horsepower ratings shall be adequate for operating the connected loads continuously in the prevailing ambient temperatures in areas where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulations.

E. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting and running torque's.

F. Motor Enclosures:

1. Shall be the NEMA types shown on the drawings for the motors.

2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types which are most suitable for the environmental conditions where the motors are being installed.
3. Thoroughly clean and paint the enclosures at the factory with manufacturer's prime coat and standard finish.

G. Additional requirements for specific motors, as indicated in other sections, shall also apply.

H. Energy-Efficient Motors: When higher than standard efficiency motors are specified or indicated, they shall be rated using the IEEE Standard No. 112, Method B, test procedures, as detailed in NEMA MG1, 12.53.a. The nameplate shall identify the NEMA Nominal Efficiency indicated on the drawings.

I. E Frame Energy Efficient Motors: All equipment provided with E frame motors shall have a performance controller as manufactured by "Performance Control" provided and installed in addition to the across the line starter in all cases except when motor is controlled by a variable frequency drive.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Installation shall be in accordance with the NEC, as shown on the drawings, and as required by other sections of these specifications.

END OF SECTION 262900

SECTION 262923 - MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This section includes all motor starters and motor control stations, either stand alone in NEMA enclosures, combination type with disconnect, or in panelboards or motor control centers.

B. All starters shall be protected by a time delay 'J' fuse providing Type '2'. No damage protection. Submit specific fuse to be used on this project and manufacturing information to indicate required protection.

PART 2 - PRODUCTS

2.1 NEMA RATED MOTOR STARTERS:

A. Approved manufacturers: Square 'D', Cutler Hammer, Siemens/ITE, General Electric, and Allen Bradley. NEMA and NEC shall apply.

B. All starters shall be fully NEMA rated, shall have all components made by one manufacturer, and shall have the following features:

1. Enclosed type as shown on the drawings.
2. Safety switches within the motor controller enclosures shall have external operating handles with lock-open padlocking provisions and shall indicate the ON and OFF positions.
3. Motor control circuits:

    a. Shall operate at not more than 120 volts.
    b. Shall be grounded except as follows:

        1) Where isolated control circuits are shown.
        2) Where manufacturers of equipment assemblies recommend that the control circuits be isolated.

    c. Incorporate a separate, heavy duty, control transformer within each motor controller enclosure to provide the control voltage for each motor operating over 120 volts.
    d. Incorporate two primary and one secondary time delay fuses for control power transformers sized in accordance with NEC and UL requirements.

4. Overload current protective devices:

    a. Melting alloy type Class 20 trip.
    b. One for each pole.

c. Manual reset on the door of each motor controller enclosure.
d. Overloads shall be field installed and correctly sized for the associated motor's rated full load current.
e. Check every motor controller after installation and verify that correct sizes of protective devices have been installed.

5. H-O-A selector switch, Red "on" pilot light and a minimum of One N.O. auxiliary contact (field convertible to N.C.).
6. Other devices and accessories as shown on the drawings or otherwise required by control drawings and approved shop drawings.
7. Enclosures:

a. Shall be NEMA 1 for interior, NEMA 3R for exterior and other types as shown on the drawings for the motor controllers.
b. Where the types of motor controller enclosures are not indicated, they shall be the NEMA types which are the most suitable for the environmental conditions where the motor controllers are being installed.
c. Doors shall be mechanically interlocked to prevent opening unless the breaker or switch within the enclosure is open.
d. Thoroughly clean and paint the enclosures at the factory with manufacturer's prime coat and standard finish.

8. Each controller for motors 10 HP and larger shall be equipped with a 3 phase sensing loss of phase relay with automatic reset. Equal to Time Mark model 258.

C. Motor controllers incorporated with equipment assemblies shall also be designed for the specific requirements of the assemblies.

D. Additional requirements for specific motor controllers, as indicated in other sections, shall also apply.

E. Install a disconnect safety switch near and within sight of each motor. Combination type switch/starter in one enclosure are acceptable if listed as one piece. Switches shall comply with specifications.

F. E Frame Energy Efficient Motors: All equipment provided with E frame motors shall have a performance controller as manufactured by "Performance Control" provided and installed in addition to the across the line starter in all cases except when motor is controlled by a variable frequency drive.

G. Reduced Voltage Motor Controllers:

1. Shall be installed for all motors 25HP and larger and where shown on the drawings.
2. Shall be solid state RV as indicated on the drawings, or included in the temperature control section of these specifications.

3. Shall have closed circuit transition for the types which can incorporate such transition.
4. Shall limit inrush currents to not more than 70 percent of the locked rotor currents.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Installation shall be in accordance with the NEC, and as shown on the drawings.

END OF SECTION 262923

SECTION 263213 - GENSETS AND ACCESSORY EQUIPMENT

PART 1 - GENERAL PROVISIONS

1.1 SCOPE:

A. This specification covers requirements for providing a complete and operable electric generating system, including all devices and equipment specified herein, shown on the drawings, and/or as required for the service. Materials and equipment shall be new, and delivered to the site completely wired, tested, and ready for installation. Each system shall include the following:

1. Engine-generator set as shown on the drawings and as herein specified.
2. Engine-generator control console resiliently mounted on each generating set shall include complete engine start-stop control and solid-state monitoring system.
3. Mounted and loose accessories, control devices, and other equipment as specified herein and/or as shown on drawings.
4. Such other components, accessories, parts, tests, documents, and services, as needed to meet the performance requirements of this specification.

B. The equipment and services specified herein shall be provided by a single supplier who has been regularly engaged in the sales and service of engines, generators, generator sets, medium voltage switchgear, paralleling controls, and controls for a minimum of ten years. The emergency electric generating system described herein, including those components along with the engine auxiliaries shall be factory built, factory tested, and shipped by this single supplier, so there is one source of supply and responsibility for warranty, parts, and service. Supplier shall maintain a service and maintenance facility within 50 miles of jobsite. Supplier shall directly employ service technicians specifically trained and qualified on the diagnosis and repair of engines, alternators, power transfer equipment, medium voltage switchgear, and paralleling equipment. The technicians shall be trained in the installation and commissioning of complex generator systems, including medium voltage generator paralleling equipment.

C. The responsibility for performance to this specification in its entirety cannot be split among individual suppliers of components comprising the system, but must be assumed solely by the local authorized dealer of the generator set manufacturer. Specifically, note requirements for total system testing, equipment coordination and documentation.

D. The system supplier shall provide literature and other information describing the equipment specified; data and other information shall be on the manufacturer's printed literature or letter head. Performance data shall be the result of test procedures in accordance with nationally recognized standards, in addition to such other procedures that are judged necessary by the manufacturer to insure

maximum service reliability for emergency systems, and shall be available for inspection by the Engineer upon request.

E. The generator set installation and on-site testing shall conform to the requirements of the following codes and standards, as applicable. The generator set shall include necessary features to meet the requirements of these standards.

1. IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
2. NFPA37 – Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
3. NFPA70 – National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 702.
4. NFPA110 – Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 2 systems. Level 2 prototype tests required by this standard shall have been performed on a complete and functional unit, component level type tests will not substitute for this requirement.

F. The generator set and supplied accessories shall meet the requirements of the following standards and be labeled to demonstrate compliance where available:

1. NEMA MG1-1998 part 32. Alternator shall comply with the requirements of this standard.
2. UL1236 – Battery Chargers
3. UL2200. The generator set shall be listed to UL2200 or submit to an independent third party certification process to verify compliance as installed.

G. The control system for the generator set shall comply with the following requirements.

1. CSA C22.2, No. 14 – M91 Industrial Control Equipment.
2. EN50082-2, Electromagnetic Compatibility – Generic Immunity Requirements, Part 2: Industrial.
3. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
4. FCC Part 15, Subpart B.
5. IEC8528 part 4. Control Systems for Generator Sets
6. IEC Std 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.
7. UL508. The entire control system of the generator set shall be UL508 listed and labeled.

H. The generator set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality

assurance in design/development, production, installation, and service, in accordance with ISO 9001.

I. Training: The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided. The training program shall be not less than 3 days at 8 hours in duration and the class size shall be limited to 5 persons. Training date shall be coordinated with the facility owner. This training shall also include the paralleling switchgear training. All training shall be documented with sign in sheets for persons in attendance and training shall be recorded in DVD format and provided to the Owner for future reference. Provide three copies of all DVDs.

J. Service and support: The manufacturer of the generator set shall maintain service parts inventory at a central location which is accessible to the service location 24 hours per day, 365 days per year.

1. The generator set, paralleling and power transfer equipment shall be serviced by a local service organization that is trained and factory certified in the service of this equipment. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.
2. The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.

1.2 ACCEPTABLE MANUFACTURERS:

A. Only pre-approved bidders shall supply equipment provided under this contract. Equipment shall be Cummins or Caterpillar, and shall be supplied by the authorized local distributor of Cummins Power Generation or Caterpillar.

B. Manufacturers shall have completed a minimum of 10 medium voltage generator/switchgear projects during the past two years. Submit completed project list with references with proposal.

1.3 TESTING:

A. The intent of this specification is to provide equipment of proven reliability and compatibility.

B. Factory Production Model Tests:

1. Before shipment of the equipment to the jobsite, the generator set, and other system components shall be tested together under rated load and power factor for proper functioning at the generator set manufacturer's facility, including control and interfacing circuits per the requirements of NFPA 110. No exceptions to the requirements of this paragraph will be accepted.

2. Other Tests Shall Include:

   a. Transient response and steady state governing, to demonstrate compliance with this specification.
   b. Full load test: The genset shall be operated for 4 hours at rated load and power factor. Throughout the test, instrument readings from the gensets, calibrated load bank instruments, and ambient temperature shall be recorded at 15 minute intervals.

3. The Engineer shall be notified in advance of these tests, and shall be able to witness these tests. Certified copies of test results shall be forwarded to the Engineer for review, and approval before shipment of equipment to jobsite.

C. Field Tests After Installation:

1. The complete installation shall be initially started and checked out for operational compliance by factory trained representative(s) of the manufacturer of the generator sets and paralleling equipment. The engine lubrication oil and antifreeze, as recommended by the manufacturer for operation under environmental conditions specified, shall be provided by the supplier of the generator sets. Water used in the engine cooling system shall be "soft" demineralized water.
2. Upon completion of initial start-up and system checkout, the supplier of the generator sets shall perform a field test, with the Engineer notified in advance, to demonstrate load carrying capability, stability, voltage and frequency response.
3. Simulated power failure test - generator sets shall be made ready for automatic operation and started by means of the paralleling controls on the paralleling gear. Units shall run for the duration of all time delays and then automatically shut down.
4. The system shall be operated for six hours continuously at the maximum rated load level; except that load shall not exceed 50 percent of generator set rating for first 1/2 hour, during first initial run for proper engine break-in. Records shall be maintained throughout this period to record water temperature, oil pressure, ambient air temperature, voltage, current, frequency and kilowatts. The above data shall be recorded at 15 minute intervals throughout the test. There shall be a 10 minute unloaded run at the conclusion of the test to allow engine to cool before shutdown. Electronic copies of the field test data shall be furnished to the Engineer. The contractor shall provide necessary cable and make all necessary hook-ups to accomplish field tests and shall furnish all fuel necessary for field test and refill all tanks with winterized fuel after testing.
5. The emergency system is to be tested at 100 percent of its nameplate kW rating at the jobsite.

1.4 WARRANTY:

A. The complete standby electric power system, including engine-generator sets, switchgear, and automatic transfer switches shall be warranted for a period of five (5) years from the date of commissioning. Warranty shall cover 100 percent of all parts and labor for the full warranty period. Multiple warranties for individual components (engine, alternator, controls, etc.) will not be acceptable.

B. Satisfactory warranty documents must be provided with submittal documentation. In the judgment of the specifying authority, the manufacturer supplying the warranty for the complete system must have necessary financial strength and technical expertise with all components supplied to provide adequate warranty support.

C. No deductible shall be allowed for travel time, service hours, repair parts, costs, etc. The warranty shall include a comprehensive yearly maintenance plan for routine maintenance, oil change, belt, hoses, fuel filters, etc. as required for proper operation for the duration of the warranty period.

1.5 LAYOUT AND DESIGN:

A. The equipment spacing, mounts, electrical wiring, ventilation equipment, fuel, and exhaust components have all been sized and designed around a single manufacturers equipment.

B. The installing contractor shall be responsible for changes in the site work, made necessary from the installation of equipment other than specified, without additional cost to the Owner. (Verify all work with the equipment manufacturer.)

1.6 CODES AND STANDARDS:

A. The complete emergency power system, as installed, shall comply with all applicable local, state, and national standards. In particular, the equipment shall comply with the requirements of NFPA 99, and NFPA 110 for level 2 systems.

PART 2 - IMPLEMENTATION

2.1 INSTALLATION:

A. Standby electric generating system, along with transfer switches, annunciators, generator sets, and all components shall be installed, including all connections, at locations and as indicated on drawings, and wiring diagrams as specified herein, and in accordance with approved shop drawings, manufacturer's instructions, and manufacturer's standard specification and dimension sheets.

2.2 SUBMITTALS: THE FOLLOWING INFORMATION MUST BE SUBMITTED FOR APPROVAL:

A. Proposals must include a line by line compliance statement based on this specification, along with outline drawings for verification of size within the building.

B. Proposals shall include a technical submittal including catalog information of all proposed equipment, technical description of the project and all technical information required to properly evaluate the proposal submitted.

C. Outline drawings of the equipment showing overall dimensions, power and control wiring entrance locations, breaker sizes and locations, lug sizes and locations, and front panel drawings showing all devices to be provided, with each device referenced to a material list with a complete description for the device.

D. Interconnection detail drawing showing all control and power connections in the entire emergency system. Control connections between components are to be labeled with identical nomenclature.

E. Literature describing in detail the equipment proposed, and all possible operating modes.

F. A complete review of this specification, noting for each paragraph whether or not the proposed equipment complies with the project specifications, or deviates in some fashion. For each deviation, a justification for that deviation must be given.

G. Complete test specification detailing the testing procedure to be used to verify the performance of the equipment provided.

H. Submit generator sizing calculations based on the loads and steps indicated on the drawings and/or in this specification. Include the following:

1. Steps/Loads detail report to include loads on each step and the generator load requirements for each step.
2. Voltage dip and frequency dip per step.
3. Recommended generator report indicating generator performance and load requirements.

I. On the request of the project engineer, the manufacturer shall provide a complete set of operation manuals for the equipment proposed, at the time of the submittal for the Engineer's review and approval.

J. Submit voltage drop calculations.

2.3 INSTRUCTIONS, DRAWINGS, PARTS, AND OPERATION INFORMATION:

A. Two copies of complete instructions shall be supplied to Owner prior to final acceptance.

B. Material shall be in booklet form and shall consist of operating and maintenance manuals, parts manuals, dimensional drawings, wiring diagrams and schematics, interconnection wiring diagrams, and necessary information for proper operation, service, and maintenance of the equipment and major components supplied.

2.4 OWNER ORIENTATION:

A. A representative of the supplier shall meet with a representative of the Owner at the time of final acceptance tests and shall review the operation and parts books, correct starting and control methods, and recommend preventive maintenance procedures.

PART 3 - EQUIPMENT DESIGN REQUIREMENTS AND FEATURES

3.1 PERFORMANCE:

A. Each generator set shall provide 2500 kW and 3125 KVA for an unlimited period of time under specified altitude and ambient conditions for all standby applications.

B. The output of each generator set with specified governor and voltage regulator shall meet the following requirements:

1. Random frequency variation will not exceed +/-0.5 percent (+/-0.3Hz) of its mean value for constant loads, no load to full load.
2. Random voltage variation will not exceed +/-0.5 percent of its mean value for constant loads, from no load to full load.
3. Frequency regulation under varying loads from no load to full load shall be isochronous.
4. Voltage regulation under varying loads from no load to full load shall not exceed +/-1.0 percent.
5. On application of maximum demand kW and KVA step as described below or on drawings, unit shall recover to stable operation and rated conditions within 10 seconds. Maximum voltage dip under these conditions shall not exceed 35 percent.
6. The diesel engine-generator set shall be capable of single step load pick up of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature.
7. Manufacturers of Generators shall submit calculations with marked data indicating generators will start the following items maintaining a starting voltage dip of less than 10%, a peak voltage dip of less than 35%, and a

frequency dip of less than 10%. The altitude for the calculations shall be based on 1400 ft. with an ambient temperature of 110 degrees F.

8. The alternator shall produce a clean AC voltage waveform, with not more than 3% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 2% in any single harmonic, and no 3rd order harmonics or their multiples. Telephone influence factor shall be less than 40.
9. The generator set shall be certified by the engine manufacturer to be suitable for use at the installed location and rating, and shall meet all applicable exhaust emission requirements at the time of commissioning.
10. The generator set shall share real and reactive load proportionally within plus or minus 3% with all other generator sets in the system.
11. Each generator set shall be able to carry 80% of UPS transistorized or SCR load continuously.
12. The time required to automatically start, accelerate to rated speed and voltage, synchronize and parallel all generator sets to the system bus on a normal power failure shall not exceed 15 seconds, assuming that the generator sets are in an ambient temperature of 40F or greater, and water jacket heaters are operating properly.

C. Design Loads

1. The generators shall be sized to supply power to the loads listed in the appendix.
2. In the event approved manufacturers require larger kW generator sizes than specified to meet loading requirements as listed above or on the drawings, the Electrical Contractor shall include in the bid amount required to increase feeder, paralleling gear, transformers, distribution panel sizes, etc., as required for the increased kW size of the generator to be provided. These changes shall be made with no increased cost to the Owner after the bid date. The Electrical Contractor shall submit with the generator shop drawings new feeder, paralleling gear, transformer, and panel sizes for approval by the engineer. The generator shop drawings shall be submitted prior to shop drawing submittal of the service and distribution equipment and any changes required to the equipment because of increased generator sizes shall be reflected on the equipment shop drawings prior to submittal to the Engineer.

3.2 ENGINE-GENERATOR SET DESIGN:

A. General: Each generator-set shall be mounted on suitable welded steel base to maintain proper alignment between components.

B. Engine:

1. Engine shall be stationary, liquid-cooled, diesel for use with number 2 diesel fuel. Design shall be four cycle. Engine shall be certified by

manufacturer as capable of driving a generator of kW rating as specified herein, for an unlimited period of time, in a standby application.

2. Engine shall be capable of driving the generator of this rating for ambient conditions of 110 degrees F, 29.92 inches Hg (101 Kpa) barometric pressure, and 1400 ft. elevation.
3. Arranged for direct connection to the alternating current generator.
4. An electronic governor system shall provide automatic isochronous frequency regulation. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous or parallel states.

C. Engine equipment shall include:

1. Remote two-wire, negative ground, 12/24 V.D.C. starting system. Provide electric starter, with two independent systems to disconnect the starting circuit upon engine starting.
2. Positive displacement, mechanical, full pressure lubrication oil pump with pressure regulation valve, full flow oil filters with replaceable elements, integral oil cooler, dipstick oil level indicator, oil drain valve with hose extension.
3. Primary and secondary fuel filters with replaceable elements, automatic shutoff all mounted on the engine. Replaceable dry element air cleaner.
4. Necessary protective devices and engine gauges shall have sensing elements located on the engine to interface with the generator set control; as specified under "Engine-Generator Control" herein.
5. 35 Amp battery charging alternator with transistorized voltage regulator.
6. Two Engine mounted, tank-type, engine coolant heaters, UL499 Listed single-phase, 277 VAC, minimum 4000 watts, shall be provided for each engine. Final voltage and size to be coordinated with Building Contractor.
7. The coolant heater shall be installed on the engine with silicone hose connections. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches. The coolant heater installation shall be specifically designed to provide proper venting of the system. The coolant heaters shall be installed with provisions to isolate the heater for replacement of the heater element without coolant loss.
8. The coolant heater shall be provided with a 24VDC thermostat, installed at the engine thermostat housing. An AC power connection box shall be provided for a single AC power connection to the coolant heater system.
9. The coolant heater(s) shall be sized as recommended by the engine manufacturer to warm the engine to a minimum of 100F (40C) in a 40F ambient, in compliance with NFPA110 requirements, or the temperature required for starting and load pickup requirements of this specification.

10. Engine protective devices shall include overcranking protection, low oil pressure, high coolant temperature, and overspeed shutdown.

3.3 ENGINE COOLING SYSTEMS:

A. Engine shall be radiator cooled by a skid mounted radiator system. Genset cooling system shall be designed to allow operation of the genset at rated load in a 122 degree F ambient at site elevation. Based on 0.5 in H_20 external static head. The Remote radiator shall have a low Db sound fan and motor. Provide static calculations to show radiator fan is sized for specific installation.

B. Provide 50% ethylene glycol antifreeze solution with engine-manufacturer-required additives to fill entire cooling system.

C. The system shall include, unit mounted radiator, blower fan, water pump, thermostat and radiator duct fan.

3.4 ENGINE EXHAUST SYSTEM:

A. Exhaust silencer shall be provided for each engine of size as recommended by manufacturer. Silencer shall be chambered construction of the residential type. **A critical (most quiet) type silencer shall be quoted as an alternate adder.** Contractor shall mount silencer so its weight is not supported by the engine. Silencer shall be mounted as close as practical to the engine.

B. Flexible seamless stainless steel exhaust connection shall be provided as required for connection between engine exhaust manifold and exhaust line (24" minimum).

C. Provide an exhaust condensation trap with manual drain valve to trap and drain off exhaust condensation and to prevent condensation from entering the engine.

D. Provide all necessary flanges and special fittings, etc. for proper installation.

E. Contractor shall mount and install all exhaust components as shown on drawings and as required for code compliance. All components shall be properly sized to assure proper operation without excessive back pressure when installed as shown on drawings.

F. Make provisions as required for pipe expansion and contraction.

G. Contractor shall cover exhaust silencer and all indoor exhaust piping with a proper insulating material in a manner not to interfere with flexible exhaust connections.

H. Thickness and type of insulation shall be shown on mechanical drawings.

3.5 ENGINE FUEL SYSTEMS:

A. The manufacturer of the genset shall provide and warrant the complete engine fuel system, including fuel tank, rupture basin, fuel tank controls and leakage detection alarm. Provide all required items including, flexible fuel connector, fuel filter, leak detection alarm and cable.

B. Contractor shall provide proper electric circuits for pumps that are energized from load side of generator building service breaker; day tank float switches shall cycle pumps to control fuel level in day tanks. Contractor shall provide necessary items to assure proper priming of all fuel pumps.

1. Fuel line from tank to fuel lines and to engine generator shall have a flexible connection installed by engine generator supplier.
2. Fuel line shall be painted black iron pipe.

C. Fill all fuel tanks with winterized fuel of the type required by the generator manufacturer. Label tank to indicate the type of fuel to be used, the nominal capacity of the tank and include "FUEL MUST BE WINTERIZED".

3.6 GENERATOR:

A. Generator shall be single-bearing, drip-proof construction, synchronous type, revolving field, with direct drive centrifugal blower for cooling and minimum noise. Stator shall be skewed design and twice impregnated with high-temperature polyester varnish. Insulation shall be Class F or Class H per NEMA MG1.65 and BS 2757. Generator shall be directly connected to engine flywheel housing. Rotor shall be driven through a flexible coupling to insure permanent alignment. The maximum temperature rise at rated load shall not exceed 130 degrees C at 40 degrees C ambient (for Class F insulation) or 150 degrees C (for Class H insulation). The maximum subtransient reactance of the generator shall not exceed 13%. Generator design shall prevent potentially damaging shaft currents.

B. The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.

C. Voltage regulator:

1. Regulator shall be three phase sensing, solid-state temperature compensated design and shall function by controlling the exciter magnetic field between stator and rotor. The voltage regulation system shall be insensitive to severe, load induced waveshape distortion from SCR or thyristor circuits such as those used in battery charging (UPS) and motor speed control equipment loads. Voltage regulator shall be mounted in the genset control panel.

2. Voltage regulation system shall include overvoltage protection to protect the system against voltage regulator failure or loss of reference, and to protect the system loads from damaging overvoltage conditions.
3. Voltage regulation system shall include permanent magnet exciter (PMG), to provide 250% of rated current for 10 seconds without damage to generator. After 10 seconds the generator field shall collapse to protect genset to switchgear power connections.
4. Voltage regulation system shall also be provided with loss of field monitor (or reverse VAR protection) and KVAR control, which may be mounted in the paralleling switchgear at the discretion of the supplier.

D. The alternator, exciter, and voltage regulator shall be designed and manufactured by the generator set manufacturer so that the characteristics shall be matched to the torque curve of the prime mover. System shall provide automatic voltage reduction if the load demand exceeds the engine capacity to prevent engine stalling and saturation of magnetic components.

E. Generator set shall be capable of safe stable operation with SCR loads of up to 80% of the unit's KVA rating, without exceeding the temperature rise limits of the generator insulation system.

3.7 ENGINE-GENERATOR CONTROL:

A. All switches, lamps, and meters in the control system shall be oil-tight and dust-tight. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts. Provide a unit mounted control console that is factory built, wired, tested, and shock-mounted by the engine and generator manufacturer. Control console shall be mounted on the generator end of the set. Control wire shall have termination identification on each wire for ease of tracing. Control wires which run between generator set controls, and automatic load transfer controls shall have termination identification on both ends. Nameplates shall be provided to identify each device or function and shall be silk-screened white on a black background. The genset shall be capable of independent operation, without any control from remote equipment. Control panel shall meet NFPA 110.

B. Generator set Control. The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.

C. The control shall be mounted on the generator set. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.

D. Provide loss of field monitor and interface to alarm circuit (Parallel applications).

E. All wiring for connection to remote devices shall be wired to properly numbered and labeled terminal blocks. Contractor shall install stranded wires to all remote devices.

F. Provide cycle cranking system as recommended by engine manufacturer and cranking limiter with 75 second cranking cycle with lockout.

G. Generator set monitoring system shall include solid-state engine monitor with individual lights with lamp test switch and one common external alarm contact to indicate each of the following conditions for each unit:

1. Green Light

    a. Engine Run/Supplying Load

2. Yellow Light

    a. High Coolant (Engine) Temperature (Pre-Alarm)
    b. Low Oil Pressure (Pre-Alarm)
    c. Low Fuel (Pre-Alarm) Pressure
    d. Low Battery Voltage
    e. High Battery Voltage
    f. Low Coolant Level
    g. Control Switch not in Automatic Position
    h. Low Cranking Voltage

3. Red Light

    a. Overcrank Shutdown
    b. Overspeed Shutdown
    c. High Coolant (Engine) Temperature Shutdown
    d. Low Oil Pressure Shutdown
    e. Low Coolant Temperature
    f. Low Fuel
    g. Battery Charger AC Failure

4. Flashing Red Light

    a. Switch Off
    b. Open/Tripped Circuit Breaker

5. Control Switches

    a. Mode Select Switch. The mode select switch shall initiate the following control modes. When in the run or manual position the generator set shall start, and accelerate to rated speed and voltage as directed by the operator. In the off position the generator set shall immediately stop, bypassing all time delays. In the auto

position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.

b. Emergency Stop Switch: Shall be red "mushroom-head" push-button. Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.

c. Reset switch. The reset switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.

d. Panel Lamp Switch. Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.

6. Generator Set AC Output Metering. The generator set shall be provided with a metering set including the following features and functions:

a. Analog voltmeter, ammeter, frequency meter, and kilowatt (KW) meter. Voltmeter and ammeter shall display all three phases. Ammeter and KW meter scales shall be color coded in the following fashion: readings from 0-90% of generator set standby rating: green; readings from 90-100% of standby rating: amber; readings in excess of 100%: red.

b. Digital metering set, 0.5% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three phase voltages (line to neutral or line to line) simultaneously.

c. Both analog and digital metering are required. The analog and digital metering equipment shall be driven by a single microprocessor, to provide consistent readings and performance.

7. Generator Set Alarm and Status Display.

a. The generator set shall be provided with alarm and status indicating lamps to indicate non-automatic generator status, and existing warning and shutdown conditions. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown conditions on an alphanumeric digital display panel:

8. Provide two sets of "form C" N.O./N.C. contacts to signal operation whenever the genset is running.

9. Provide lubricating oil temperature gauge.

10. Provide low coolant level alarm and shutdown, which shall activate high engine temperature shutdown lamp and alarm.

H. Engine Control Functions.

1. The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and number of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15-second rest period between cranking periods.
2. The control system shall include an idle mode control, which allows the engine to run in idle mode in the run position only. In this mode, the alternator excitation system shall be disabled.
3. The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.
4. The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.
5. The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed senders or wiring components, and an actual failure conditions.
6. The control system shall include all interfaces necessary for proper operation with the paralleling equipment provided under this contract. The generator set supplier shall be responsible for complete compliance to all specification requirements for both the generator set and the paralleling equipment.

I. Alternator Control Functions:

1. The generator set shall include an automatic digital voltage regulation system that is matched and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from misoperation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of [58-59] HZ. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level. Rotary potentiometers for system adjustments are not acceptable.

2. Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (over current shutdown). The protective functions provided shall be in compliance to the requirements of NFPA 70 Article 445
3. Controls shall be provided to individually monitor all three phases of the output current for short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). The protective functions provided shall be in compliance to the requirements of NFPA 70 Article 445.
4. A low resistance neutral grounding resistor or other means shall be provided to prevent damage to the alternator due to single phase fault.
5. Controls shall be provided to monitor the KW load on the generator set, and initiate an alarm condition (over load) when total load on the generator set exceeds the generator set rating for 5 seconds. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.
6. An AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.
7. A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25VDC or more than 32 VDC. During engine cranking (starter engaged), the low voltage limit shall be disabled, and if DC voltage drops to less than 14.4 volts for more than two seconds a "weak battery" alarm shall be initiated.
8. The voltage regulation system shall include reactive load sharing and electronic voltage matching for paralleling applications. Motorized voltage adjust pot is not acceptable for voltage matching.

J. Network Interface:

1. The generator set shall be provided with a Modbus TCP/IP network communication module to allow monitoring and control by remote devices.
2. The control shall communicate all engine and alternator data, and allow starting and stopping of the generator set via the network in both test and emergency modes.
3. The system shall fully interface with the SCADA system specified as part of this contract and be fully compatible.

K. Provide wiring for normally open auxiliary dry contacts from each circuit breaker located between the generator and paralleling gear (including generator mounted circuit breakers).

L. Sequence of Operation

1. Generator set shall start on receipt of a start signal from remote equipment. The start signal shall be via hardwired connection to the generator set control.
2. The generator set shall complete a time delay start period as programmed into the control.
3. The generator set control shall initiate the starting sequence for the generator set. The starting sequence shall include the following functions:
4. The control system shall verify that the engine is rotating when the starter is signaled to operate. If the engine does not rotate after two attempts, the control system shall shut down and lock out the generator set, and indicate "fail to crank" shutdown.
5. The engine shall fire and accelerate as quickly as practical to start disconnect speed. If the engine does not start, it shall complete a cycle cranking process as described elsewhere in this specification. If the engine has not started by the completion of the cycle cranking sequence, it shall be shut down and locked out, and the control system shall indicate "fail to start".
6. The engine shall accelerate to rated speed and the alternator to rated voltage. Excitation shall be disabled until the engine has exceeded programmed idle speed, and regulated to prevent over voltage conditions and oscillation as the engine accelerates and the alternator builds to rated voltage.
7. On reaching rated speed and voltage, the generator set shall operate as dictated by the control system in isochronous, synchronize, load share, load demand, or load govern state.
8. When all start signals have been removed from the generator set, it shall complete a time delay stop sequence. The duration of the time delay stop period shall be adjustable by the operator.
9. On completion of the time delay stop period, the generator set control shall switch off the excitation system and shall shut down.
10. Any start signal received after the time stop sequence has begun shall immediately terminate the stopping sequence and return the generator set to isochronous operation.

3.8 AUXILIARY EQUIPMENT AND ACCESSORIES:

A. Starting Batteries: A heavy-duty, diesel starting, lead-acid battery set shall be provided for each engine and shall be mounted on a battery rack furnished with the generator set. Provide all intercell and connecting battery cables.

B. Battery Chargers:

1. Provide two fully regulated, constant voltage, current limited, multi-rate battery chargers connected in parallel redundant configuration for each generator set. The chargers shall be designed for heavy-duty industrial service, primarily to quickly recharge and maintain batteries that start internal combustion engines. Charger shall be rated a minimum of 12 amps.
2. Charger shall provide 4 distinct charge states: "dead battery", "bulk charge", "absorption", and "float". Charge rate shall be temperature compensated to provide proper charging in ambient conditions from –20 to +55C. Provider LED indication of general charger condition, including charging, fault, and equalize. Provide a 2 line LCD display to indicate charge rate, battery voltage, faults, and provide for charger set up. Charger shall provide relay contacts for fault conditions as required by NFPA110.
3. The charger shall operate properly during fault conditions, including battery disconnection while charging, reversed battery polarity connections, and shorted battery.
4. The charger shall be compliant to the same RFI/EMI and voltage surge conditions as are specified for the generator set controller.
5. Charger design shall allow charging current to taper to zero amperage when batteries are fully charged.

C. Provide spring vibration isolators. Number and size as required by total system. Springs shall be near mid-point in field after complete installation.

D. Each generator shall have a concrete isolation pad with raised portion under skids per the detail on the drawings. Exact size, depth, and steel arrangements shall be verified with the structural engineer after the generator shop drawings are approved.

E. Connections: The generator set load connections shall be composed of silver or tin plated copper bus bars, drilled to accept mechanical or compression terminations of the number and type as shown on the drawings. Sufficient lug space shall be provided for use with cables of the number and size as shown on the drawings.

F. Power connections to auxiliary devices shall be made at the devices, with required protection located at a wall-mounted common distribution panel.

G. Generator set control interfaces to other system components shall be made on a common, permanently labeled terminal block assembly.

H. Main Unit Circuit breaker(s) at the generator. Sized per the drawings. Provide with normally open auxiliary dry contacts to indicate open or tripped condition. Connect to generator monitoring system and remote generator annunciator.

I. Emergency Shutdown Switch: Exterior Generator Installation: Switch is to be installed as shown on drawings, within sight of but not within 25 feet of the generator. It shall be of the break-glass type, surface mounted, NEMA-3R rated. The operator shall be a maintained push-on/push-off button located behind the glass. Switch shall be provided with lettering to read "Emergency Generator Stop". Activation of switch shall alarm the remote annunciator and generator control panel. Switch shall be Pilla Electrical Products #ST120SN3RBP2SL or equal approved by Engineer.

J. Provide all - weather lockable enclosure to protect the generator system. Exhaust silencer shall be mounted on top of the enclosure. Make all required modifications to the exhaust in the field.

3.9 INSTALLATION

A. Equipment shall be installed by the contractor in accordance with final submittals and contract documents. Installation shall comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions included in the listing or labeling of UL listed products.

B. Installation of equipment shall include furnishing and installing all interconnecting wiring between all major equipment provided for the on-site power system. The contractor shall also perform interconnecting wiring between equipment sections (when required), under the supervision of the equipment supplier.

C. Equipment shall be installed on concrete housekeeping pads. Equipment shall be permanently fastened to the pad in accordance with manufacturer's instructions and seismic requirements of the site.

D. Equipment shall be initially started and operated by representatives of the manufacturer.

E. All equipment shall be physically inspected for damage. Scratches and other installation damage shall be repaired prior to final system testing. Equipment shall be thoroughly cleaned to remove all dirt and construction debris prior to initial operation and final testing of the system.

3.10 CAUTION SIGN:

A. Electrical contractor shall provide and install an 8" x 11" white enamel finish on 20 gage steel panel (minimum size) secured to the perimeter fence on all four sides with 3/4" high stenciled red letters: "CAUTION". This Plant Starts Automatically. It May Start At Any Time." Letters shall be neat and legible. Panel shall be visible to anyone approaching the generator plant.

END OF SECTION 263213

Appendix

Loads Summary Report

Project - WWTP #2, Final Scenario Two Generators (2)

Comments -

Project Requirements			
Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 2
Duty	: Standby	**Site Altitude, ft(m)**	: 1400(427)
Voltage	: 277/480, Series Wye	**Site Temperature, °C**	: 43
Phase	: 3	**Max. Altr Temp Rise, °C**	: 150
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	: 10
Emissions	: EPA, stationary emergency application		

Loads Summary List

***Note: Detailed Loads and Step Report available below**

Step No.	Load Name	Quantity	Running		Starting		Peak		Dip Limits, %		VTHD% Limit
			kW	kVA	kW	kVA	kW	kVA	Vdip	Fdip	
Step01 - Base Loads	Light Load 1	1	112.5	125.0	84.38	99.27	None	None	35.0	10.0	0.0
Step01 - Base Loads	General Receptacle Load 1	1	545.57	606.19	545.57	606.19	None	None	35.0	10.0	0.0
Step01 - Base Loads	Power	1	520.91	578.79	520.91	578.79	None	None	35.0	10.0	0.0
Step01 - Base Loads	Cooling	1	71.0	78.89	71.0	78.89	None	None	35.0	10.0	0.0
Step Summary			625.0	694.0	611.0	682.0	None	None	35.0	10.0	0.0
Step02 - Headworks	1 HP	3	0.92	1.31	8.97	11.8	None	None	35.0	10.0	0.0
Step02 - Headworks	2 HP	2	1.7	2.15	13.3	19.0	None	None	35.0	10.0	0.0
Step02 - Headworks	5 HP	4	4.0	4.71	22.88	37.5	None	None	35.0	10.0	0.0
Step02 - Headworks	7.5 HP	3	5.92	6.8	28.14	50.25	None	None	35.0	10.0	0.0
Step02 - Headworks	10 HP	5	7.8	8.97	35.51	67.0	None	None	35.0	10.0	0.0
Step02 - Headworks	20 HP	1	15.25	17.13	54.28	118.0	None	None	35.0	10.0	0.0
Step02 - Headworks	40 HP VFD	2	29.84	33.16	33.16	36.84	None	None	35.0	10.0	10.0
Step02 - Headworks	75 HP VFD	1	55.95	62.17	62.17	69.08	None	None	35.0	10.0	10.0
Step02 - Headworks	100 HP VFD	1	74.6	82.89	82.89	92.1	None	None	35.0	10.0	10.0

Step02 - Headworks	0.75 HP	1	0.78	1.15	6.81	8.85	None	None	35.0	10.0	0.0
Step02 - Headworks	15 HP	3	11.57	13.15	43.36	88.5	None	None	35.0	10.0	0.0
Step02 - Headworks	50 HP	1	37.72	41.91	62.03	167.64	None	None	35.0	10.0	10.0
Step02 - Headworks	125 HP VFD	1	93.25	103.61	103.61	115.12	None	None	35.0	10.0	10.0
Step Summary			225.0	253.0	488.0	810.0	None	None	35.0	10.0	10.0
Step03 - Secondary (Intermediate) Pumps	2 HP	10	1.7	2.15	13.3	19.0	None	None	35.0	10.0	0.0
Step03 - Secondary (Intermediate) Pumps	10 HP	2	7.8	8.97	35.51	67.0	None	None	35.0	10.0	0.0
Step03 - Secondary (Intermediate) Pumps	40 HP VFD	1	29.84	33.16	33.16	36.84	None	None	35.0	10.0	10.0
Step03 - Secondary (Intermediate) Pumps	100 HP VFD	2	74.6	82.89	82.89	92.1	None	None	35.0	10.0	10.0
Step Summary			106.0	119.0	201.0	273.0	None	None	35.0	10.0	10.0
Step04 - Blower and RAS #1 Pumps	300 HP VFD	4	223.8	248.67	248.67	276.3	None	None	35.0	10.0	10.0
Step04 - Blower and RAS #1 Pumps	2 HP	4	1.7	2.15	13.3	19.0	None	None	35.0	10.0	0.0
Step04 - Blower and RAS #1 Pumps	15 HP	10	11.57	13.15	43.36	88.5	None	None	35.0	10.0	0.0
Step Summary			509.0	567.0	741.0	1033.0	None	None	35.0	10.0	10.0
Step05 - UV Disinfection	7.5 HP	4	5.92	6.8	28.14	50.25	None	None	35.0	10.0	0.0
Step05 - UV Disinfection	50 HP VFD	3	37.3	41.44	41.44	46.04	None	None	35.0	10.0	10.0
Step05 - UV Disinfection	UV Panel	4	149.47	166.08	166.08	207.6	None	None	35.0	10.0	0.0
Step Summary			367.0	408.0	451.0	585.0	None	None	35.0	10.0	10.0
Step06 - Digesters	0.75 HP	1	0.78	1.15	6.81	8.85	None	None	35.0	10.0	0.0
Step06 - Digesters	1 HP	1	0.92	1.31	8.97	11.8	None	None	35.0	10.0	0.0
Step06 - Digesters	2 HP	4	1.7	2.15	13.3	19.0	None	None	35.0	10.0	0.0
Step06 - Digesters	3 HP	3	2.73	3.33	16.83	25.5	None	None	35.0	10.0	0.0
Step06 - Digesters	7.5 HP	11	5.92	6.8	28.14	50.25	None	None	35.0	10.0	0.0
Step06 - Digesters	10 HP	14	7.8	8.97	35.51	67.0	None	None	35.0	10.0	0.0

Step06 - Digesters	15 HP	2	11.57	13.15	43.36	88.5	None	None	35.0	10.0	0.0
Step06 - Digesters	20 HP VFD	2	14.92	16.58	16.58	18.42	None	None	35.0	10.0	10.0
Step06 - Digesters	20 HP	3	15.25	17.13	54.28	118.0	None	None	35.0	10.0	0.0
Step06 - Digesters	100 HP VFD	1	74.6	82.89	82.89	92.1	None	None	35.0	10.0	10.0
Step Summary			182.0	208.0	646.0	1162.0	None	None	35.0	10.0	10.0
Project Summary			Running		Max Starting		Cumulative Step		Cumulative Peak		Project VTHD% Limit
			kW	kVA	kW	kVA	kW	kVA	kW	kVA	
			2014.0	2250.0	740.7	1161.9	2477.7	3204.3	0.0	0.0	10.0

***Note: Detailed Loads and Step Report available below**

Loads and Steps Detail Report

Project - WWTP #2, Final Scenario Two Generators (2)

Comments -

Project Requirements

Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 2
Duty	: Standby	**Site Altitude, ft(m)**	: 1400(427)
Voltage	: 277/480, Series Wye	**Site Temperature, °C**	: 43
Phase	: 3	**Max. Altr Temp Rise, °C**	: 150
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	: 10
Emissions	: EPA, stationary emergency application		

Calculated Individual Generator Set Load Running and Peak Requirements

Running kW	: 2014.0	**Max. Step kW**	: 740.7 In Step 4	**Cumulative Step kW**	: 2477.7
Running kVA	: 2250.0	**Max. Step kVA**	: 1161.9 In Step 6	**Cumulative Step kVA**	: 3204.3
Running PF	: 0.9	**Peak kW**	: None	**Cumulative Peak kW**	: None
Running NLL kVA	: 874.5	**Peak kVA**	: None	**Cumulative Peak kVA**	: None
Alternator kW	: 2801.02				

Step1

Calculated Individual Generator Set Step Load Requirements

Running kW	: 625.0	**Starting kW**	: 611.0	**Cumulative Step kW**	: 611.0
Running kVA	: 694.0	**Starting kVA**	: 682.0	**Cumulative Step kVA**	: 682.0
Running Amps	: 1673.0	**Starting Non-linear kVA**	: 0.0		
Running Non-linear kVA	: 0.0				
Alternator kW	: 624.99				
Voltage Distortion Limit for step	: 0				

Light Load 1 Three Phase Quantity : 1 In this Step

Category : Light - Discharge

Running kW	: 112.5	**Starting kW**	: 84.38	**Peak kW**	: None
Running kVA	: 125.0	**Starting kVA**	: 99.27	**Peak kVA**	: None
Running PF	: 0.9	**Starting PF**	: 0.85	**Cyclic**	: No
Running Amps	: 150.53	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 112.5			**Voltage**	: 480

General Receptacle Load 1 Three Phase Quantity : 1 In this Step

Category : General Receptacle

Running kW	: 545.57	**Starting kW**	: 545.57	**Peak kW**	: None
Running kVA	: 606.19	**Starting kVA**	: 606.19	**Peak kVA**	: None
Running PF	: 0.9	**Starting PF**	: 0.9	**Cyclic**	: No

Running Amps	: 730.0	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 545.57			**Voltage**	: 480

Power			Three Phase	Quantity	: 1 In this Step
Category	: General Receptacle				
Running kW	: 520.91	**Starting kW**	: 520.91	**Peak kW**	: None
Running kVA	: 578.79	**Starting kVA**	: 578.79	**Peak kVA**	: None
Running PF	: 0.9	**Starting PF**	: 0.9	**Cyclic**	: No
Running Amps	: 697.0	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 520.91			**Voltage**	: 480

Cooling			Three Phase	Quantity	: 1 In this Step
Category	: General Receptacle				
Running kW	: 71.0	**Starting kW**	: 71.0	**Peak kW**	: None
Running kVA	: 78.89	**Starting kVA**	: 78.89	**Peak kVA**	: None
Running PF	: 0.9	**Starting PF**	: 0.9	**Cyclic**	: No
Running Amps	: 95.0	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 71.0			**Voltage**	: 480

Step2

Calculated Individual Generator Set Step Load Requirements

Running kW	: 225.0	**Starting kW**	: 488.0	**Cumulative Step kW**	: 1113.0
Running kVA	: 253.0	**Starting kVA**	: 810.0	**Cumulative Step kVA**	: 1504.0
Running Amps	: 610.0	**Starting Non-linear kVA**	: 259.0		
Running Non-linear kVA	: 158.0				
Alternator kW	: 367.17				
Voltage Distortion Limit for step	: 10				

1 HP			Three Phase	Quantity	: 3 In this Step
Category	: Motor				
Running kW	: 0.92	**Starting kW**	: 8.97	**Peak kW**	: None
Running kVA	: 1.31	**Starting kVA**	: 11.8	**Peak kVA**	: None
Running PF	: 0.7	**Starting PF**	: 0.76	**Cyclic**	: No
Running Amps	: 1.58	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 0.92			**Voltage**	: 480

Shaft Hp	: 1.0	**Method**	: Across the line
Shaft kW	: 0.75	**Low Inertia**	: No
Efficiency (%)	: 0.73	**LRkVA Factor**	: 11.8
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: N
Load Factor	: 90.0		

2 HP			Three Phase	Quantity	: 2 In this Step
Category	: Motor				
Running kW	: 1.7	**Starting kW**	: 13.3	**Peak kW**	: None
Running kVA	: 2.15	**Starting kVA**	: 19.0	**Peak kVA**	: None
Running PF	: 0.79	**Starting PF**	: 0.7	**Cyclic**	: No

Running Amps	: 2.59	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 1.7			**Voltage**	: 480

Shaft Hp	: 2.0	**Method**	: Across the line
Shaft kW	: 1.49	**Low Inertia**	: No
Efficiency (%)	: 0.79	**LRkVA Factor**	: 9.5
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: L
Load Factor	: 90.0		

5 HP Three Phase Quantity : 4 In this Step

Category : Motor

Running kW	: 4.0	**Starting kW**	: 22.88	**Peak kW**	: None
Running kVA	: 4.71	**Starting kVA**	: 37.5	**Peak kVA**	: None
Running PF	: 0.85	**Starting PF**	: 0.61	**Cyclic**	: No
Running Amps	: 5.67	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 4.0			**Voltage**	: 480

Shaft Hp	: 5.0	**Method**	: Across the line
Shaft kW	: 3.73	**Low Inertia**	: No
Efficiency (%)	: 0.84	**LRkVA Factor**	: 7.5
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: J
Load Factor	: 90.0		

7.5 HP Three Phase Quantity : 3 In this Step

Category : Motor

Running kW	: 5.92	**Starting kW**	: 28.14	**Peak kW**	: None
Running kVA	: 6.8	**Starting kVA**	: 50.25	**Peak kVA**	: None
Running PF	: 0.87	**Starting PF**	: 0.56	**Cyclic**	: No
Running Amps	: 8.19	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 5.92			**Voltage**	: 480

Shaft Hp	: 7.5	**Method**	: Across the line
Shaft kW	: 5.6	**Low Inertia**	: No
Efficiency (%)	: 0.85	**LRkVA Factor**	: 6.7
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: H
Load Factor	: 90.0		

10 HP Three Phase Quantity : 5 In this Step

Category : Motor

Running kW	: 7.8	**Starting kW**	: 35.51	**Peak kW**	: None
Running kVA	: 8.97	**Starting kVA**	: 67.0	**Peak kVA**	: None
Running PF	: 0.87	**Starting PF**	: 0.53	**Cyclic**	: No
Running Amps	: 10.8	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 7.8			**Voltage**	: 480

Shaft Hp	: 10.0	**Method**	: Across the line
Shaft kW	: 7.46	**Low Inertia**	: No
Efficiency (%)	: 0.86	**LRkVA Factor**	: 6.7
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: H
Load Factor	: 90.0		

20 HP				Three Phase	Quantity	:	1 In this Step
Category	: Motor						
Running kW	: 15.25	**Starting kW**	: 54.28		**Peak kW**	:	None
Running kVA	: 17.13	**Starting kVA**	: 118.0		**Peak kVA**	:	None
Running PF	: 0.89	**Starting PF**	: 0.46		**Cyclic**	:	No
Running Amps	: 20.63	**Max. % Voltage Dip**	: 35.0		**Max. % Frequency Dip**	:	10.0
Alternator kW	: 15.25				**Voltage**	:	480
Shaft Hp	: 20.0			**Method**	: Across the line		
Shaft kW	: 14.92			**Low Inertia**	: No		
Efficiency (%)	: 0.88			**LRkVA Factor**	: 5.9		
Design	: Standard NEMA Design B,C or D			**LRkVA Code**	: G		
Load Factor	: 90.0						
40 HP VFD				Three Phase	Quantity	:	2 In this Step
Category	: Motor						
Running kW	: 29.84	**Starting kW**	: 33.16		**Peak kW**	:	None
Running kVA	: 33.16	**Starting kVA**	: 36.84		**Peak kVA**	:	None
Running PF	: 0.9	**Starting PF**	: 0.9		**Cyclic**	:	No
Running Amps	: 39.93	**Max. % Voltage Dip**	: 35.0		**Max. % Frequency Dip**	:	10.0
Running NLL kVA	: 33.16						
Starting NLL kVA	: 36.84				**Voltage**	:	480
Alternator kW	: 59.68						
Shaft Hp	: 40.0			**Type**	: Variable Frequency Drive		
Shaft kW	: 29.84			**Ramp Details**	: None		
Rectifier Type	: 6 pulse			**THDI %**	: 26		
Efficiency (%)	: 0.9			**THDV %**	: 10		
Load Factor	: 90.0						
75 HP VFD				Three Phase	Quantity	:	1 In this Step
Category	: Motor						
Running kW	: 55.95	**Starting kW**	: 62.17		**Peak kW**	:	None
Running kVA	: 62.17	**Starting kVA**	: 69.08		**Peak kVA**	:	None
Running PF	: 0.9	**Starting PF**	: 0.9		**Cyclic**	:	No
Running Amps	: 74.87	**Max. % Voltage Dip**	: 35.0		**Max. % Frequency Dip**	:	10.0
Running NLL kVA	: 62.17						
Starting NLL kVA	: 69.08				**Voltage**	:	480
Alternator kW	: 111.9						
Shaft Hp	: 75.0			**Type**	: Variable Frequency Drive		
Shaft kW	: 55.95			**Ramp Details**	: None		
Rectifier Type	: 6 pulse			**THDI %**	: 26		
Efficiency (%)	: 0.9			**THDV %**	: 10		
Load Factor	: 90.0						
100 HP VFD				Three Phase	Quantity	:	1 In this Step
Category	: Motor						

Running kW	: 74.6	Starting kW	: 82.89	Peak kW	: None
Running kVA	: 82.89	Starting kVA	: 92.1	Peak kVA	: None
Running PF	: 0.9	Starting PF	: 0.9	Cyclic	: No
Running Amps	: 99.82	Max. % Voltage Dip	: 35.0	Max. % Frequency Dip	: 10.0
Running NLL kVA	: 82.89				
Starting NLL kVA	: 92.1			Voltage	: 480
Alternator kW	: 149.2				

Shaft Hp	: 100.0	Type	: Variable Frequency Drive
Shaft kW	: 74.6	Ramp Details	: None
Rectifier Type	: 6 pulse	THDI %	: 26
Efficiency (%)	: 0.9	THDV %	: 10
Load Factor	: 90.0		

0.75 HP Three Phase Quantity : 1 In this Step

Category : Motor

Running kW	: 0.78	Starting kW	: 6.81	Peak kW	: None
Running kVA	: 1.15	Starting kVA	: 8.85	Peak kVA	: None
Running PF	: 0.68	Starting PF	: 0.77	Cyclic	: No
Running Amps	: 1.38	Max. % Voltage Dip	: 35.0	Max. % Frequency Dip	: 10.0
Alternator kW	: 0.78			Voltage	: 480

Shaft Hp	: 0.75	Method	: Across the line
Shaft kW	: 0.56	Low Inertia	: No
Efficiency (%)	: 0.72	LRkVA Factor	: 11.8
Design	: Standard NEMA Design B,C or D	LRkVA Code	: N
Load Factor	: 100.0		

15 HP Three Phase Quantity : 3 In this Step

Category : Motor

Running kW	: 11.57	Starting kW	: 43.36	Peak kW	: None
Running kVA	: 13.15	Starting kVA	: 88.5	Peak kVA	: None
Running PF	: 0.88	Starting PF	: 0.49	Cyclic	: No
Running Amps	: 15.84	Max. % Voltage Dip	: 35.0	Max. % Frequency Dip	: 10.0
Alternator kW	: 11.57			Voltage	: 480

Shaft Hp	: 15.0	Method	: Across the line
Shaft kW	: 11.19	Low Inertia	: No
Efficiency (%)	: 0.87	LRkVA Factor	: 5.9
Design	: Standard NEMA Design B,C or D	LRkVA Code	: G
Load Factor	: 90.0		

50 HP Three Phase Quantity : 1 In this Step

Category : Motor

Running kW	: 37.72	Starting kW	: 62.03	Peak kW	: None
Running kVA	: 41.91	Starting kVA	: 167.64	Peak kVA	: None
Running PF	: 0.9	Starting PF	: 0.37	Cyclic	: No
Running Amps	: 50.47	Max. % Voltage Dip	: 35.0	Max. % Frequency Dip	: 10.0
Running NLL kVA	: 0.0				

Starting NLL kVA	: 167.64			**Voltage**	: 480
Alternator kW	: 37.72				
Shaft Hp	: 50.0			**Method**	: Solid State
Shaft kW	: 37.3			**Current Limit**	: 400.0
Efficiency (%)	: 0.89			**LRkVA Factor**	: 5.9
Design	: Standard NEMA Design B,C or D			**LRkVA Code**	: G
Rectifier Type	: 6 pulse			**THDI %**	: 26
				THDV %	: 10
Load Factor	: 90.0				

125 HP VFD Three Phase Quantity : 1 In this Step

Category : Motor

Running kW	: 93.25	**Starting kW**	: 103.61	**Peak kW**	: None
Running kVA	: 103.61	**Starting kVA**	: 115.12	**Peak kVA**	: None
Running PF	: 0.9	**Starting PF**	: 0.9	**Cyclic**	: No
Running Amps	: 124.77	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Running NLL kVA	: 103.61				
Starting NLL kVA	: 115.12			**Voltage**	: 480
Alternator kW	: 186.5				
Shaft Hp	: 125.0			**Type**	: Variable Frequency Drive
Shaft kW	: 93.25			**Ramp Details**	: None
Rectifier Type	: 6 pulse			**THDI %**	: 26
Efficiency (%)	: 0.9			**THDV %**	: 10
Load Factor	: 90.0				

Step3

Calculated Individual Generator Set Step Load Requirements

Running kW	: 106.0	**Starting kW**	: 201.0	**Cumulative Step kW**	: 1052.0
Running kVA	: 119.0	**Starting kVA**	: 273.0	**Cumulative Step kVA**	: 1220.0
Running Amps	: 287.0	**Starting Non-linear kVA**	: 111.0		
Running Non-linear kVA	: 99.0				
Alternator kW	: 195.34				
Voltage Distortion Limit for step	: 10				

2 HP Three Phase Quantity : 10 In this Step

Category : Motor

Running kW	: 1.7	**Starting kW**	: 13.3	**Peak kW**	: None
Running kVA	: 2.15	**Starting kVA**	: 19.0	**Peak kVA**	: None
Running PF	: 0.79	**Starting PF**	: 0.7	**Cyclic**	: No
Running Amps	: 2.59	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 1.7			**Voltage**	: 480
Shaft Hp	: 2.0			**Method**	: Across the line
Shaft kW	: 1.49			**Low Inertia**	: No
Efficiency (%)	: 0.79			**LRkVA Factor**	: 9.5
Design	: Standard NEMA Design B,C or D			**LRkVA Code**	: L

Load Factor	: 90.0				
10 HP			Three Phase	Quantity	: 2 In this Step
Category	: Motor				
Running kW	: 7.8	**Starting kW**	: 35.51	**Peak kW**	: None
Running kVA	: 8.97	**Starting kVA**	: 67.0	**Peak kVA**	: None
Running PF	: 0.87	**Starting PF**	: 0.53	**Cyclic**	: No
Running Amps	: 10.8	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 7.8			**Voltage**	: 480
Shaft Hp	: 10.0			**Method**	: Across the line
Shaft kW	: 7.46			**Low Inertia**	: No
Efficiency (%)	: 0.86			**LRkVA Factor**	: 6.7
Design	: Standard NEMA Design B,C or D			**LRkVA Code**	: H
Load Factor	: 90.0				
40 HP VFD			Three Phase	Quantity	: 1 In this Step
Category	: Motor				
Running kW	: 29.84	**Starting kW**	: 33.16	**Peak kW**	: None
Running kVA	: 33.16	**Starting kVA**	: 36.84	**Peak kVA**	: None
Running PF	: 0.9	**Starting PF**	: 0.9	**Cyclic**	: No
Running Amps	: 39.93	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Running NLL kVA	: 33.16				
Starting NLL kVA	: 36.84			**Voltage**	: 480
Alternator kW	: 59.68				
Shaft Hp	: 40.0			**Type**	: Variable Frequency Drive
Shaft kW	: 29.84			**Ramp Details**	: None
Rectifier Type	: 6 pulse			**THDI %**	: 26
Efficiency (%)	: 0.9			**THDV %**	: 10
Load Factor	: 90.0				
100 HP VFD			Three Phase	Quantity	: 2 In this Step
Category	: Motor				
Running kW	: 74.6	**Starting kW**	: 82.89	**Peak kW**	: None
Running kVA	: 82.89	**Starting kVA**	: 92.1	**Peak kVA**	: None
Running PF	: 0.9	**Starting PF**	: 0.9	**Cyclic**	: No
Running Amps	: 99.82	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Running NLL kVA	: 82.89				
Starting NLL kVA	: 92.1			**Voltage**	: 480
Alternator kW	: 149.2				
Shaft Hp	: 100.0			**Type**	: Variable Frequency Drive
Shaft kW	: 74.6			**Ramp Details**	: None
Rectifier Type	: 6 pulse			**THDI %**	: 26
Efficiency (%)	: 0.9			**THDV %**	: 10
Load Factor	: 90.0				

Step4

Calculated Individual Generator Set Step Load Requirements

Running kW	: 509.0	**Starting kW**	: 741.0	**Cumulative Step kW**	: 1697.0
Running kVA	: 567.0	**Starting kVA**	: 1033.0	**Cumulative Step kVA**	: 2100.0
Running Amps	: 1367.0	**Starting Non-linear kVA**	: 553.0		
Running Non-linear kVA	: 497.0				
Alternator kW	: 956.45				
Voltage Distortion Limit for step	: 10				

300 HP VFD Three Phase Quantity : 4 In this Step

Category : Motor

Running kW	: 223.8	**Starting kW**	: 248.67	**Peak kW**	: None
Running kVA	: 248.67	**Starting kVA**	: 276.3	**Peak kVA**	: None
Running PF	: 0.9	**Starting PF**	: 0.9	**Cyclic**	: No
Running Amps	: 299.46	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Running NLL kVA	: 248.67				
Starting NLL kVA	: 276.3			**Voltage**	: 480
Alternator kW	: 447.6				

Shaft Hp	: 300.0	**Type**	: Variable Frequency Drive
Shaft kW	: 223.8	**Ramp Details**	: None
Rectifier Type	: 6 pulse	**THDI %**	: 26
Efficiency (%)	: 0.9	**THDV %**	: 10
Load Factor	: 90.0		

2 HP Three Phase Quantity : 4 In this Step

Category : Motor

Running kW	: 1.7	**Starting kW**	: 13.3	**Peak kW**	: None
Running kVA	: 2.15	**Starting kVA**	: 19.0	**Peak kVA**	: None
Running PF	: 0.79	**Starting PF**	: 0.7	**Cyclic**	: No
Running Amps	: 2.59	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 1.7			**Voltage**	: 480

Shaft Hp	: 2.0	**Method**	: Across the line
Shaft kW	: 1.49	**Low Inertia**	: No
Efficiency (%)	: 0.79	**LRkVA Factor**	: 9.5
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: L
Load Factor	: 90.0		

15 HP Three Phase Quantity : 10 In this Step

Category : Motor

Running kW	: 11.57	**Starting kW**	: 43.36	**Peak kW**	: None
Running kVA	: 13.15	**Starting kVA**	: 86.5	**Peak kVA**	: None
Running PF	: 0.88	**Starting PF**	: 0.49	**Cyclic**	: No
Running Amps	: 15.84	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 11.57			**Voltage**	: 480

Shaft Hp	: 15.0	**Method**	: Across the line
Shaft kW	: 11.19	**Low Inertia**	: No

Efficiency (%)	: 0.87	**LRkVA Factor**	: 5.9
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: G
Load Factor	: 90.0		

Step5

Calculated Individual Generator Set Step Load Requirements

Running kW	: 367.0	**Starting kW**	: 451.0	**Cumulative Step kW**	: 1916.0
Running kVA	: 408.0	**Starting kVA**	: 585.0	**Cumulative Step kVA**	: 2219.0
Running Amps	: 982.0	**Starting Non-linear kVA**	: 69.0		
Running Non-linear kVA	: 62.0				
Alternator kW	: 422.68				
Voltage Distortion Limit for step	: 10				

7.5 HP Three Phase Quantity : 4 In this Step

Category : Motor

Running kW	: 5.92	**Starting kW**	: 28.14	**Peak kW**	: None
Running kVA	: 6.8	**Starting kVA**	: 50.25	**Peak kVA**	: None
Running PF	: 0.87	**Starting PF**	: 0.56	**Cyclic**	: No
Running Amps	: 8.19	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 5.92			**Voltage**	: 480

Shaft Hp	: 7.5	**Method**	: Across the line
Shaft kW	: 5.6	**Low Inertia**	: No
Efficiency (%)	: 0.85	**LRkVA Factor**	: 6.7
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: H
Load Factor	: 90.0		

50 HP VFD Three Phase Quantity : 3 In this Step

Category : Motor

Running kW	: 37.3	**Starting kW**	: 41.44	**Peak kW**	: None
Running kVA	: 41.44	**Starting kVA**	: 46.04	**Peak kVA**	: None
Running PF	: 0.9	**Starting PF**	: 0.9	**Cyclic**	: No
Running Amps	: 49.9	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Running NLL kVA	: 41.44				
Starting NLL kVA	: 46.04			**Voltage**	: 480
Alternator kW	: 74.6				

Shaft Hp	: 50.0	**Type**	: Variable Frequency Drive
Shaft kW	: 37.3	**Ramp Details**	: None
Rectifier Type	: 6 pulse	**THDI %**	: 26
Efficiency (%)	: 0.9	**THDV %**	: 10
Load Factor	: 90.0		

UV Panel Three Phase Quantity : 4 In this Step

Category : User Defined

Running kW	: 149.47	**Starting kW**	: 166.08	**Peak kW**	: None
Running kVA	: 166.08	**Starting kVA**	: 207.6	**Peak kVA**	: None
Running PF	: 0.9	**Starting PF**	: 0.8	**Cyclic**	: No

Running Amps	: 200.0	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 149.47			**Voltage**	: 480

Step6

Calculated Individual Generator Set Step Load Requirements

Running kW	: 182.0	**Starting kW**	: 646.0	**Cumulative Step kW**	: 2478.0
Running kVA	: 208.0	**Starting kVA**	: 1162.0	**Cumulative Step kVA**	: 3204.0
Running Amps	: 500.0	**Starting Non-linear kVA**	: 64.0		
Running Non-linear kVA	: 58.0				
Alternator kW	: 234.39				
Voltage Distortion Limit for step	: 10				

0.75 HP Three Phase Quantity : 1 In this Step

Category : Motor

Running kW	: 0.78	**Starting kW**	: 6.81	**Peak kW**	: None
Running kVA	: 1.15	**Starting kVA**	: 8.85	**Peak kVA**	: None
Running PF	: 0.68	**Starting PF**	: 0.77	**Cyclic**	: No
Running Amps	: 1.38	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 0.78			**Voltage**	: 480

Shaft Hp	: 0.75	**Method**	: Across the line
Shaft kW	: 0.56	**Low Inertia**	: No
Efficiency (%)	: 0.72	**LRkVA Factor**	: 11.8
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: N
Load Factor	: 100.0		

1 HP Three Phase Quantity : 1 In this Step

Category : Motor

Running kW	: 0.92	**Starting kW**	: 8.97	**Peak kW**	: None
Running kVA	: 1.31	**Starting kVA**	: 11.8	**Peak kVA**	: None
Running PF	: 0.7	**Starting PF**	: 0.76	**Cyclic**	: No
Running Amps	: 1.58	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 0.92			**Voltage**	: 480

Shaft Hp	: 1.0	**Method**	: Across the line
Shaft kW	: 0.75	**Low Inertia**	: No
Efficiency (%)	: 0.73	**LRkVA Factor**	: 11.8
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: N
Load Factor	: 90.0		

2 HP Three Phase Quantity : 4 In this Step

Category : Motor

Running kW	: 1.7	**Starting kW**	: 13.3	**Peak kW**	: None
Running kVA	: 2.15	**Starting kVA**	: 19.0	**Peak kVA**	: None
Running PF	: 0.79	**Starting PF**	: 0.7	**Cyclic**	: No
Running Amps	: 2.59	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 1.7			**Voltage**	: 480

Shaft Hp	: 2.0	**Method**	: Across the line
Shaft kW	: 1.49	**Low Inertia**	: No
Efficiency (%)	: 0.79	**LRkVA Factor**	: 9.5
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: L
Load Factor	: 90.0		

3 HP Three Phase Quantity : 3 In this Step

Category : Motor

Running kW	: 2.73	**Starting kW**	: 16.83	**Peak kW**	: None
Running kVA	: 3.33	**Starting kVA**	: 25.5	**Peak kVA**	: None
Running PF	: 0.82	**Starting PF**	: 0.66	**Cyclic**	: No
Running Amps	: 4.01	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 2.73			**Voltage**	: 480

Shaft Hp	: 3.0	**Method**	: Across the line
Shaft kW	: 2.24	**Low Inertia**	: No
Efficiency (%)	: 0.82	**LRkVA Factor**	: 8.5
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: K
Load Factor	: 100.0		

7.5 HP Three Phase Quantity : 11 In this Step

Category : Motor

Running kW	: 5.92	**Starting kW**	: 28.14	**Peak kW**	: None
Running kVA	: 6.8	**Starting kVA**	: 50.25	**Peak kVA**	: None
Running PF	: 0.87	**Starting PF**	: 0.56	**Cyclic**	: No
Running Amps	: 8.19	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 5.92			**Voltage**	: 480

Shaft Hp	: 7.5	**Method**	: Across the line
Shaft kW	: 5.6	**Low Inertia**	: No
Efficiency (%)	: 0.85	**LRkVA Factor**	: 6.7
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: H
Load Factor	: 90.0		

10 HP Three Phase Quantity : 14 In this Step

Category : Motor

Running kW	: 7.8	**Starting kW**	: 35.51	**Peak kW**	: None
Running kVA	: 8.97	**Starting kVA**	: 67.0	**Peak kVA**	: None
Running PF	: 0.87	**Starting PF**	: 0.53	**Cyclic**	: No
Running Amps	: 10.8	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 7.8			**Voltage**	: 480

Shaft Hp	: 10.0	**Method**	: Across the line
Shaft kW	: 7.46	**Low Inertia**	: No
Efficiency (%)	: 0.86	**LRkVA Factor**	: 6.7
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: H
Load Factor	: 90.0		

15 HP				Three Phase	Quantity	: 2 In this Step	
Category	: Motor						
Running kW	: 11.57	**Starting kW**	: 43.36		**Peak kW**	: None	
Running kVA	: 13.15	**Starting kVA**	: 88.5		**Peak kVA**	: None	
Running PF	: 0.88	**Starting PF**	: 0.49		**Cyclic**	: No	
Running Amps	: 15.84	**Max. % Voltage Dip**	: 35.0		**Max. % Frequency Dip**	: 10.0	
Alternator kW	: 11.57				**Voltage**	: 480	
Shaft Hp	: 15.0			**Method**	: Across the line		
Shaft kW	: 11.19			**Low Inertia**	: No		
Efficiency (%)	: 0.87			**LRkVA Factor**	: 5.9		
Design	: Standard NEMA Design B,C or D			**LRkVA Code**	: G		
Load Factor	: 90.0						
20 HP VFD				Three Phase	Quantity	: 2 In this Step	
Category	: Motor						
Running kW	: 14.92	**Starting kW**	: 16.58		**Peak kW**	: None	
Running kVA	: 16.58	**Starting kVA**	: 18.42		**Peak kVA**	: None	
Running PF	: 0.9	**Starting PF**	: 0.9		**Cyclic**	: No	
Running Amps	: 19.97	**Max. % Voltage Dip**	: 35.0		**Max. % Frequency Dip**	: 10.0	
Running NLL kVA	: 16.58						
Starting NLL kVA	: 18.42				**Voltage**	: 480	
Alternator kW	: 29.84						
Shaft Hp	: 20.0			**Type**	: Variable Frequency Drive		
Shaft kW	: 14.92			**Ramp Details**	: None		
Rectifier Type	: 6 pulse			**THDI %**	: 26		
Efficiency (%)	: 0.9			**THDV %**	: 10		
Load Factor	: 90.0						
20 HP				Three Phase	Quantity	: 3 In this Step	
Category	: Motor						
Running kW	: 15.25	**Starting kW**	: 54.28		**Peak kW**	: None	
Running kVA	: 17.13	**Starting kVA**	: 118.0		**Peak kVA**	: None	
Running PF	: 0.89	**Starting PF**	: 0.46		**Cyclic**	: No	
Running Amps	: 20.63	**Max. % Voltage Dip**	: 35.0		**Max. % Frequency Dip**	: 10.0	
Alternator kW	: 15.25				**Voltage**	: 480	
Shaft Hp	: 20.0			**Method**	: Across the line		
Shaft kW	: 14.92			**Low Inertia**	: No		
Efficiency (%)	: 0.88			**LRkVA Factor**	: 5.9		
Design	: Standard NEMA Design B,C or D			**LRkVA Code**	: G		
Load Factor	: 90.0						
100 HP VFD				Three Phase	Quantity	: 1 In this Step	
Category	: Motor						
Running kW	: 74.6	**Starting kW**	: 82.89		**Peak kW**	: None	
Running kVA	: 82.89	**Starting kVA**	: 92.1		**Peak kVA**	: None	
Running PF	: 0.9	**Starting PF**	: 0.9		**Cyclic**	: No	

Running Amps	: 99.82	**Max. % Voltage Dip**	: 35.0	**Max. % Frequency Dip**	: 10.0
Running NLL kVA	: 82.89				
Starting NLL kVA	: 92.1			**Voltage**	: 480
Alternator kW	: 149.2				

Shaft Hp	: 100.0	**Type**	: Variable Frequency Drive
Shaft kW	: 74.6	**Ramp Details**	: None
Rectifier Type	: 6 pulse	**THDI %**	: 26
Efficiency (%)	: 0.9	**THDV %**	: 10
Load Factor	: 90.0		

SECTION 263215 – GENERATORS AND PARALLELING GEAR COMMISSIONING

PART 1 - GENERAL

1.1 DESCRIPTION:

A. The purpose of this section is to specify all division's responsibilities and participation in the commissioning process.

B. Commissioning testing of the generators, paralleling gear and associated equipment shall be performed by the Generator System and paralleling gear manufacturers with assistance from the responsible contractors for the generator equipment. For these systems, Commissioning is primarily the responsibility of the Generator System manufacturer with support for commissioning the responsibility of Installation contractors and the Engineer. The commissioning process does not relieve this Contractor from participation in the process or diminish the role and obligations to complete all portions of work in a satisfactory and fully operational manner.

C. Commissioning testing of the entire facility shall be performed by the General Contractor, Sub-Contractors, Systems Integrator, paralleling gear and generator manufacturers and associated sub-contractors. Commissioning of the facility is primarily the responsibility of the General Contractor. The commissioning process does not relieve this Contractor from participation in the process or diminish the role and obligations to complete all portions of work in a satisfactory and fully operational manner.

D. Commissioning-related Work of Division 26 includes:

1. Testing and start-up of the Generator Equipment and Paralleling Gear.
2. Providing qualified personnel for participation in commissioning tests.
3. Providing training to the Engineer and Owner on basic operation of all systems.
4. Fulfilling contract and warranty requirements by providing equipment and labor necessary to correct deficiencies found during the commissioning process.
5. Completion and endorsement of pre-functional test checklists provided by the Generator Equipment and Paralleling Gear manufacturers to assure that Division 26 equipment and systems are fully operational and ready for functional testing.
6. Providing operation and maintenance information and as-built drawings to the Engineer for review, verification, and organization, prior to final distribution.
7. Develop, edit, and document system operation descriptions and commissioning check lists.
8. Providing training for the systems specified in all divisions of this Specification.

9. Include commissioning of communications, controls, monitoring, and interface with Wastewater Treatment Plant #2 SCADA system.

1.2 RELATED WORK:

All testing and start-up procedures and documentation requirements required for a complete and operable installation.

1.3 SUBMITTALS:

A. Submit a detailed schedule, commissioning worksheets, and commission plan for approval two months prior to commissioning start.

B. Submit completed commissioning documentation after final acceptance.

C. A representative of the Engineer and Owner (if requested) shall be on site for all commissioning of the system. Owner and engineer shall be notified 30 days prior to commissioning to ensure all parties can be present.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT:

A. This Contractor shall provide all test equipment, software, and all test programming support as necessary to start up and verify standards performance compliance. This equipment and software shall be provided for use during the commissioning.

B. Proprietary test equipment, including hardware, software, and specialized test instruments, required by the manufacturer for system testing and commissioning, whether specified or not, shall be provided by the contractor. This Contractor shall provide the test equipment, demonstrate its use, and perform all testing during commissioning.

PART 3 - EXECUTION

3.1 WORK PRIOR TO COMMISSIONING:

A. Complete all phases of work so the system can be started, tested, and otherwise commissioned for beneficial use by the Owner. The Generator System and Paralleling Gear manufacturers have primary start-up responsibilities with obligations to complete systems, including all sub-systems, so they are functional. This includes the complete installation, checkout, and testing of equipment, per the Contract Documents and related directives, clarifications, change orders, etc.

B. A Commissioning Plan will be developed by the Generator System and Paralleling Gear manufacturers and the General Contractor. The Commissioning Plan will be developed prior to completion of the installation. Provide all necessary information pertaining to the actual equipment and installation.

Commissioning including completed check lists and testing for Engineer's review and approval as part of the system submittals.

C. If Contractor-initiated system changes have been made that alter the commissioning process, the Generator System manufacturer will notify the Engineer and the Owner.

D. Specific pre-commissioning responsibilities are as follows:

1. Factory-trained technician for start-up, checkout, and testing services for the all systems to be commissioned.
2. Normal start-up services required to bring each system into a fully operational state. This also includes all software and hardware to render systems fully operational. The commissioning process will not be started until each system is complete, and functionality verified by the Engineer.
3. Factory start-up services will be provided for key equipment and systems specified in Divisions 26 as well as other sections of the specifications. This Contractor shall coordinate this work.
4. Notify the Engineer when systems are ready for functional testing.

E. Commissioning is intended to begin upon completion of a system. Commissioning may proceed prior to the completion of systems and/or sub-systems if expediting this work is in the best interests of the Owner. Commissioning activities and schedule will be coordinated with the Owner and Engineer. Start of commissioning before system completion will not relieve the Contractor from completing those systems per the schedule.

3.2 SYSTEMS TO BE COMMISSIONED:

A. Systems to be commissioned include:

1. Generators
2. Paralleling Switchgear
3. Radiators
4. Fuel Tanks and Pumps
5. * All systems will be tested under load with WWTP #2 on line.
6. Fuel delivery system.
7. All computers and SCADA system Programming.
8. Ordering of Fuel upon low level fuel in the large above ground fuel Storage tank.
9. Monitoring of the leak Detection System
10. Operation of all systems for a complete and functional system and facility once operational.
11. Operation of SCADA system controls and monitoring.

3.3 PARTICIPATION IN COMMISSIONING:

A. Commissioning testing shall be performed by the General Contractor and Generator System and Paralleling Gear manufacturers with assistance from the responsible contractors. Provide skilled technicians to start up and debug all systems within all divisions of work. These same technicians shall be made available to assist in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc. will be requested by and coordinated by this Contractor. Contractor will ensure qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete necessary tests, adjustments, and/or problem resolutions.

B. System problems and discrepancies may require additional technician time, commissioning time, redesign and/or reconstruction of systems and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained at no additional cost to the owner.

C. The Engineer reserves the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the Engineer and Owner to get the job done. A liaison or intermediary does not constitute the availability of a qualified technician for purposes of this work.

3.4 WORK TO RESOLVE DEFICIENCIES:

A. In some systems, mis-adjustment, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the Engineer, with input from the Contractor, equipment suppliers, and the Generator System manufacturer. Whereas all members will have input and the opportunity to discuss, debate, and work out problems, the Engineer will have final jurisdiction on the necessary work to be done to achieve performance.

B. Corrective work shall be completed in a timely fashion to permit the timely completion of the commissioning process. Experimentation to render system performance will be permitted. If the Engineer deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the General Contractor and/or the Generator System manufacturer will notify the Engineer indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If the deadline(s) passes without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

3.5 ADDITIONAL COMMISSIONING:

A. Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The Contractor, suppliers, and Generator System manufacturer shall include a reasonable reserve to complete this work as part of their standard contractual obligations.

B. The cost of compensation of the commissioning for repeat testing or troubleshooting due to systems that do not meet specified performance, shall be borne by this Contractor.

3.6 TRAINING:

A. A training session, before functional testing starts, shall be conducted with sufficient detail and duration to give the Owner's staff a complete working knowledge of all the systems. This training shall provide all necessary software, passwords, reference materials, and/or proprietary hardware necessary to allow the Owner's staff to operate the system.

B. This Contractor will be required to participate in the training of the Owner's engineering and maintenance staff for the generator systems, switchgear, controls systems and the related components. Training may be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids, or in the field with the specific equipment. The type of training will be per the Owner's option.

C. Training may be conducted jointly with the Owner, the design engineers, the equipment vendors, and the Contractor. This Contractor will be responsible for the generic training, as well as instructing the Owner's staff on the system peculiarities specific to this project.

3.7 SYSTEMS DOCUMENTATION:

A. In addition to the requirements of Division 1, update Contract Documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. All drawings shall be red-lined on two sets. As-built drawings shall include floor plans, and the individual system's one-lines, controls, miscellaneous drawings and layouts for all systems.

B. Maintain as-built red-lines on the job site. Given the size and complexity of this project, red-lining of the drawings at completion of construction, based on memory of key personnel, is not satisfactory. Continuous and regular red-lining and/or posting of the drawings is considered essential and mandatory.

C. In addition to the stated requirements for operation and maintenance data, provide one copy of equipment technical literature, operation and maintenance literature, and shop drawings to the Engineer as soon as they are available. This

requirement is for review of these documents prior to finalization and distribution of multiple copies for the Owner's final use.

D. Detailed commissioning plan, schedule and final documentation of successful completion of all commissioning work.

END OF SECTION 263215

SECTION 263216 – ELECTRICAL SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The purpose of this section is to specify all division's responsibilities and participation in the commissioning process.

B. Commissioning testing of the generators and associated equipment shall be performed by the Generator System manufacturer with assistance from the responsible contractors for the generator equipment. For these systems, Commissioning is primarily the responsibility of the Generator System manufacturer with support for commissioning the responsibility of Installation contractors and the Engineer. The commissioning process does not relieve this Contractor from participation in the process or diminish the role and obligations to complete all portions of work in a satisfactory and fully operational manner.

C. Commissioning-related Work of Division 26 includes:

1. Testing and start-up of the Generator Equipment and Switchgear.
2. Providing qualified personnel for participation in commissioning tests.
3. Providing training to the Engineer and Owner on basic operation of all the systems.
4. Fulfilling contract and warranty requirements by providing equipment and labor necessary to correct deficiencies found during the commissioning process.
5. Completion and endorsement of pre-functional test checklists provided by the Generator Equipment manufacturer to assure that Division 26 equipment and systems are fully operational and ready for functional testing.
6. Providing operation and maintenance information and as-built drawings to the Engineer for review, verification, and organization, prior to final distribution.
7. Develop, edit, and document system operation descriptions and commissioning check lists.
8. Providing training for the systems specified in all divisions of this Specification.
9. Include commissioning of communications, controls, monitoring, and interface with Plant SCADA system.

1.2 RELATED WORK

All testing and start-up procedures and documentation requirements required for a complete and operable installation.

1.3 SUBMITTALS

A. Submit a detailed schedule, commissioning worksheets, and commissioning plan for approval two months prior to commissioning start.

B. Submit completed commissioning documentation after final acceptance.

C. A representative of the Engineer and Owner (if requested) shall be on site for all commissioning of the system. Owner and engineer shall be notified 30 days prior to commissioning to ensure all parties can be present.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. This Contractor shall provide all test equipment, software, and all test programming support as necessary to start up and verify standards performance compliance. This equipment and software shall be provided for use during commissioning.

B. Proprietary test equipment, including hardware, software, and specialized test instruments, required by the manufacturer for system testing and commissioning, whether specified or not, shall be provided by the contractor. This Contractor shall provide the test equipment, demonstrate its use, and perform all testing during commissioning.

PART 3 - EXECUTION

3.1 WORK PRIOR TO COMMISSIONING

A. Complete all phases of work so the system can be started, tested, and otherwise commissioned for beneficial use by the Owner. The Generator System manufacturer has primary start-up responsibilities with obligations to complete systems, including all sub-systems, so they are functional. This includes the complete installation, checkout, and testing of equipment, per the Contract Documents and related directives, clarifications, change orders, etc.

B. A Commissioning Plan will be developed by the Generator System manufacturer and the General Contractor. The Commissioning Plan will be developed prior to completion of the installation. Provide all necessary information pertaining to the actual equipment and installation. Commissioning including completed check lists and testing for Engineer’s review and approval as part of the system submittals.

C. If Contractor-initiated system changes have been made that alter the commissioning process, the Generator System manufacturer will notify the Engineer and the Owner.

D. Specific pre-commissioning responsibilities are as follows:

1. Factory-trained technician for start-up, checkout, and testing services for all systems to be commissioned.
2. Normal start-up services required to bring each system into a fully operational state. This also includes all software and hardware to render fully operational systems. The commissioning process will not be started until each system is complete, and functionality verified by the Engineer.
3. Factory start-up services will be provided for key equipment and systems specified in Divisions 26 as well as other sections of the specifications. This Contractor shall coordinate this work.
4. Notify the Engineer when systems are ready for functional testing.

E. Commissioning is intended to begin upon completion of a system. Commissioning may proceed prior to the completion of systems and/or sub-systems if expediting this work is in the best interests of the Owner. Commissioning activities and schedule will be coordinated with the Engineer. Start of commissioning before system completion will not relieve the Contractor from completing those systems as per the schedule.

3.2 SYSTEMS TO BE COMMISSIONED

A. Systems to be commissioned include:

1. Generators.
2. Paralleling Switchgear.
3. All Switchgear.
4. Fuel Tanks and Pumps.
5. All systems will be tested under load with the Plant on line.
6. All computers and SCADA system Programming.
7. Ordering of Fuel upon low level fuel in the aboveground fuel Storage tank.
8. Monitoring of the leak Detection System
9. Operation of all systems for a complete and functional system and facility once operational.

3.3 PARTICIPATION IN COMMISSIONING

A. Commissioning testing shall be performed by the General Contractor and Generator System manufacturer with assistance from the responsible contractors. Provide skilled technicians to start up and debug all systems within all divisions of work. These same technicians shall be made available to assist in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc. will be requested by and coordinated by this Contractor. Contractor will ensure the qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

B. System problems and discrepancies may require additional technician time, commissioning time, redesign and/or reconstruction of systems and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained at no additional cost to the owner.

C. The Engineer reserves the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the Engineer and Owner to get the job done. A liaison or intermediary does not constitute the availability of a qualified technician for purposes of this work.

3.4 WORK TO RESOLVE DEFICIENCIES

A. In some systems, mis-adjustment, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the Engineer, with input from the Contractor, equipment suppliers, and the Generator System manufacturer. Whereas all members will have input and the opportunity to discuss, debate, and work out problems, the Engineer will have final jurisdiction on the necessary work to be done to achieve performance.

B. Corrective work shall be completed in a timely fashion to permit the timely completion of the commissioning process. Experimentation to render system performance will be permitted. If the Engineer deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the General Contractor and/or the Generator System manufacturer will notify the Engineer indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If the deadline(s) passes without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

3.5 ADDITIONAL COMMISSIONING

A. Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The Contractor, suppliers, and Generator System manufacturer shall include a reasonable reserve to complete this work as part of their standard contractual obligations.

B. The cost of compensation of the commissioning for repeat testing or troubleshooting due to systems that do not meet specified performance, shall be borne by this Contractor.

3.6 TRAINING

A. A training session, before functional testing starts, shall be conducted with sufficient detail and duration to give the Owner's staff a complete working knowledge of all systems. This training shall provide all necessary software, passwords, reference materials, and/or proprietary hardware necessary to allow the Owner's staff to operate the system.

B. This Contractor will be required to participate in the training of the Owner's engineering and maintenance staff for the generator systems, switchgear, controls systems and the related components. Training may be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids, or in the field with the specific equipment. The type of training will be per the Owner's option.

C. Training may be conducted jointly with the Owner, the design engineers, the equipment vendors, and the Contractor. This Contractor will be responsible for the generic training, as well as instructing the Owner's staff on the system peculiarities specific to this project.

3.7 SYSTEMS DOCUMENTATION

A. In addition to the requirements of Division 1, update Contract Documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. All drawings shall be red-lined on two sets. As-built drawings shall include individual systems one-lines, controls, and miscellaneous drawings layouts for all systems.

B. Maintain as-built red-lines on the job site. Given the size and complexity of this project, red-lining of the drawings at completion of construction, based on memory of key personnel, is not satisfactory. Continuous and regular red-lining and/or posting of the drawings is considered essential and mandatory.

C. In addition to the stated requirements for operation and maintenance data, provide one copy of equipment technical literature, operation and maintenance literature, and shop drawings to the Engineer as soon as they are available. This requirement is for review of these documents prior to finalization and distribution of multiple copies for the Owner's final use.

D. Detailed commissioning plan, schedule and final documentation of successful completion of all commissioning work.

END OF SECTION 263216

SECTION 263600 - AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the contract, including general and supplemental conditions, apply to this section.

1.2 DESCRIPTION:

A. This section includes the furnishing, installation, and connection of automatic transfer switches.

1.3 SUBMITTALS:

A. Product Data: For each type of automatic transfer switch include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material list for each switch specified.

C. Operation and Maintenance Data: Include operation and maintenance data for all automatic transfer switches and components in the operation and maintenance manuals. Data shall include but not be limited to:

1. Features and operating sequences.
2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE:

A. Source Limitation: Obtain automatic transfer switches, components, and accessories from a single manufacturer.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR AUTOMATIC TRANSFER SWITCHES:

A. Automatic transfer switches shall be in accordance with UL, NEMA, NEC, ANSI, NFPA, as specified and as shown on the drawings.

B. Automatic transfer switches are to be electrically operated, mechanically held, open contact type, without integral overcurrent protection. Transfer switches utilizing automatic or non-automatic molded case circuit breakers as switching mechanisms are not acceptable.

C. Automatic transfer switches shall be UL listed under UL 1008 and, where applicable, also meet the additional withstand test requirements as specified.

D. The unit shall be completely assembled and factory wired so that only external circuit connections are required in the field. The unit shall include, but not be limited to, operating mechanism, main contact, auxiliary contacts, timers, pilot lights, switches, and auxiliary sensing devices.

2.2 APPROVED MANUFACTURERS:

A. Russell Electric, ASCO, Zenith, Onan, Cummins, Kohler and Caterpillar. If ASCO transfer switches are provided, contractor shall provide electrical room layout showing adequate space for all equipment due to the larger size of ASCO transfer switches.

2.3 RATINGS, MARKINGS AND TESTS:

A. Ratings:

1. Phase, voltage and ampere rating shall be as shown on the drawings. Switches shall be break before make switched neutral 4 pole for 3 phase 4 wire systems. The ampere rating shall be for 100 percent continuous load current.
2. Transfer switches are to be rated for total system transfer on emergency systems.
3. Ratings shall be with non-welding of contacts during the performance of the withstand and closing tests.

B. Markings:

1. Markings shall be in accordance with UL 1008.
2. Markings for the additional withstand test hereinafter specified are waived when the testing laboratory is other than UL.

C. Tests:

1. Transfer switches shall be tested in accordance with UL 1008. The contacts of the transfer switch shall not weld during the performance of the withstand and closing tests.

2.4 HOUSING:

A. Enclose transfer switches in steel cabinets in accordance with UL 508, or in a switchboard assembly in accordance with UL 891, as shown on the drawings. Enclosures shall be NEMA 1 for interior applications and NEMA 3R with cabinet heater and thermostat for exterior applications.

B. Doors: Shall have three-point latching mechanism where required.

C. Padlocking Provisions: Provide chain for attaching a padlock. Attach chain to the cabinet by welding or riveting.

D. Finish: Cabinets shall be given a phosphate treatment, painted with rust inhibiting primer, and finish painted with the manufacturer's standard enamel or lacquer finish.

2.5 FEATURES: TRANSFER SWITCHES SHALL INCLUDE THE FOLLOWING:

A. Operating Mechanism:

1. Activated by an electrical operator.
2. Electrically and mechanically interlocked so that the main contact cannot be closed simultaneously in both normal and emergency position.
3. Normal and emergency main contacts shall be mechanically locked in position by the operating linkage upon completion of transfer. Release of the locking mechanism shall be possible only by normal operating action.
4. Contact transfer time shall not exceed six cycles.
5. Do not use as a current carrying part. Components and mechanical interlocks shall be insulated or grounded.

B. Contacts:

1. On switch sizes 400 amperes and larger, protect main contacts by separate arcing contacts and magnetic blowouts for each pole. Arc quenching provisions equivalent to magnetic blowouts will be considered for approval.
2. Current carrying capacity of arcing contacts shall not be used in the determination of the transfer switch rating, and shall be separate from the main contacts.
3. Main and arcing contacts shall be visible for inspection with cabinet door open and barrier covers removed.

C. Manual Operator:

1. Capable of operation in either direction under no load.
2. Capable of operation by one person.
3. Provide a warning sign to caution against operation when energized.

D. Replaceable Parts:

1. Include the main and arcing contact individually or as units, relays, and control devices.
2. Switch contacts and accessories are to be replaceable from the front without removing the switch from the cabinet and without removing main conductors.

E. Sensing Relays:

1. Provide voltage sensing relays in each phase of the normal power supply.
2. Provide a voltage frequency sensing relay in one phase of the auxiliary power supply.

2.6 ACCESSORIES: TRANSFER SWITCHES SHALL INCLUDE THE FOLLOWING:

A. Indicating Lights:

1. Provide a signal light for normal source position.
2. Provide a signal light for emergency source position.
3. Lights shall be different colors.
4. Provide laminated phenolic plastic, white front and back with black core, nameplates to indicate transfer switch position.

B. Manual Test Switch: Shall simulate normal source failure.

C. Engine starting contacts.

D. Time Delay Relays:

1. Provide time-delay relays to accomplish the function as specified below and on drawings.

E. Auxiliary Contacts:

1. Provide contacts for connection to controls, one closed when transfer switch is connected to normal, and one closed when transfer switch is connected to emergency.
2. Provide additional contacts as necessary to accomplish the functions shown on the drawings, specified, and designated in other sections of these specifications.
3. Contacts shall have a minimum rating of ten amperes and be positive acting on pickup and dropout.

F. In phase monitor or center neutral position with time delay in neutral when switch controls motor larger than 10 HP.

G. Automatic Exerciser:

1. Clock exerciser for use with load.
2. Exerciser for use without load.

H. Automatic Transfer Switch Digital AC Meter package: Provide an AC Voltmeter, an Ammeter, a Frequency meter, and a Peak Demand Load Meter. Provide a phase selector switch to allow reading voltage and current line to line or three

phase. Meters shall read either normal or emergency source. Meter package shall be provided on each automatic transfer switch.

I. Heater: For exterior applications, provide electric heater with thermostat to maintain minimum temperature within enclosure at 40 degrees F. Heater shall be sized based on ASHRAE 99.5% minimum temperatures for the project location. Heater shall be 240V. rated and operated at 120V. Manufacturer shall derate heater as required based on 120V. operating voltage.

2.7 TRANSFER SWITCH OPERATION:

A. A voltage decrease in one or more phases of the normal power source to less than 70 percent of normal shall initiate the transfer sequence. The transfer switch shall start the engine-generator unit after a time-delay of two or three seconds to permit override of momentary dips in the normal power source. The time-delay shall be field adjustable from 0.5 to 6 seconds and factory set at 1 second.

B. The transfer switch shall transfer the load from normal to emergency source when the frequency and voltage of the engine-generator unit have attained 90 percent of rated value.

C. Unload running time delay for emergency generator cool down. The time delay shall be field adjustable from 0 to 5 minutes and factory set at 5 minutes.

D. Retransfer to Normal (All Loads): Transfer switch shall retransfer to normal source upon restoration of normal supply in all phases to 90 percent or more of normal voltage, and after a time-delay. Time-delays shall be field adjustable from five to twenty-five minutes (preset for twenty-five minutes). Should the emergency source fail during the timing, the transfer switch shall immediately transfer to normal when the source is available.

E. Transfer to Emergency (Emergency System Loads): Transfer switches for emergency system loads shall transfer their loads from normal to emergency source when frequency and voltage of the engine-generator unit have attained 90 percent of rated value. Only those switches with deficient normal source voltage shall transfer.

F. Transfer to Emergency (Equipment System Loads): Transfer switches for equipment system loads shall transfer their loads to the generator on a time-delayed staggered basis, after the emergency system switches have transferred. Total delayed transfer time of an equipment system switches shall not exceed two minutes. Time-delay relays shall be field adjustable from zero to two minutes.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Installation shall be in accordance with the NEC and as shown on the drawings.

3.2 SPARE PARTS: FURNISH THE FOLLOWING:

A. Six spare control fuses of each rating.

B. Six spare pilot lamps of each type used.

3.3 TESTING:

A. When the complete system has been installed, and prior to the final inspection, test all components of the system in the presence of the engineer for proper operation of the individual components and the complete system and to eliminate electrical and mechanical defects.

B. When any defects are detected, correct the defects and repeat the test as requested by the engineer, at no additional cost to the Owner.

3.4 INSTRUCTIONS AND FINAL INSPECTIONS:

A. At the final inspection in the presence of the engineer, demonstrate that the complete auxiliary electrical power system operates properly in every respect.

B. Furnish the services of a competent, factory-trained engineer or technician for one four hour period, for instructing personnel in adjustment, operation, and maintenance of the equipment, on a date requested by the engineer.

END OF SECTION 263600

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

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

1.2 SUMMARY:

A. This section includes the layout, furnishing and installation of a complete U. L. master labeled lightning protection system complying with UL 96, UL 96A, L.P.I. 176, and NFPA 780.

B. Provide and install all points, point bases, conductors, lugs, cable hold downs, thru-roof assemblies, ground rods, etc. as required for a complete and operational installation. The layout shall be done by a Certified Master Installer/Designer (MID) of the Lightning Protection Institute. Coordinate design and installation with the architectural, mechanical and structural drawings. Verify the types of roofing materials.

1.3 SUBMITTALS:

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

B. Shop Drawings: For air terminals and mounting accessories.

1. Submit complete design and layout drawings including isometric and plan views showing layout and connections to the required metal surfaces.
2. Show the methods of mounting the system to the adjacent construction and to the specific roofing materials on this project.

C. Qualifications: Submit proof that the installer of the lightning protection system is a U.L. Listed lightning protection installer, and is capable of installing the system as recommended by the manufacturer of the equipment.

D. Certification: Two weeks prior to final inspection, deliver to the engineer four copies of the certification that the installed lightning protection system has been inspected by a UL representative and has been approved by UL without variation.

1.4 QUALITY ASSURANCE:

A. Installer qualifications: Certified by UL as a Master Installer/Designer (MID), trained and approved for installation of components required for this Project.

B. System Certificate:

1. UL Master Label.
2. UL Master Label Recertification.
3. UL Letter of Finding.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

1.5 COORDINATION:

A. Coordinate installation of lightning protection system with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and installer. Do not void roof system warranty.

C. Flashings for through-roof assemblies shall comply with roofing manufacturer's specifications.

1.6 APPROVED SUPPLIER:

A. Preferred Lightning Protection
Attn: Rich Ferguson
27687 275th Street
Maryville, MO 64468
1-866-299-7406
1-660-562-2771 (local)
1-660-582-2603 (fax)

B. Robbins Lightning, Inc.
Attention: Patricia Robbins
124 East Second Street
Maryville, MO 64468
1-800-426-3792
1-660-582-3156 (local)
1-660-582-3039 (fax)

C. Thompson Lightning Protection, Inc.
Attention: Steve Easton
25705 State Highway V
Maryville, MO 64468
1-816-390-3921
1-660-582-2438
1-660-582-2438 (fax)

D. East Coast Lightning Equipment
Attn: Mark Morgan
24 Lamson Drive
Winsted, CT 06098
1-860-379-9072

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS:

A. Comply with UL 96 and NFPA 780.

B. Material shall comply with NFPA 780, Class I or Class II as required for height of structure.

C. Roof-Mounted Air Terminals:

1. Solid copper, not less than 3/8” diameter, with sharp points.
2. Air Terminals More Than 24 inches Long: Provide with brace attached to the terminal at not less than half the height of the terminal.
3. Shall be specifically designed for mounting to the type of roofing system(s) on the Project.

D. Main and Bonding Conductors: Electrical grade copper.

E. Ground Rods: Copperclad steel, not less than 3/4-inch diameter by 10 feet long.

F. Ground Loop Conductor: Tinned electrical grade copper.

G. The use of aluminum components shall be limited to where required to maintain compatibility with aluminum roofing systems, aluminum building systems, or aluminum roof mounted equipment.

H. Anchors and fasteners: Bolted type most suitable for the specific anchor and fastener installations.

2.2 SURGE PROTECTIVE DEVICES:

A. Electrical Service: Comply with NFPA 780 and Section SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS.

B. Communication and Antenna Systems: Comply with NFPA 780.

PART 3 - INSTALLATION:

3.1 GENERAL

A. Install lightning protection system components and systems according to UL 96A and NFPA 780.

B. Install the conductors in direct paths from air terminals to ground connections and as inconspicuously as practical and with the proper bends.

C. Install the vertical conductors within the concealed cavity of exterior walls. Run the conductors to the exterior at elevations below the finished grade and make the ground connections to the earth outside of the building.

D. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies.

E. Make connections of dissimilar metal with bimetallic type fittings to prevent electrolytic action.

F. Use the exothermic welding type connections which form solid metal joints in the main vertical and horizontal conductors, and for connections that are not exposed in the finish work.

G. For exposed cable downleads, protect copper conductors with stiff copper or brass tubing, which enclose the conductors from the top to the bottom of the tubing, between one foot below and six feet above the finished grade.

H. For the earth connections, install ground rods and ground plates, and the conductor connections to them and the main water pipes in the presence of the engineer. For the conductors located outside of the building or stack, install the conductors not less than two feet below the finished grade.

I. For structural steel buildings, connect the steel framework of the buildings to the main water pipe near the water system entrance to the building.

J. Connect exterior metal surfaces, located within three feet of the lightning protection system conductors, to the lightning protection system conductors to prevent flashovers.

K. Grounding: Test the ground resistance to earth by standard methods and conform to the ground resistance requirements specified in Section, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

L. Where shown, use the structural steel framework or reinforcing steel as the main conductor (minimum steel thickness is 3/16-inch):

1. Weld or bond the non-electrically-continuous sections together and make them electrically-continuous.
2. Verify the electrical continuity by measuring the ground resistance's to earth at the ground level, at the top of the building or stack, and at intermediate points with a sensitive ohmmeter. Compare the resistance readings.

3. Connect the air terminals together with an exterior conductor connected to the structural steel framework at not more than 100 foot intervals or tie each air terminal directly to roof steel and delete perimeter roof cable.
4. Install ground connections to earth at not more than 60 foot intervals around the perimeter of the building.
5. Weld or braze bonding plates, not less than eight inches square, to cleaned sections of the steel and connect the conductors to the plates or exothermic weld such as Cadweld, Thermoweld, etc..
6. Do not pierce the structural steel in any manner. Connections to the structural steel shall conform to the UL Publication No. 96A.

M. When the lightning protection systems have been installed, have the systems inspected and tested by a UL representative. Obtain and install a UL numbered master level "C" for each of the lightning protection systems at the location directed by the UL representative and the engineer.

3.2 FIELD QUALITY CONTROL:

A. Notify Architect a minimum of 48 hours in advance of inspection before concealing lightning protection components.

B. UL Inspection: Meet requirements to obtain a UL Master Label for system.

END OF SECTION 264113

SECTION 264313– SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

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

1.2 SUMMARY:

A. Section includes field-mounted and factory-mounted surge protective devices for low-voltage (120 to 600 V) power distribution and control equipment.

1.3 DEFINITIONS:

A. ATS: Acceptance Testing Specifications.

B. SPD: Surge Protective Device.

C. TVSS: Transient voltage surge suppressor(s), both singular and plural; also, transient voltage surge suppression.

D. VPR: Voltage Protection Rating.

1.4 SUBMITTALS:

A. Product Data: For each type of product indicated. Include rated capacities; installed dimensions and operating weights; electrical characteristics, furnished specialties, and accessories.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work. Include wiring diagrams for power, signal, and control wiring.

C. Operation and Maintenance Data: Include operation and maintenance data for all surge protective devices in the operation and maintenance manuals.

1.5 QUALITY ASSURANCE:

A. Source Limitations: Obtain surge protective devices, components, and accessories, within same product category, through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for the intended locations and application.

C. The unit shall be UL 1449 Listed (internally mounted units shall be UL recognized) as a Surge Protective Device and UL 1283 Listed as an Electromagnetic Interference Filter. Internally mounted units shall maintain the UL Listing of the equipment they are mounted in.

D. Comply with NFPA 70.

E. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.

1.6 COORDINATION:

A. Coordinate layout and installation of surge protective devices and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.7 PROJECT CONDITIONS:

A. Service Conditions: Rate surge protective devices for continuous operation under the following conditions unless otherwise indicated:

1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage for 480/277Y and not less than 125 percent of nominal system operating voltage for 208/120Y.
2. Operating Temperature: 30 to 150 deg F (0 to 65 deg C).
3. Humidity: 0 to 95 percent, non-condensing.
4. Altitude: Less than 12,000 feet above sea level.

1.8 EXTRA MATERIALS:

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Replaceable Protection Modules: 1 of each size and type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturers: Subject to compliance with requirements, provide product from one of the following list of manufacturers:

1. Current Technologies
2. Cutler Hammer
3. General Electric Company
4. Liebert Corp.
5. Siemens Infrastructure and Cities (Siemens IC)
6. Square D by Schneider Electric
7. Transtector
8. Leviton (For Retrofit and Add-On Devices Only)

9. Innovative Technology Inc. (For Retrofit and Add-On Devices Only)

2.2 GENERAL REQUIREMENTS:

A. UL 1449 Listed.

B. Internally mounted within the electrical equipment unless noted otherwise.

C. Modular design with field-replaceable modules, minimum of 1 module per phase.

D. MOV's shall be individually fused per mode, with a 200-kA minimum interrupting capacity and shall be classified by the NEC as an overcurrent protection device allowing tapped device conductors from a disconnect without an overcurrent device.

E. UL 1449 3rd Edition minimum nominal discharge current rating of 20kA per mode.

F. Bolted compression lugs for internal wiring.

G. Integral disconnecting means if direct bussed connected.

H. Redundant suppression circuits.

I. LED indicator lights for power and protection status.

J. On board diagnostic monitoring with audible alarm, and silencing switch, to indicate when protection has failed and when failure of even one MOV has occurred.

K. Surge-event operations counter.

L. EMI/RFI filtering of -50dB @ 100kHz.

M. One set of dry contacts rated at 5 A and 250 V ac, for remote monitoring of protection status. Coordinate with building power monitoring and control system.

N. Protection Modes and UL 1449 3rd Edition Maximum Voltage Protection Ratings shall be as follows:

Voltage	Line-to-Neutral	Line-to-Ground	Neutral-to-Ground	Line-to-Line
120/240Y, 1 Phase, 3 Wire	700V	800V	700V	1200V

2.3 SERVICE ENTRANCE SURGE PROTECTIVE DEVICES:

A. Devices shall be factory installed and built-in with direct bussed connections.

B. Include integral 60A disconnect switch.

C. Peak Single-Impulse Surge Current Rating: 160 kA per phase / 80 kA per mode.

2.4 PANELBOARD SURGE PROTECTIVE DEVICES:

A. Devices shall be factory installed with direct bussed connections where possible.

B. If the manufacturer requires a disconnect, an integral disconnect switch or molded case breaker (60 amp min.) shall be provided. Submit testing to demonstrate that overcurrent devices do not open upon peak single impulse surge current test.

C. Arrangement with bussed or wire connections to phase buses, neutral bus, and ground bus. Ground and neutral buses should be relocated to minimize connection lengths. If cables are used, they shall be the lowest impedance possible. Wires shall be kept as short and straight as possible. Do not exceed manufacturer's recommended lead lengths.

D. Modifications to the panelboard shall be UL labeled as a panelboard and as a SPD. For two and three section panelboards, the SPD module shall be installed in the first section where the line connections occur.

E. Peak Single-Impulse Surge Current Rating: 160 kA per phase / 80 kA per mode.

2.5 ADD-ON SURGE PROTECTIVE DEVICES:

A. Add-on SPD's shall be used to protect equipment that the SPD cannot be built-in (Example: Control Panels.).

B. Fed from disconnect switch or molded case breaker (60 amp min.).

1. Arrangement with wire connections to phase buses, neutral bus, and ground bus to utilize the absolute minimum cable length. Ground bus should be relocated to minimize cable lengths

2.6 CONTROL PANELS AND MISCELLANEOUS 120V. EQUIPMENT:

A. Peak Single-Impulse Surge Current Rating: 80 kA per phase / 40 kA per mode.

2.7 ENCLOSURES:

A. Internally mounted unless otherwise specified. Add-on devices shall comply with NEMA 250, matching the enclosure or panel being protected.

PART 3 - EXECUTION

3.1 INSTALLATION OF SURGE PROTECTIVE DEVICES:

A. Install devices at service entrance on load side of main disconnect, with ground lead bonded to service entrance ground.

B. SPD equipment and devices. Upon completion the Representative shall submit a letter certifying the complete installation is per this specification and per all manufacturer's requirements and recommendations.

C. Add-On Surge Protective Devices:

1. Do not exceed manufacturer’s recommended lead lengths.

3.2 CONNECTIONS:

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL:

A. Testing: Perform the following field quality-control testing:

1. After installing surge protective devices, but before electrical circuitry has been energized, test for compliance with manufacturer's published field testing requirements.
2. Complete startup checks according to manufacturer's written instructions.
3. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.19. Certify compliance with test parameters.

B. Manufacturer shall repair or replace malfunctioning units. Retest after repairs or replacements are made.

C. Verify that electrical wiring installation complies with this specification and manufacturer's installation requirements.

D. Do not perform insulation resistance (megger) tests of the distribution wiring equipment with the surge protective devices installed. Disconnect all wires, including neutral, before conducting insulation resistance tests, and reconnect immediately after the testing is over.

3.4 START-UP SERVICE::

A. The manufacturer shall train the Owner's maintenance personnel to adjust, operate, and maintain surge protective devices (minimum one (1) hr of field training).

1. Train Owner's maintenance personnel on procedures and schedules for maintaining suppressors.
2. Review data in maintenance manuals.
3. Contractor shall schedule training with Owner, through Architect, with at least seven days advance notice.

END OF SECTION 264313

SECTION 265600 - SITE LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This section includes the furnishing, installation, and connection of the exterior lighting.

PART 2 - PRODUCTS

2.1 MATERIAL AND EQUIPMENT, GENERALLY:

A. Material and equipment shall be in accordance with NEC, UL, ANSI, as shown on the drawings, and as specified.

2.2 FOUNDATIONS FOR POLES:

A. Foundations shall be cast-in-place concrete.

B. Concrete foundations shall be poured in forms. Forms shall be spirally wrapped treated paper for round foundations, and shall be constructed for square foundations. All concrete surfaces above grade shall be rub-finished with all edges rounded to approximately 1/4-inch radius.

1. Concrete shall have 3000 psi minimum 28 day compressive strength.
2. Anchor bolt assemblies and reinforcing of concrete foundations shall be as shown on the drawings. Anchor bolts shall be in a welded cage or properly positioned by the tie wire to stirrups.
3. Install copperclad steel ground rods, not less than 3/4-inch diameter by 10-feet long, at each foundation. For poles 30-feet and larger drive the rods vertically beside the foundations. Where rock or layered rock is present, drill a hole not less than two inches in diameter, backfill with tamped fine sand and drive the rod into the hole. Bond the rods to the poles with not less than No. 6 AWG bare copper wires. The method of bonding shall be approved for the purpose.
4. Contractor shall remove all rock encountered to the full indicated depth of the pier without any additional cost to the Owner. Verify conditions with soil borings.

2.3 POLES:

A. General:

1. Poles 60-feet and below shall be as shown on the drawings, and as herein specified.

2. The pole and arm assembly shall be capable of supporting itself and the specified luminaire under wind forces of 110 mph with an additional 30 percent gust factor.
3. High mast poles shall be galvanized designed for 90 MPH winds with a 1.3 gust factor.
4. Poles shall be supplied by associated luminaire manufacturer.
5. Poles 30 feet and taller shall be provided with factory installed vibration dampener.

B. Types:

1. Square and Round Tapered Type Pole: Shall be of 6005-T5 wrought aluminum alloy (ANSI 135.1) or steel, not less than 0.125 inch wall thickness. Square poles shall be square in section, seamless, with outside dimensions of 4, 5, and 6 inches for maximum mounting heights of 15, 20 and 30 feet respectively. Finish shall be duranodic (or approved equal), or type as shown on the drawings. The pole shall include an appropriately sized hand hole and matching flush mounted cover, held in place by a captive flat head screw.
2. Provide a pole cap with finish to match the shaft, forming a neat water repellent closure.
3. Provide all poles with hand holes and a steel grounding stud opposite hand hole openings.

C. Base Assembly: Provide a base cover to conceal the mounting hardware and all pole-base welds. Square pole bases shall have a sleeve within the pole capable of supporting the pole before welding.

D. Bracket Arm(s): Shall be of 6063-T6 seamless tubing (ANSI H-35.1), of minimum 0.125 inch wall thickness, bolted to the pole by means of a steel plate welded to the arm.

E. Hardware: All necessary hardware shall be 300 series stainless steel.

2.4 LUMINARIES:

A. Shall be weatherproof, heavy duty, outdoor types designed for efficient light utilization, adequate dissipation of lamp and ballast heat and safe cleaning and relamping.

B. Illuminating Engineering Society light distribution pattern types shall be as shown on the drawings.

C. Incorporate ballasts in the luminaire housing except where otherwise shown on the drawings.

D. Luminaries shall be sealed.

E. Lenses shall be heat-resistant, borosilicate glass, prismatic refractors, or as specified on the drawings. Retain each refractor in a frame. Restrain the frame to the luminaire housing by hinges or chain.

F. Lamp sockets for high intensity discharge (H.I.D.) fixture shall have locking type porcelain enclosures in conformance to the applicable requirements of ANSI C-81.

G. Pre-wire internal components to terminal strips at the factory.

H. Bracket mounted luminaries shall have leveling provisions and clamp type adjustable slip-fitters with locking screws.

I. Materials shall be rustproof. Latches and fittings shall be non-ferrous metal.

2.5 DISCONNECTING DEVICES:

A. Shall be watertight, submersible types suitable for the cables being installed and for use in outdoor lighting systems.

2.6 LAMPS:

A. Install the proper lamps in every luminaire installed and every luminaire relocated or reinstalled.

B. Lamps to be general-service, outdoor lighting types. High pressure sodium fixtures connected to standby power shall be twin tube standby type.

2.7 CIRCUITS: FOR CIRCUITS, SEE OTHER SECTIONS OF THESE SPECIFICATIONS.

2.8 LIGHTING CONTROL EQUIPMENT: SEE SECTION 265100.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Installation shall be in accordance with the NEC, and as shown on the drawings.

B. Poles with Concrete Foundations:

1. After the poles have been installed, and plumbed, grout the spaces between the pole bases and the concrete base with non-shrink concrete grout material. Provide a plastic or copper tube, of not less than 3/8-inch inside diameter, through the grout tight to the top of the concrete base for weeping.

END OF SECTION 265600

SECTION 270501 - COMMON WORK RESULTS FOR LOW VOLTAGE SYSTEMS CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

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

B. Installation of raceways, conduit sleeves etc. as required for routing of low voltage systems cabling shall be per specifications Section “RACEWAY SYSTEMS”.

1.2 SUMMARY:

A. The extent of the low voltage systems cabling work is indicated by drawings, details and other specification sections. Low voltage systems cabling installation is hereby defined to include, but not be limited to the installation of cabling for voice, data, video, CATV, CCTV, security, nurse call, code blue, fire alarm, access control, public address (P.A.), lighting, and temperature control systems.

B. All cabling materials, cabling, jacks, patch panels, racks, etc. are specified in other sections and shall be provided by the Contractor. The Contractor shall be responsible for all testing as specified in individual specifications sections.

C. It is the intent of the Drawings and Specifications to provide a complete workable telecommunication cabling system ready for the Owner’s use. Any item not specifically shown on the Drawings or called for in the Specification, but normally required for a complete system, are to be considered a part of the contract.

1.3 SUBMITTALS:

A. Product Data: Provide submittals for each type of product specified with this section, including but not limited to cable supports, cable wraps, fire rated sleeves, etc.

B. Statement of Warranty

C. Manuals and Technical “Documents

D. Record Drawings

1.4 COORDINATION:

A. The Contractor will cooperate and coordinate with the Owner to minimize conflict with Owner's operations.

B. Coordinate with other building trades and electrical work including wires and cables, electrical boxes and fittings, and raceways to properly interface installation of systems with other work.

C. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

D. Sequence installation of low voltage systems cabling with other work to minimize possibility of damage and soiling during remainder of construction.

E. Contractor will be responsible for ceiling tile replacement, wall repainting, etc. due to damage caused by installation of this equipment and cabling.

1.5 PERFORMANCE AND QUALITY ASSURANCE:

A. National Fire Protection Association:

1. NFPA 70: National Electrical Code.

B. Underwriters Laboratories, Inc. (UL):

1. UL 486A-91: Wire connectors and soldering lugs for use with copper conductors.
2. UL 1449-85: Transient voltage surge suppressors.
3. UL 1863: Communications - Circuit Accessories
4. UL 813: Commercial Audio Equipment

C. Telecommunications Industry Association (TIA):

1. ANSI/TIA-568-C.0-1-2010 and addenda "Generic Telecommunications Cabling for Customer Premises".
2. ANSI/TIA-568-C.1-2-2011 and addenda "Commercial Building Telecommunications Cabling Standard".
3. ANSI/TIA-568-C.2 and addenda "Balanced Twisted-Pair Telecommunications Cabling & Component Standard".
4. TIA-160: Sound Systems.
5. TIA-299A: Loudspeakers, Dynamic Magnetic Structures and Impedance.
6. CEA-310-E "Design Requirements for Cabinets, Panels, Racks, and sub-Racks".
7. SE-101-A: Amplifier for Sound Equipment.
8. SE-103: Speakers for Sound Equipment.

D. Federal Communications Commission (FCC):

1. FCC Regulations, Part 15 Title 47.

E. Maintenance Qualifications:

1. Experienced in manufacturing equipment of the types and capacities specified for this project.
2. Equipment has a record of successful in-service performance.

F. Contractor Qualifications:

1. Established communications and electronics contractor for at least five (5) years.
2. Authorized distributor for the equipment supplied with full manufacturer's warranty privileges.
3. Maintains a fully equipped service organization capable of providing full maintenance and service of the installed system within twenty four (24) hours.
4. Maintains the necessary spare parts in the proper proportion as recommended by the manufacturer to maintain and service the equipment being installed.

G. Manufacturer's Instructions: Comply with all installation instructions and methods recommended or required by the manufacturer.

1.6 EQUIPMENT AND MATERIALS:

A. Contractor shall install low voltage systems cabling per the system manufacturer recommendations or requirements or as otherwise specified on the drawings or elsewhere in the specifications.

1. The Manufacturers and Products specified in this document are to be used. No substitutions of components specifically referenced will be allowed without approval prior to bid.
2. All products and materials shall be new, clean, free of defects and free of damage and corrosion.
3. All products installed will meet or exceed the minimum performance requirement as listed in the technical specification of this document and its corresponding addendums.

1.7 WORKMANSHIP:

A. All work shall be done in a workman like fashion. All equipment and materials are to be installed in a neat and secure manner, while cables are to be properly dressed. Workers must clean any debris and trash at the close of each workday.

B. No substitution of product or services will be accepted without prior approval from both the Owner and the Manufacturer providing the Application warranty.

1.8 DELIVERY, STORAGE, AND HANDLING:

A. Delivery: Deliver low voltage system equipment and components in factory-fabricated containers or wrappings, which properly protect equipment from damage.

B. Storage: Store low voltage system equipment and components in original packaging. Store inside in a well-ventilated space protected from weather, moisture, soiling, humidity, extreme temperatures and vandalism. Protection against vandalism will be at the Contractor's expense. Storage recommendations by manufacturer shall be followed.

C. Handling: Handle low voltage system equipment and components carefully to prevent damage, breaking, and scoring of finishes. Do not install damaged units or components; replace with new.

1.9 AS-BUILT DRAWINGS:

A. Show on black line prints in red ink all low voltage cable system jack identification numbers, actual cable routing paths, as well as all changes from original plans made during the installation. Separate As-Built drawings shall be provided for each low voltage system installed. Return the "as-built" red lined drawings, specifications and addenda, as set forth in the General conditions, to the Architect/Engineer upon completion of the project.

PART 2 - PRODUCTS

2.1 RACEWAYS

A. All low voltage cabling shall be installed in raceway systems when located in concealed, non accessible locations. In general, raceways are required for outlets in walls up to above accessible ceilings, above non accessible ceilings, all wall penetrations etc. Provide bushings at all raceway terminations. Fire stop and fire seal all penetrations of fire rated walls.

B. Surface Raceway:

1. Surface raceway shall only be used with prior approval in remodels and modifications to existing spaces where wall and ceiling voids do not permit concealed installation. Surface raceway shall not be used at any other location unless called for on the drawings. All surface raceway and outlets must be painted to match the surface it is attached to. Use outlets and fittings by the same Manufacturer and approved for use with the raceway.

2. Surface raceways shall be Wiremold #500 or #700 series, or approved equal. In all cases, do not exceed the fill per the Manufacturers published data.

2.2 CABLE SUPPORTS:

A. Appropriate cable supports shall be used at all times to prevent unnecessary tension or slag in the cable bundles. Support spacing and size shall be as required to comply with applicable ANSI Standards and manufacturers recommendations.

B. Cable Tray: Wire mesh basket cable tray shall be provided as shown on the drawings. Cable tray shall be sized to support all cable with a maximum fill of 40%. Wire mesh spacing shall not exceed 2 inches (5 cm) by 4 inches (10 cm). Refer to section “COMMUNICATIONS CABLE TRAY”.

C. J-Hooks: J-Hooks shall be sized to support all cable with a maximum fill of 40%.

D. Cable Wraps: All cable wraps shall be plenum rated re-enterable hook and loop type, sized as required.

2.3 CONDUIT SLEEVES:

A. Conduit sleeves shall be one of the following:

1. Rigid steel or IMC conduit with threaded ends and non-metallic bushings on each end.
2. EMT conduit with U.L. Listed slide on non-metallic bushings on each end.

B. Fire rated conduit sleeves shall be:

1. Provided at fire rated walls or penetrations and as indicated on the drawings.
2. ‘Hilti’ #CP 653, or approved equal.

2.4 CABLE LABELS:

A. Shall meet the legibility, defacement, exposure, and adhesion requirements of UL 969. Cable labels shall be preprinted or computer printed type. Handwritten labels are not acceptable. Labels shall be flexible vinyl, laminating type resistant to moderate amounts of oil, dirt, and temperature ranges from -40°F to 158°F. Label color shall contrast with cable jacket color to make labels easily distinguishable. (Brady material B-427 or equal thermal transfer printable vinyl tape.)

B. Labeling of cable shall consist of lettering or numbering as required by Owner to coordinate with existing labeling schemes. Contractor to coordinate exact labeling scheme of cables with Owner.

2.5 GROUNDING AND BONDING: REFER TO "GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS".

PART 3 - EXECUTION

3.1 REQUIREMENTS FOR LOW VOLTAGE SYSTEMS CABLE INSTALLATION:

A. General: Examine areas and conditions under which low voltage cabling systems are to be installed. Notify the Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in an acceptable manner.

B. Cable Pathways:

1. Pathways shall be designed and installed to meet applicable local and national building and electrical codes or regulations.
2. All pathway components shall be installed according to manufacturer's specifications.
3. Grounding/Earthing and bonding of pathways shall comply with applicable codes and regulations.
4. Pathways shall not have exposed sharp edges that may come into contact with low voltage systems cables.
5. The number of cables placed in a pathway shall not exceed manufacturer specifications, nor, shall the geometric shape of a cable be affected.
6. Pathways shall not be located in elevator shafts.
7. Vertically routed cables through chases must be supported per manufacturers and applicable ANSI Standards to prevent cable tension from occurring.
8. All cables above accessible ceilings shall be supported by cable trays and/or j-hooks located approximately 6" above lay-in ceilings below all mechanical and other electrical equipment.
9. Cable Tray: All cabling should be installed in low voltage cable trays where possible. Power cable must never reside in the same cable tray as the low voltage system cabling. All cabling installation procedures shall also adhere to the recommended "Do's and Don'ts" in TIA 568.
10. J-Hooks: J-Hooks shall be used in common areas where cable trays are not available and/or as indicated on the plans. J-Hooks shall be located with a maximum spacing of 4'-0" on center. Cables shall not contact the ceilings, piping, light fixtures, ducts, etc. All cables must be suspended independently from other supports.
11. Cable Wraps: Cable wraps shall be used at appropriate intervals to secure cable between j-hooks or cable trays,and to provide strain relief at termination points. These wraps shall not be over tightened to the point of deforming or crimping the cable sheath. Cable wraps should rotate 360 degrees when applied correctly. Spacing shall be a maximum of 4'-0".

Placement shall not be over cable labels. Cable wraps (zip-tie type or Velcro type) shall not be used as a means of support.

12. Conduit Sleeves: Conduit sleeves shall be provided where cables are indicated to pass through walls and at other locations as indicated on the plans. Sleeves shall be 2-inch conduit minimum extending 6-inches on either side of walls. Where possible, sleeves shall be located 6-inches above ceiling. See paragraph "FIRESTOPPING" for sleeves located in fire rated partitions or floors.

C. Bend Radius:

1. The maximum cable bend radii shall not exceed manufacturer's specifications.

D. Wiring Methods

1. Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

a. Install plenum rated cable in environmental air spaces, including plenum ceilings.

2. Bundle, lace and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.2 FIRESTOPPING:

A. Properly installed fire stop systems shall be installed to prevent or retard the spread of fire, smoke, water, and gases through all floors, and fire/smoke walls. Fire stops shall be UL listed for the wall rating and construction method. This requirement applies to openings designed for low voltage systems cabling use that may or may not be penetrated by cables, wires, or raceways.

1. Raceways: Completely fill and seal clearances between raceways and openings with fire stop material.
2. Fire Rated Sleeves: Completely fill and seal clearances between sleeves and openings with fire stop material. Fire rated conduit sleeves shall comply with paragraph "CONDUIT SLEEVES".

B. Fire stops shall be installed according to applicable codes.

C. Documentation of fire stops shall be in accordance with the latest edition of TIA-606.

3.3 ADJUSTING AND CLEANING:

A. Cleaning: Clean all equipment and components of dirt and construction debris upon completion of installation. Remove scrap cable components off site as required.

B. Touch-up: Touch-up scratched or marred enclosure surfaces to match original finishes.

C. Protection: Protect installed equipment, cabling and components from damage during remainder of construction period.

3.4 REMOVAL OF EXISTING CABLE:

A. Existing low voltage systems cable that is not terminated at both ends at a connector or other equipment shall be removed unless identified for future use with a tag.

3.5 LABELING:

A. Labeling of cable shall consist of lettering or numbering as required by Owner to coordinate with existing labeling schemes. Contractor to coordinate exact labeling scheme of cables with Owner.

B. Documentation of labeling shall be in accordance with the latest edition of TIA-606.

END OF SECTION 270501

SECTION 270502 - COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

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

B. Refer to section “COMMON WORK RESULTS FOR LOW VOLTAGE CABLING SYSTEMS” for additional information.

1.2 SUMMARY:

A. The extent of the communications system work is indicated by drawings and details, and is hereby defined to include, but not be limited to the installation of voice, data, fiber, video, CATV, and CCTV.

B. All cabling materials, cabling, jacks, patch panels, racks, etc. are specified in other sections and shall be provided by the Contractor. The Contractor shall be responsible for all testing as specified in individual specifications sections.

C. It is the intent of the Drawings and Specifications to provide a complete workable telecommunication cabling system ready for the Owner’s use. Any item not specifically shown on the Drawings or called for in the Specification, but normally required for a complete system, are to be considered a part of the contract.

1.3 SUBMITTALS:

A. Installers qualifications (including references).

B. Statement of Warranty

C. Manuals and Technical Documents

D. Record Drawings

1.4 QUALITY ASSURANCE:

A. Codes and Standards: Refer to section “COMMON WORK RESULTS FOR LOW VOLTAGE SYSTEMS” in addition to the following:

1. Rural Utilities Service (RUS): Comply with Rural Utilities Service specifications pertaining to construction and installation of telephone cabling.

B. System Manufacturers Application Warranty: The system manufacturer shall provide a total application assurance warranty per Part 3 of this section. Contractors shall be certified by the manufacturer to be an approved system installer. The manufacturer and the certified installer shall take full responsibility for a quality installation complying with all applicable standards.

C. Contractor Qualifications and Training:

1. The Contractor shall be fully conversant and capable in the cabling of low voltage applications such as, but not limited to data, voice and imaging network systems. The Contractor shall at a minimum possess the following qualifications:

    a. Licenses/permits required performing telecommunications installations in the specified jurisdiction.
    b. Personnel trained and certified by the proposed Cabling System Manufacturer.
    c. All installation Personnel on site must be under the supervision of an individual trained and certified to install the approved manufacturers cabling System.
    d. The Designer and Installers shall show proof of current certification of the proposed Cabling System Manufacturer via a current card given after attending a minimum 5- day course or a re-certification class. This card must be current and be in the possession at all times they are on the project.
    e. Provide (3) previous references of the type of installation provided in this specification.
    f. Personnel trained and certified in fiber optic cabling, splicing, termination and testing techniques. Personnel must have experience using a light meter and OTDR.
    g. Personnel trained in the installation of pathways and support for housing horizontal and backbone cabling.
    h. Personnel knowledgeable in local, state, province and national codes, and regulations. All work shall comply with the latest revision of the codes or regulations. When conflict exists between local or national codes or regulations, the most stringent codes or regulations shall be followed.
    i. Have at least (5) years successful installation experience with projects utilizing telephone, data, video and other low voltage systems and wiring similar to that required for this project to ensure system is compliant with standards.
    j. Must be a Building Industry Consulting Service International (BICSI) member and have an RCDD or BICSI certified ITS Technician on staff.
    k. Must possess current liability insurance certificates.

1.5 EQUIPMENT AND MATERIALS:

A. Refer to section “COMMON WORK RESULTS FOR LOW VOLTAGE SYSTEMS”.

B. All products installed will meet or exceed the minimum performance requirement as listed in the technical specification of this document and its corresponding addendums.

1.6 WORKMANSHIP AND SUBSTITUTIONS:

A. Refer to section “Common Work Results for Low Voltage Systems”.

B. All work shall be done in a workman like fashion of the highest standards in the telecommunications industry. All equipment and materials are to be installed in a neat and secure manner, while cables are to be properly dressed.

C. No substitution of product or services will be accepted without prior approval from both the Owner and the Manufacturer providing the Application warranty.

1.7 AS-BUILT DRAWINGS:

A. See Section “COMMON WORK RESULTS FOR LOW VOLTAGE SYSTEMS”.

1.8 SUPPORT AND WARRANTY:

A. Applications Supported:

1. Existing and future applications supported for a channel model warranty include those approved by the Institute of Electronic and Electrical Engineers (IEEE), the Asynchronous Transfer Mode (ATM) Forum, the American National Standards Institute (ANSI) or the International Organization of Standards (ISO) that specify compatibility with the cable referenced herein. Additional applications that are covered by this warranty include all future applications developed for the specified structured cabling system.

B. Basic Warranty:

1. Either a basic link or channel model configuration may be applied to the horizontal and/or backbone sub-systems of the structured cabling system. Applications assurance is only applied to a channel model configuration.

C. Applications Assurance Warranty:

1. A twenty (20) year warranty shall be provided for an end-to-end channel model installation which covers applications assurance, cable, connecting hardware and the labor cost for the repair or replacement.

D. Product Warranty:

1. The manufacturer of passive telecommunications equipment used in a manner not associated with the Systems Warranty must have a minimum five (5) year Component Warranty on its entire product. The Products Warranty covers the components against defects in material or workmanship under normal and proper use.

PART 2 - PRODUCTS

2.1 RACEWAYS

A. Refer to section “COMMON WORK RESULTS FOR LOW VOLTAGE SYSTEMS” Execution and section “RACEWAY SYSTEMS”.

2.2 REQUIREMENTS FOR COMMUNICATIONS INSTALLATION:

A. General: Examine areas and conditions under which systems are to be installed. Notify the Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in an acceptable manner.

B. Horizontal Cable Routing:

1. All horizontal cables, regardless of media type, shall not exceed 295 ft (90 m) in total length from the telecommunications outlets in the work area to the horizontal cross connect. This does not include the allowable distances for equipment cords and patch cords as listed below.
2. The length of patch cords in the telecommunications room/closet shall not exceed 16 ft (4.9 m) and equipment cords in the work area shall not exceed 16 ft (4.9 m) unless used in conjunction with a multi-user telecommunications outlet assembly (MUTOA).
3. Horizontal pathways shall be installed or selected such that the minimum bend radius of horizontal cables is kept within manufacturer specifications both during and after installation.

    a. Minimum conduit bend radius shall not be less than 6 times the diameter for 2” conduit and smaller.
    b. Minimum conduit bend radius shall not be less than 10 times the diameter for conduits larger than 2”.

4. Cables shall be supported by means that are structurally independent of the suspended ceiling, its framework, or supports. These supports shall be spaced no more than 4 ft apart.
5. The installation of telecommunications cabling installed in grounded metallic conduit shall maintain a 12 inch minimum distance from all sources of Electrical Magnetic Interference (EMI), such as; fans, motors, fluorescent fixtures, transformers, etc. Cabling installed in cable tray or j-hooks shall maintain a 24 inch minimum distance from all sources of EMI. All cables shall maintain a 48 inch minimum distance from transformers. Engineer shall be notified in advance if these clearances cannot be met.
6. The installation of telecommunications cabling shall maintain a minimum clearance of 10 ft from power cables in excess of 480 Vrms. No telecommunications cross-connects shall be physically located within 20 ft (6 m) of electrical distribution panels, step down devices, or transformers, which carry voltages in excess of 480 Vrms. Engineer shall be notified in advance if these clearances cannot be met.
7. Cables shall be run using a star topology from the telecommunications room serving that floor to every individual telecommunications outlet.
8. The Contractor shall observe the bending radius and pulling strength requirements of the 4-pair UTP and fiber optic cable during handling and installation.

    a. Pulling force on 4-pair UTP cable shall not exceed 25lb/f.
    b. Pulling force on 2 or 4-strand optical fiber shall not exceed 50lb/f.

9. Each run of UTP cable shall not contain splices between the horizontal portion of the cross-connect in the telecommunication room and the telecommunications outlet.
10. In the telecommunications room where cable trays or cable racking are used, the contractor shall provide appropriate means of cable management such as hook and loop cable managers to create a neat appearance and practical installation.
11. Continuous conduit runs installed by the contractor should not exceed 100 ft (30.5 m) or contain more than two (2) 90 degree bends without utilizing appropriately sized pull boxes.
12. All horizontal pathways shall be installed and grounded to meet applicable local and national building and electrical codes.
13. The number of horizontal cables placed in a cable support or pathway shall not exceed manufacturer's recommendations and shall not cause a change in the geometric shape of the cables.
14. Maximum conduit pathway capacity shall not exceed a 40% fill. Perimeter and furniture fill shall be limited to 60% fill for moves, adds and changes.
15. Horizontal distribution cables shall not be exposed in the work area or other locations with public access.
16. Cables routed in a suspended ceiling shall not be draped across the ceiling tiles. Cable supports shall be mounted as close as possible to 6 in (15 cm) above the ceiling grid supporting the tiles.

C. Work Area Termination:

1. All UTP cables wired to the telecommunications outlet/connector shall have 4-pairs terminated in eight-position eight conductor (8P8C) modular outlets in the work area. All pairs shall be terminated.
2. The telecommunications outlet/connector shall be securely mounted.
3. The height of the telecommunications faceplates shall be to applicable codes and regulations, and/or the same height of nearby electrical faceplates.
4. Provide specialized outlets for the specific systems furniture manufacturer. Outlets must be fully compatible. Verify systems furniture manufacturer with Architect or Owner.

D. Tightening: Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors.

E. Bend Radius:

1. The maximum cable bend radii shall not exceed manufacturer’s specifications.
2. In spaces with UTP cable terminations, the maximum bend radius for 4-pair cables shall not exceed four times the outside diameter of the cable. The maximum bend radius for mult-pair cables shall not exceed ten times the outside diameter of the cable. Manufacturer specifications shall be followed if more stringent.
3. During the actual installation, bend radius on 4-pair cables shall not exceed eight times the outside diameter of the cable and multi-pair cables shall not exceed ten times the outside diameter of the cable. Manufacturer specifications shall be followed if more stringent.
4. The bend radius of 2 or 4-strand optical fiber cable shall be 1” (2.5 cm) minimum under no load and 2” (5 cm) minimum under load. Manufacturer specifications shall be followed if more stringent.

F. Slack:

1. In the work area, a minimum of 12 in (30 cm) shall be left for UTP cables. A minimum of 3 ft (1 m) shall be left for fiber cables.
2. In telecommunications room/closets a minimum of 10 ft (3 m) of slack shall be left for all fiber cables and a minimum of 3 ft (1 m) of slack shall be left for all UTP cables. This slack must be neatly managed on trays or other support types.

2.3 GROUNDING:

A. See Section “Grounding and Bonding for Communications Systems”.

PART 3 - EXECUTION

3.1 TESTING PROCEDURES:

A. Testing of each system shall be performed in accordance with the manufacturer's specifications and as outlined in the other individual low sections of this specification.

B. All installed channels shall perform equal to or better than the minimum standards.

3.2 LABELING

A. Labeling of data outlets shall consist of non-permanent lettering indicating a "data" port and extension located above the port. Numbering shall be as required by owner to coordinate with existing labeling schemes. Contractor shall coordinate exact labeling of outlets with Owner. The label shall consist of 2 lines. Line 1 shall be 6 characters (Example "A2A05K") as follows; 1st character – Zone, 2nd character - Floor; 3rd -5th characters - area location, 6th character - multiple jack designation at that location. Line 2 shall be 11 characters (Example "WC2NE-01447") as follows; 1st & 2nd characters-room/closet type (WC stands for wiring closet); 3rd character – floor, 4th & 5th characters - closet location, 7th & 8th characters - rack #; 9th character - panel designation, 10th & 11th character - Port #.

B. Cables:

1. Horizontal and backbone cables shall be labeled at each end. The cable or its label shall be marked with its identifier
2. All cables shall be appropriately labeled in all junction boxes.
3. No cabling identifier will duplicate any previous, active cable identifier.

C. Faceplates:

1. A unique identifier shall be marked on each faceplate to identify it as connecting hardware.
2. Each port in the faceplate shall be labeled with its identifier.

D. Racks, Panels, Blocks:

1. A unique identifier shall be marked on each piece of connecting hardware to identify it as connecting hardware.
2. Each port on the connecting hardware shall be labeled with its identifier.

a. Telecommunications outlets/connectors.
b. Backbone cable routing and terminations.
c. Horizontal cable routing and terminations.

E. Documentation of labeling shall be in accordance with the latest edition of TIA-606.

3.3 RECORDS:

A. All records shall be created by the installation contractor and turned over at the completion of work. The format shall be computer based. Both soft copies and hard copies shall be included as part of the As-Built package. The minimum requirements include:

1. Cable records must contain the identifier, cable type, and termination positions at both ends, splice information as well as any damaged pairs/conductors.
2. Connecting hardware and connecting hardware position records must contain the identifier, type, damaged position numbers, and references to the cable identifier attached to it.
3. Test documentation on all cable types shall be included as part of the As-built package.

3.4 DOCUMENTATION/AS-BUILTS/RECORDS:

A. All cables shall be labeled in accordance with the Owner's labeling standards.

B. All cables shall be labeled at minimum with-in 12-inches of each end of the cable jacket, ((to include each end in the telecom space, at the work area, and at the consolidaiota point (CP) if present) per the latest edition of the ANSI/TIA-606 Standard. Prior to bidding, Contractor shall verify with Designer of Record whether a higher class of labeling is required for the project, per the latest edition of the ANSI/TIA-606 Standard.

C. No cabling identifiers shall duplicate any previous active cable identifier.

D. All documentation, such as, As-Builts and records shall be kept on file by the Certified Installer for the entire term of the warranty.

E. As-built drawing shall be supplied by the contractor showing the locations of and identifiers for all components.

END OF SECTION 270502

SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Grounding conductors.
2. Grounding connectors.
3. Grounding busbars.
4. Grounding rods.
5. Grounding labeling.

1.3 DEFINITIONS

A. BCT: Bonding conductor for telecommunications.

B. EMT: Electrical metallic tubing.

C. TGB: Telecommunications grounding busbar.

D. TMGB: Telecommunications main grounding busbar.

1.4 SUBMITTALS

A. Product Data: For each type of product.

B. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE: REFER TO SECTION “COMMON WORK RESULTS FOR COMMUNICATIONS”.

PART 2 - PRODUCTS

2.1 SYSTEM COMPONENTS

A. Comply with latest edition of J-STD-607.

2.2 CONDUCTORS

A. Comply with UL 486A-486B.

B. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.

1. Ground wire for custom-length equipment ground jumpers shall be AWG copper, 19-strand, UL-listed, Type THHN wire.
2. Cable Tray Equipment Grounding Wire: #6 AWG copper.

C. Cable Tray Grounding Jumper:

1. Not smaller than AWG copper and not longer than 12 inches (300 mm). If jumper is a wire, it shall have a crimped grounding lug with two holes and long barrel for two crimps. If jumper is a flexible braid, it shall have a one-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.

D. Bare Copper Conductors:

1. Stranded Conductors: ASTM B 8.
2. Tinned Conductors: ASTM B 33.
3. Bonding Cable: 28 kcmils, 14 strands of No. 17 AWG copper conductor, and 1/4 inch in diameter.
4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
5. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.3 CONNECTORS

A. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.

B. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.

1. Electroplated tinned copper, C and H shaped.

C. Signal Reference Grid Connectors: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.

D. Busbar Connectors: Cast silicon bronze, solderless compression-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch centers for a two-bolt connection to the busbar.

E. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING BUSBARS

A. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as indicated on Drawings. Minimum length shall be 12 inches. The busbar shall be NRTL listed for use as TMGB and shall comply with J-STD-607-A.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide a 4-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

B. TGB: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 inches in cross section, length as indicated on Drawings. The busbar shall be NRTL listed as complying with UL 467, and shall comply with J-STD-607.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.)
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

C. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with J-STD-607-A. Predrilling shall be with holes for use with lugs specified in this Section.

1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
3. Rack-Mounted Vertical Busbar: 72 or 36 inches long with stainless-steel or copper-plated hardware for attachment to the rack.

2.5 GROUND RODS:

A. Cooper clad, section type: 3/4 inch by 20 feet.

2.6 LABELING: REFER TO SECTION “COMMON WORK RESULTS FOR LOW VOLTAGE CABLING SYSTEMS”.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.

B. Inspect the test results of the ac grounding system measured at the point of BCT connection.

C. Notify the Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory condtions have been corrected in an acceptable manner.

3.2 INSTALLATION

A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.

B. Comply with NECA 1.

C. Comply with J-STD-607.

3.3 GROUNDING CONDUCTORS:

A. All grounding/earthing and bonding shall be done to applicable codes and regulations. All telecommunications spaces, including rooms and cabinets shall have a minimum 12” x 2” x 1/4” copper ground bus tied together to the main telecommunications room ground bus with a ground conductor (TBB - Telecommunications Boding Backbone) size per ANSI-J-STD-607-B-2011.

B. The main ground bus shall be a minimum 12” x 4” x 1/4” copper ground bus and must be tied back to the grounding electrode system at the main service panel with a ground conductor (BCT - Bonding Conductor for Telecommunications) sized per ANSI-J-STD-607-B-2011.

TBB/GE Length (FT)	TBB/GE Size (AWG)
Less than 13	6
14-20	4
21-26	3
27-33	2
34-41	1
42-52	1/0
53-66	2/0
67-84	3/0
85-105	4/0

TBB/GE Length (FT)	TBB/GE Size (AWG)
106-125	250 kcmil
126-150	300 kcmil
151-175	350 kcmil
176-250	500 kcmil
351-300	600 kcmil
301>	750 kcmil

The minimum TBB conductor size shall be a No. 6 (AWG). The TBB should be sized at 2 kcmil per linear foot of conductor to be sized up to a maximum size of 750 kcmil.
The BCT shall be, as a minimum, the same size as the largest TBB.
The GE (Grounding Equalizer) shall be, as a minimum, the same size as the largest TBB.
The BCT, each TBB, and each GE shall be green or marked with a distinctive green color.
Splices to the TBB shall only occur in telecommunications spaces and shall be installed such that they may be visually inspected.

C. All metallic items and equipment, including building steel, wiring blocks, patch panels metal troughs, protectors, racks, cabinets, receptacles, cable tray, shields, etc, within each telecommunications space must be bonded to the local ground bus with a #6 cu. ground conductor.

3.4 APPLICATION

A. Bonding: Conductors shall not be smaller than #6 AWG copper..

B. Underground Grounding Conductors: Install bare copper conductor, #3/0AWG minimum.

C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

D. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than 36 inches.

E. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
2. Install without splices.

3.5 GROUNDING ELECTRODE SYSTEM

A. The BCT between the TMBG and the ac service equipment ground shall not be smaller than #3/0 AWG copper. Refer to construction drawings.

3.6 CONNECTIONS: REFER TO SECTION “COMMON WORK RESULTS FOR COMMUNICATIONS”.

A. Stacking of conductors under a single bolt is not permitted when connecting to busbars.

B. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:

1. Use crimping tool and the die specific to the connector.
2. Pretwist the conductor.
3. Apply an antioxidant compound to all bolted and compression connections.

C. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each TGB and TMGB to the vertical steel of the building frame.

D. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each TGB to the ground bar of the panelboard.

E. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA/EIA-568-B.1 and TIA/EIA-568-B.2 when grounding screened, balanced, twisted-pair cables.

F. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

G. Access Floors: Bond all metal parts of access floors to the TGB.

H. Signal Reference Grid: Provide a low-impedance path between telecommunications cabinets, equipment racks, and the reference grid, using #6 AWG copper bonding conductors.

1. Install the conductors in grid pattern on 4-foot (1200-mm) centers, allowing bonding of one pedestal from each access floor tile.
2. Bond the TGB of the equipment room to the reference grid at two or more locations.
3. Bond all conduits and piping entering the equipment room to the TGB at the perimeter of the room.

3.7 IDENTIFICATION

A. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
2. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a TMGB and a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.

    a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.

3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.

    a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TMGB. Maximum acceptable ac current level is 1 A.

C. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 ohms, notify Architect promptly and include recommendations to reduce ground resistance.

D. Grounding system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 270526

SECTION 274000 - SUPERVISORY CONTROL SYSTEM (GENERAL)

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This Section covers, in general, the overall purchase, installation, startup and warranty of the combined hardware and software to operate, control, monitor and report on the status of the equipment in the Wichita Wastewater or Water Treatment Facility. Deviations from this specification shall be listed upon pre-submittal.

1.2 CONTROL SYSTEM DESCRIPTION:

A. The system shall consist of a network of programmable logic controllers (PLC's) located in the supervisory control panels networked with Supervisory Computers and Laptops. The supervisory computers are shown on the floor plans and in the control schematic. Each control panel shall be a "smart remote" composed of an Ethernet capable PLC and supervisory computer communicating via a local Ethernet network that shall monitor and respond to a number of discrete and analog input/output conditions. Each control panel shall consist of an enclosure with a computer terminal, PLC, surge protection, uninterruptable power supply, wireways, terminal blocks, I/O rack and relays all necessary to control the equipment. Provide fusible terminal blocks for all discrete and analog I/O points. Separate fusible terminal strips shall be provided for discrete I/O and analog I/O i.e. analog I/O shall be separated from discrete I/O.

B. A Central Supervisory Computer shall monitor and provide supervisory control of the system and shall record the system condition in memory storage and generate monitoring reports. The Supervisory Control Computer shall report any alarm conditions and sound alarms.

C. Failure of any Supervisory Computer shall not affect operation of the plant. The Personal Computers at the PLC panels will be able to function during failure of the Central Supervisory Control Computer. Performance of the system shall be updated in real time

D. The Ethernet network (Local Area Network – LAN) shall be connected to each computer that may exert supervisory control for set point modification and enabling/disabling pumps and other control points.

E. Each Supervisory Computer shall contain the control functions for each screen, and have the ability to store and transmit data on the Ethernet network. The networks shall use "twisted pair" Cat 5E switched Ethernet 100 Base TX communication wiring and if there are failures in the communications links the operation of the plant shall not be affected nor shall the integrity of the control panel cabinet be compromised.

F. In the event of failure of any of the Supervisory Computers, any other supervisory computers and the network shall continue control of the systems until the Central Supervisory Computer is placed back into service. Upon placement of the Central Supervisory Computer back into service, the analog data accumulated shall be able to be acquired for updating the data banks so as to have a continuous record of the preceding events and alarms. The alarm function shall not be placed out of service in the event of failure of any of the Computers but shall be announced via the network recognized at the PLC showing the alarm condition. In the event of failure of any PLC or personal computer, an alarm shall be given.

G. The software for building display screens and reports shall be a commercially available package designed specifically for process control. Refer to specification section SUPERVISORY CONTROL SYSTEM (PC) for system control software requirements.

1.3 SCOPE:

A. The Contractor shall furnish and install the SCADA system and all wiring, cables, and conduit required to have an operational and functional system. A System Integrator will be required for actual SCADA system installation and programming. All testing, programming and check out must be performed by the Systems Integrator.

1.4 SYSTEMS INTEGRATOR:

A. Systems Integrator Qualifications: The Systems Integrator will be Pedrotti.

B. The Systems Integrator and/or system manufacturer shall make available on a 24-hour delivery of any replaceable modules and/or program development. This is to ensure that the Owner will receive prompt maintenance service and a single source of responsibility. The Systems integrator and/or system manufacturer shall certify this to the Consulting Engineer in writing at the time of bidder pre-approval.

1.5 REFERENCE STANDARDS:

A. Reference to the standards of any technical society, organization, or association, or to codes of local and state authorities, shall mean the latest standard, code, specification, or tentative specification adopted and published at the date of taking bids, unless specifically stated otherwise.

1.6 PERMITS, EASEMENTS, CODES, FEES AND NOTICES:

A. All work shall be installed in strict accordance with all local and state codes and ordinances. Should any change in, or addition to, the plans and specifications be required to make them conform to these codes and ordinances, the system integrator shall so state when submitting his pre-bid qualification.

B. The control system and its components shall comply will all applicable requirements of the following:

1. Electrical Code Compliance (National & Local)
2. National Fire Protection Agency Compliance
3. UL Compliance
4. NEMA Compliance
5. IEEE Compliance
6. EIA Compliance
7. FCC Compliance

1.7 RESPONSIBILITIES:

A. Manufacturer: The manufacturer shall provide the computer system, programmable logic controller(s), power supply, I/O modules, chassis, operator interface, communication wiring, uninterruptable power supplies, warranty, programming guides, and system support. The manufacturer must be listed in the pre-bid submittal, and must be approved prior to bidding.

B. Systems Integrator: The Systems Integrator shall obtain the necessary equipment containing microprocessors from an approved manufacturer and shall assemble the control system. The Systems Integrator shall provide the control, monitoring, and reporting programs to operate the facilities as indicated. The Systems Integrator shall direct the contractor as to the support needs; i.e. power requirements, control wiring, panel installation and specials.

C. Start Up and Field Service:

1. The systems integrator shall be responsible for verifying all control connections and the system is “de-bugged” prior to placing the system into service. Startup shall include operator interface, reports, O & E manuals and the Management Program.
2. The system integrator shall include in his price the services of a competent field technician for a period of not less than 4 trips and 10 days. This service shall be for the purpose of commissioning the system, initial startup, certification, and instruction of treatment plant personnel.
3. Start up Report

    a. A written report covering the Systems integrator’s field service technician’s findings and installation approval shall be submitted to the engineer covering all inspections, and outlining in detail all deficiencies that were noted.
    b. The deficiencies noted in the report shall be corrected by the systems integrator or to the systems integrator’s satisfaction and so noted.

D. Warranty:

1. The warranty shall cover all parts, materials, labor, programming, O&M manual documentation revisions, and site visits for the duration of the warranty.
2. Lightning damage shall be included as part of the warranty.
3. The Systems Integrator shall provide start up services plus a minimum of six (6) days and four (4) trips support service.
4. The warranty period for the SCADA system shall be for 2 years for the date of acceptance. The warranty shall ensure that the system work as it is specified.

1.8 SUBMITTALS:

A. Complete electrical and dimensional drawings (including front panel and sub-panel layouts) shall be provided prior to fabrication for approval by the Consulting Engineer. The submittal data shall include the following:

B. Product Data: Provide product data sheets for each component supplied in the system. The data sheets shall show the component name as used on reference drawings, manufacturer's model number or other product designator, electrical or mechanical requirements, and materials compatibility's.

C. Shop Drawings: Drawings for the SCADA system shall include wiring diagrams for control circuits and interconnections of all components including wiring diagrams for all remote devices, and instruments connected to the system.

D. Connection and interconnection wiring diagrams furnished by the Contractor shall meet the requirements of ANSI Y 14.5a1971. The wiring diagrams shall be drawn with all devices indicated in their relative physical locations. Wiring diagrams shall be rear view. Each device connection shall have near each termination, indicated in separate breaks, the opposite end destination.

E. Wiring diagrams shall be prepared on appropriately sized sheets. Where interconnecting wiring from different items of equipment or sectional wiring diagrams of the same item of equipment appear on different wiring diagram sheets, all interconnections shall be clearly identified. Where sectional wiring diagrams are required for a single item of equipment such as a relay panel or control panel, that section of the panel which is represented by each individual wiring diagram sheet shall be keyed on that sheet in a manner acceptable to the Consulting Engineer.

F. Information indicated on the Systems Integrator's drawings shall include wiring of the individual panel items, as they actually will appear in the panel, contact arrangements of switches and internal wiring of relays and instruments.

G. Elementary diagrams shall be cross-referenced to terminal markings on the connection and interconnection diagrams, but need not indicate complete details of circuits external to the panel. Each item of panel mounted equipment indicated on the diagrams shall be identified by item number and name.

H. Sufficient space shall be left on the outgoing terminal blocks for adding cable color codes and circuit numbers.

I. Ladder type diagrams with English description of operation shall also be acceptable for wiring diagrams.

J. Panel Layout Drawings: A front panel and sub-panel layout shall be included as part of each control panel drawing. Components shall be clearly labeled on the drawing.

K. Test Reports: Submit test reports of factory “burn-in”.

1. The submittal shall include full color printouts of screens including icons, animation and navigation between the levels and screens and present an example for review by the engineer and owner.

L. Other Items: Other items and additional information and details of submittals as required providing complete clarity of the submittal.

M. The documentation shall be approved by the engineer and owner. The review submittal shall be completed on computers provided by the systems integrator for this project.

N. Refer to Specification section SUBMITTALS for additional requirements.

1.9 DELIVERY, STORAGE, AND HANDLING:

A. All items shall be stored in a dry, sheltered place, not exposed to the outside elements, until ready for installation these items shall be the responsibility of the subcontractor until installation. All items shall be handled with appropriate care to avoid damage during transport and installation.

1.10 FACTORY TESTS:

A. The PLC's and all electronic equipment shall be tested at the factory (place of assembly and debugging) prior to being shipped to the job site for connection into the Control system. The Owner reserves the right to witness the testing.

B. A minimum of one week's notice to the Owner shall precede all tests. In addition, all supplied equipment shall have been factory tested at the operational temperatures at 110 degrees F. Submit with shop drawings a copy of these test reports.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CONDUIT – MATERIALS:

A. Low Voltage Wire (600V): See Section LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

B. Control and Monitor Conductors: All control/monitor conductors shall be copper, 19-strand, #16 gauge or larger. 7-strand wire will not be permitted. Insulation type shall be for 90 degrees C. Provide spade type insulated copper connectors for all wire terminations. See Drawings. All wiring shall be color coded from terminal to terminal. Multiple conductor cables will be acceptable.

C. Paired Shielded Cable: All paired shielded cables shall be #18 gauge 16/30 stranded copper conductors with .018 polyethylene insulation, twisted into pairs, stranded into a core and enclosed in a non-hydroscopic core tape, 100% coverage helically wound aluminum foil shield, drain wire, and .028" minimum extruded PVC jacket. Pairs shall be black/red. Cables shall be rated at 300 volts to meet NEC-725 and IEEE 383, and shall be Belden #8760, or approved equal. See Drawings.

D. Fiber-Optic Cable: See Section COMMON WORK RESULTS FOR COMMUNICATIONS.

E. Plastic Conduit: See Section RACEWAY SYSTEMS. To be used only for buried service.

F. Rigid Steel Conduit: See Section RACEWAY SYSTEMS.

G. Liquid Tight Flexible Conduit: See Section RACEWAY SYSTEMS.

2.2 EQUIPMENT:

A. Enclosures: See specification section SUPERVISORY CONTROL SYSTEM (PC).

B. Surge Protection: Provide L.E.A. Dynatech Series TE-B transient surge protection device for all communication lines to/from the PLC that terminate external to the building. Additional surge protection shall be provided on the source of power to protect the electronic equipment from lightning induced surges and shall also be effective in rejecting switching line transients produced by other equipment.

C. Control Interposing Relay: Control relays shall be industrial plug in type 600 volt with N.O/N.C. contacts rated 10 amps at 120 VAC continuous duty, General Electric CR 120 Line, Square D by Schneider Electric Class 8501, or approved equal. Provide in NEMA 1 enclosure. Verify all requirements in field per site.

D. Control Switches: Control switches shall be oil tight pushbutton type; Cutler Hammer Series E-30 or approved equal. Auxiliary contact blocks shall be provided as required.

E. Alarm Horn Exterior: The alarm horn shall be weatherproof suitable for exterior mounting. The unit shall be a heavy duty model with a megaphone that can be rotated 180° horizontally and 90° vertically. The unit shall be solid-state with a high decibel sound output (112-114 dB 10 feet) and shall operate on 120VAC. The electrical contractor shall provide a 120V. 1P. contactor with a coil (voltage compatible with the control system) for operation of this device. This contactor shall be used to operate all alarm horns and beacon lights shown on the plans.

F. Flashing Beacon Light Exterior: The flashing beacon light shall be weatherproof suitable for exterior mounting. The unit shall have a red lens and shall flash approximately 60 flashes per minute. The unit shall be UL listed and operate on 120 volts. Two (2) replacement bulbs shall be provided with the unit. The electrical contractor shall provide a 120V. 1P. contactor with a coil (voltage compatible with the control system) for operation of this device. This contactor shall be used to operate all alarm horns and beacon lights shown on the plans.

G. Mandown Alarm Contact: The mandown alarm shall be a Type T oil tight momentary contact pushbutton with a red jumbo mushroom head (2-inches dia.) with the word "Emergency" engraved on the operator. The unit shall be similar to a Cutler Hammer Series E-20.

H. Phase Failure Relay: The Phase Failure relay is a three phase voltage sensing device that will trip on phase loss, phase reversal, voltage unbalance or undervoltage. Voltage unbalance shall trip the device when any voltage drops 10% below the average. Undervoltage is externally adjustable from 75% to 100% of the rated voltage. The relay shall be a plug in type relay.

I. Load Relay Detector: The load detector monitors the motor load and has two separate output relays to indicate when a trip point has been exceeded. The two output relays correspond to a maximum and minimum trip point. Relays correspond to two maximum trip points. Separate pushbutton switches, located on the face of the device, are used to select the trip points. Standard Features shall include:

1. Two SPDT relay outputs to indicate maximum or minimum trip
2. Adjustments for startup delay, response delay and compensation of motor losses.
3. LEDs to indicate power on, maximum trip or minimum trip.

J. Provide current transformers to match design voltage and motor draw.

PART 3 - EXECUTION

3.1 MATERIALS:

A. The Systems Integrator shall furnish all components necessary, including communication wiring, jacks, cables, hardware and software to make the SCADA system operational.

3.2 WORKMANSHIP:

A. These specifications contain detailed instructions and descriptions covering the major items of construction and workmanship necessary for building and completing the various units or elements of the project. The specifications require first class workmanship and the furnishing of the best grade and quality of materials. These specifications may fail to include all details but this will not relieve the system integrator of full responsibility for providing a completed project of high quality, first class finish and appearance, and satisfactory operation, all within the apparent intent of the plans and specifications.

3.3 SERVICE FOR PANELS, INSTRUMENTS AND CONTROLS:

A. The Systems Integrator shall furnish qualified, experienced and competent service personnel for inspection, calibration and checking of all equipment prior to initial operation. The systems integrator shall furnish all special tools and equipment required for calibration purposes such as hand loaders, manometers, test gauges, etc. The special tools that will be required for owner maintenance shall be provided to the owner upon acceptance of the project and the owner shall be instructed on the proper use of these special tools.

B. The Systems Integrator shall be responsible for all time spent by service personnel to correct system design or equipment defects. This time spent shall not be considered as service to place equipment in service.

C. Service personnel who lack technical competence and experience or who are unacceptable to the Engineer shall be removed from the job site and replaced with acceptable personnel. Service personnel who visit the site who are new employees of the Systems Integrator or who are classified as trainees shall be accompanied by a service engineer who has had startup experience on equipment of this type.

D. All costs of time, traveling and living expense, etc. shall be included for instrument and control startup service. The Systems Integrator shall include in his Proposal all time required to start up panels, instruments, and controls.

3.4 INSTRUCTION FOR PANELS, INSTRUMENTS AND CONTROLS:

A. The instruction of plant operating personnel shall be considered a part of this Contract. The explanation of how and what the instrument measures, and its application to plant process; explanation of the several control loops and the actual operation of the system should be included. This explanation shall be conducted as a five (5) day, 8 hrs/day school for the City of //ANYTOWN// operators, and written documentation shall be provided.

B. The training shall provide instruction and experience such that maintenance personnel with no previous programming or configuring experience shall be capable of operation of the control system with no guidance or with only minimum supervision on unusually complex problems.

C. All class time shall be recorded in Electronic Format. Two (2) copies shall be provided to the owner for his use.

The training shall cover the following subjects, as a minimum:

1. PLC and personal computer overview in which the basic system design, configuration, and purpose is covered.
2. PLC hardware in which the specific hardware elements and specific configurations provided are covered.
3. How the actual PLC programs operate.
4. Specific application program instruction covering the overall design and philosophy of the applications as provided under this Contract. The intent shall be to make the student fully knowledgeable in all aspects of the provided system along with the methods for making additions, modifications, and deletions to the PLC program.
5. Supervisory Computer System overview of operation report generation, data storage and retrieval, and access and execution of the control, monitoring and reporting programs.
6. General review of the use of the computer system including the monitor and printer.
7. Complete controls and computer system backup and reload procedures.
8. Diagnostic software details including capabilities, usage and interpretation of results.

D. In addition to the operator instruction, and after final acceptance of the SCADA system by the owner and engineer, the Systems Integrator shall complete an operations and maintenance manual that reflects the "As Constructed" system and provide two (2) copies to the owner. Each manual shall be properly labeled, indexed and tabbed for quick reference. This manual shall include a copy of the program with documentation, all equipment manuals, a troubleshooting guide, a maintenance schedule, wiring and piping diagrams, and a spare parts listing with supplier addresses and phone numbers. The Systems Integrator shall update each copy of the O&M manuals to reflect any changes made to the system during

installation, start-up, or warranty period. The final O& M Manual shall also be provided on Compact Disc.

1. Upon job close out, Manuals shall be submitted also to comply with the requirements as outlined in Section 01700 Contract Closeout, OPERATIONS AND MAINTENANCE MANUALS.
2. Copies of the operations and maintenance manuals shall be on site for equipment startup and initial operations.

3.5 CONDUCTORS – INSTALLATION:

A. General: See Section COMMON WORK RESULTS FOR ELECTRICAL. All electrical wiring systems shall be color coded in accordance with the National Electrical Code. In conduits or runs containing from two to seven conductors, no two conductors shall be of the same color. In conduits or runs containing from eight to fourteen conductors, the same color shall not appear more than twice. For runs of more than fourteen conductors, the same color shall not appear more than three times. Unless necessary for pulling purposes, conductors shall be continuous from terminal block to terminal block without splice. Under no condition shall conductors of a different color be spliced together. All circuits shall be tagged at terminals.

B. Low Voltage: All conductors shall be continuous from outlet to outlet and no splices shall be made except at outlets. Sufficient wire shall be left at all outlets to make connections to equipment without straining. No slices allowed without prior approved by the Engineer of Record.

C. All splices and taps shall be made with mechanical type, compression type or spring connectors. Splices and taps shall be reinsulated with Scotch Tape No. 33, half-lapped to a thickness of 1-1/2 times the conductors and insulation thickness.

D. Paired Shielded Cable: Paired shielded cables shall be grounded at the PLC end only and shall be insulated from ground elsewhere. The shield shall be made continuous for the entire run. The 300 volt cable shall not be laced with or in the same conduit with cable rated at 600 volts or greater.

E. Grounding: Provide full size separate green ground conductors in all conduit containing 120 volts or above. Do not install control/monitor conductors and/or shielded cable in the same conduit with conductors of 120 volts and above.

F. All conduits, cabinets, outlets, and other equipment shall be properly grounded in accordance with National Electrical Code requirements. Where ground wire is exposed to mechanical damage, it shall be installed in thick wall conduit. Connections shall be made to equipment with solderless connections. Wire connections to the ground conductor shall be of the exothermic type equal to the Cadweld process.

G. The metal surface under the grounding lug shall be cleaned to bright metal. Equipment not specifically shown connected to a grounding conductor shall be grounded by means of a conduit supplying the equipment. Where direct metallic connections cannot be made, bonding jumpers shall be used.

3.6 CONDUIT – INSTALLATION:

A. General: See Section RACEWAY SYSTEMS.

END OF SECTION 274000

SECTION 274118 - SUPERVISORY CONTROL SYSTEM (CONTROL PANEL CONSTRUCTION)

PART 1 - GENERAL

1.1 This section covers the specific construction requirements for the supervisory control panels as discussed in section SUPERVISORY CONTROL SYSTEM (GENERAL).

PART 2 - PRODUCTS

2.1 CONTROL PANEL CONSTRUCTION:

A. Panels shall be completely shop fabricated, piped, wired and tested. The work shall conform to the latest applicable requirements of the National Electrical Code, the National Board of Fire Underwriters, and the American Standard Code for Pressure Piping, and NEMA WCI standards.

B. The panels shall be fabricated, all cutouts made and finish painted in the shop of the supplier. All recorders, indicators, and control switches shall be installed, piped and wired in the System Integrator's shop. Low voltage systems, piping, telephone and control switches shall be isolated from the high voltage items.

C. All panels shall be constructed of specially leveled steel plate with rolled edges. Panels shall have internal reinforcement as required to maintain flat surfaces and to provide adequate support of all instruments and controls to be mounted thereon. Each panel shall be of unit construction. Extra bracing, if required, shall be bolted in place for shipping purposes.

D. The Control Panels shall be constructed of a minimum of 14 gauge thick steel. The panel interiors shall incorporate all bracing and necessary brackets required for mounting of auxiliary equipment such as pneumatic controls, electric relays, switches, contactors, pressure switches, piping and terminal blocks.

E. Engraved nameplates shall be provided to properly identify each piece of equipment mounted in and on each piece of equipment represented on the external surface of the panel. All equipment mounted inside the panel that cannot be labeled shall be tagged. These identifications need not be duplicated if other permanent visible means of identifications exist.

F. Instrument and controllers shall be provided with all necessary mounting hardware, cables, signal resistor units, power supplies, etc., for mounting in the panels complete and readied for operation.

G. The supplier shall mount all specified instruments on the panel providing all necessary cutouts, electrical and mechanical service connections.

H. Control panels shall be provided with a viewing window in the door so that the supervisory computer monitor can be viewed without opening the control panel door. The glass shall be low glare type and large enough for the monitor used on the project.

I. Panel and Indicating Lights: The indicating lights shall be heavy duty 120 VAC lights with engraved lenses of the color specified. A box of spare light bulbs shall be supplied with the panel. The lamp removal tool shall also be supplied. The unit shall be Cutler Hammer Series E-30 or approved equal.

PART 3 - EXECUTION

3.1 Refer to section SUPERVISORY CONTROL SYSTEM (GENERAL) for installation, testing, and warranty requirements for the supervisory control panels.

END OF SECTION 274118