SPANISH FORK CITY CORPORATION

SPANISH FORK & MAPLETON WRF PROJECT

VOLUME II
TECHNICAL SPECIFICATIONS

Agency Review

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Prepared by

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Project No 55-20-124

SECTION	RESPONSIBLE ENGINEER OR ARCHITECT	TITLE
22 40 00	J. Berrett	Plumbing Fixtures
22 45 00	J. Berrett	Emergency Plumbing Fixtures
DIVISION 23 – HEATING, VENTILATION, & AIR CONDITIONING		
23 05 00	J. Berrett	Common Work Results for HVAC
23 05 29	J. Berrett	Hangers and Supports for HVAC Piping and Equipment
23 05 48	J. Berrett	Vibration and Seismic Controls for HVAC Piping and Equipment
23 05 53	J. Berrett	Identification for HVAC Piping and Equipment
23 05 93	J. Berrett	Testing, Adjusting, And Balancing for HVAC
23 07 00	J. Berrett	HVAC Insulation
23 09 00	J. Berrett	Instrumentation and Control for HVAC
23 23 00	J. Berrett	Refrigerant Piping
23 31 13	J. Berrett	Metal Ducts
23 32 16	J. Berrett	Non-Metal Ducts
23 33 00	J. Berrett	Air Duct Accessories
23 34 13	J. Berrett	Axial Mixed Flow Fans
23 34 23	J. Berrett	HVAC Power Ventilators
23 37 13	J. Berrett	Diffusers, Registers, And Grilles
23 37 23	J. Berrett	HVAC Gravity Ventilators
23 51 00	J. Berrett	Gas Fired Appliance Vent Stacks
23 55 33	J. Berrett	Fuel-Fired Unit Heaters
23 74 13	J. Berrett	Packaged, Outdoor, Central-Station Air-Handling Units
23 74 33	J. Berrett	Make-up Air Units
23 81 26	J. Berrett	Split-System Air-Conditioners
DIVISION 26 – ELECTRICAL		
26 00 00	K. Smith	Electrical Work, General
26 01 26	K. Smith	Electrical Tests
26 05 10	K. Smith	Electric Motors
26 05 15	K. Smith	Industrial Control Panels
26 05 19	K. Smith	Wire and Cabling
26 05 26	K. Smith	Grounding
26 05 33	K. Smith	Electrical Raceway Systems
26 05 36	K. Smith	Wiring Devices
26 05 43	K. Smith	Underground Raceway Systems
26 05 50	K. Smith	Electric Heat Tracing
26 05 73	K. Smith	Protective Device Studies
26 12 16	K. Smith	Panelboards and General-Purpose Dry Type Transformers

SECTION	RESPONSIBLE ENGINEER OR ARCHITECT	TITLE
26 23 13	K. Smith	Medium Voltage Metal-Clad Switchgear
26 24 13	K. Smith	480-Volt Switchboard
26 29 00	K. Smith	Low-Voltage Motor Control Centers
26 29 13	K. Smith	Solid-State Reduced Voltage Starters
26 29 23	K. Smith	Variable Frequency Drive Units
26 32 13	K. Smith	Standby Power Generation
26 33 53	K. Smith	Uninterruptible Power, Single Phase
26 35 26	K. Smith	Active Harmonic Filters
26 41 23	K. Smith	Lightning Protection System
26 43 00	K. Smith	Surge Protection Devices
26 50 00	K. Smith	Lighting
DIVISION 31 – EARTHWORK		
31 05 16	J. Goodley	Aggregate Materials
31 10 00	J. Goodley	Site Clearing
31 11 20	J. Goodley	Soil Materials
31 11 23	J. Goodley	Aggregate Base Coarse
31 22 13	J. Goodley	Rough Grading
31 23 16	J. Goodley	Excavation
31 23 19	J. Goodley	Dewatering
31 23 23	J. Goodley	Backfilling for Structures
31 23 33	J. Goodley	Trenching and Backfilling for Pipelines and Utilities
DIVISION 32 – EXTERIOR IMPROVEMENTS		
32 17 23	J. Goodley	Pavement Markings
32 31 13	J. Goodley	Chain Link Fencing
32 31 19	J. Goodley	Ornamental Vertical Pivot Gate
32 90 00	J. Goodley	Plantings
DIVISION 33 – UTILITIES		
33 05 07	K. Reams	Horizontal Directional Drilling
33 05 60	K. Reams	Precast Concrete Utility Structures
33 05 77	K. Reams	Metering Manholes
33 30 00	K. Reams	Sewer Bypass Pumping
DIVISION 40 – PROCESS INTERCONNECTIONS		
40 05 07	S. Winfree	Pipe Supports
40 06 00	J. Goodley	Pipe and Fittings
40 91 00	B. Herrera	Process Control and Instrumentation Systems
40 91 02	B. Herrera	In-Line Liquid Flow Measuring Systems

SECTION	RESPONSIBLE ENGINEER OR ARCHITECT	TITLE
40 91 03	B. Herrera	Liquid Flow Detection Devices
40 91 06	B. Herrera	Level Measuring Systems
40 91 07	B. Herrera	Level Detection Switches
40 91 08	B. Herrera	Pressure Measuring Devices
40 91 09	B. Herrera	Pressure Detection Switches
40 91 10	B. Herrera	Temperature Measuring Systems
40 91 11	B. Herrera	Temperature Detection Switches
40 91 12	B. Herrera	Process Analyzer Measuring Systems
40 92 00	B. Herrera	Control Panels
40 92 01	B. Herrera	Control Panel Instrumentation
40 93 00	B. Herrera	Plant Control Philosophy
40 95 10	B. Herrera	Plc Based Control System Hardware
40 95 20	B. Herrera	Plc Based Control System Software
DIVISION 41 – PROCESS EQUIPMENT		
41 12 18	J. Goodley	Self-Contained Leveling Cover
41 70 10	J. Goodley	Activated Carbon Odor Control System
DIVISION 43 – MATERIAL HANDLING EQUIPMENT		
43 05 10	J. Goodley	Equipment General Provisions
43 10 65	S. Winfree	Double Containment Piping
43 11 33	J. Goodley	Positive Displacement Blowers
43 12 10	J. Goodley	Blowers Positive Displacement
43 12 93	S. Winfree	Inlet Air Filter
43 24 13	J. Goodley	Vertical Turbine Pumps
43 24 15	S. Winfree	Axial Flow Pumps
43 25 05	J. Goodley	Submersible Wastewater Pumps
43 25 06	J. Goodley	Dry-Pit Submersible Wastewater Pumps – Influent Lift Station
43 25 08	S. Winfree	Submersible Wastewater Pumps for Waste Activated Sludge
43 25 20	J. Goodley	Headworks Booster Pump Skid
43 30 00	J. Goodley	Hydraulic Process Valves
43 30 12	S. Winfree	Valve and Gate Actuators
43 30 50	S. Winfree	Telescoping Valves
43 30 62	J. Goodley	Stainless Steel Slide Gates and Weir Gates
43 30 64	S. Winfree	Bulkhead Gates
43 40 08	S. Winfree	Polyethylene Tanks
43 40 11	S. Winfree	Fiberglass Reinforced Underground Storage Tanks
43 52 00	S. Winfree	Hoists and Cranes General

SECTION 26 00 00
ELECTRICAL WORK, GENERAL

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide the electrical WORK, complete and operable, as indicated in accordance with the Contract Documents.

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

C. The WORK of this Section is required for operation of electrically-driven equipment provided under Specifications in other Divisions.

D. The CONTRACTOR'S attention is directed to the requirement for proper coordination of the WORK of this Section with the WORK of equipment Specifications, the WORK of instrumentation Sections, and the WORK of Section 26 05 10 – Electric Motors.

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

F. Equipment supports and foundations shall be in conformance with the requirements of Section 43 05 10 – Equipment General Provisions.

1.2 REFERENCE STANDARDS

NEC (NFPA 70)	National Electrical Code (NEC): 2020 Edition
NETA	International Electrical Testing Association
NEMA 250	Enclosure for Electrical Equipment (1000 Volts Maximum)

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

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

C. Where the requirements of the specifications conflict with UL, LLC (UL), National Electrical Manufacturers Association (NEMA), National Fire Protection Agency (NFPA), or other applicable standards, the more stringent requirements shall govern.

1.3 SIGNAGE AND MARKINGS

A. Identification

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

B. Local Disconnect Switches

1. Legibly mark each local disconnect switch for motors and equipment in order to indicate its purpose, unless the purpose is indicated by the location and arrangement.

C. Warning Signs

1. 600 Volts Nominal, or Less

a. Mark entrances to rooms and other guarded locations that contain live parts with conspicuous signs prohibiting unqualified persons from entering.

2. Greater than 600 Volts

a. Buildings, rooms, or enclosures containing exposed live parts or exposed conductors operating at greater than 600 volts nominal shall be lockable.

b. Provide permanent and conspicuous warning signs reading as follows: DANGER – HIGH VOLTAGE – KEEP OUT.

3. Mark indoor electrical installations that are open to unqualified persons and contain metal-enclosed switchgear, unit substations, transformers, and other similar associated equipment over 600 volts nominal, with appropriate caution signs.

4. Outside Branch Circuits and Feeders over 600 Volts

a. Post warning signs in plain view where unauthorized persons might come in contact with live parts: WARNING – HIGH VOLTAGE – KEEP OUT.

D. Isolating Switches

1. Provide isolating switches not interlocked with an approved circuit-interrupting device with a sign warning against opening them under load.

1.4 PUBLIC UTILITIES REQUIREMENTS

A. Contact the serving utility and verify compliance with requirements before construction.

B. Coordinate schedules and payments for WORK by utilities.

C. Where conduits and conductors in the WORK are indicated to be larger, heavier schedule, or have greater protective coating than utility requirements, provide the larger size, heavier schedule, or greater protection.

D. Provide electrical service as indicated and as required by the serving utility.

E. Verify and provide service conduits, fittings, transformer pad, grounding devices, and service wires not provided by the serving utility.

F. Verify with the utility the exact location of each service point and type of service, and pay charges levied by the serving utilities as part of the WORK.

1.5 PUBLIC UTILITY WORK

A. Spanish Fork Power and Light shall perform the following as part of the work:

1. Provide and install all medium voltage, padmount switches

2. Provide and install all padmount 15kv:480v transformers

3. Provide and install electrical meter cabinet

4. Provide electric meter cabinet pad for installation by the CONTRACTOR

5. Provide and install all 15kv cable

1.6 PERMITS AND INSPECTION

A. Obtain permits and pay inspection fees according to the General Conditions.

B. Pay connection and turn-on service charges required by the utility company.

1.7 CONTRACTOR SUBMITTALS

A. General

1. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures.

2. Custom-prepare Shop Drawings.

3. Drawings or data indicating "optional" or "as required" equipment will not be accepted.

4. Cross out options not proposed or delete from the Shop Drawings.

B. Shop Drawings: Include the following:

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

2. Shop Drawings for grounding WORK not specifically indicated

3. front, side, rear elevations, and top views with dimensional data

4. location of conduit entrances and access plates

5. component data

6. connection diagrams, terminal numbers, internal wiring diagrams, conductor size, and cable numbers

7. method of anchoring, seismic requirements, weight

8. types of materials and finish

9. nameplates

10. temperature limitations, as applicable

11. voltage requirement, phase, and current, as applicable

12. front and rear access requirements

13. test reports

14. grounding requirements

C. Catalog Cuts

1. Submit catalog cuts or photocopies of applicable pages of bulletins or brochures for mass produced, non-custom manufactured material.

2. Stamp the catalog data sheets in order to indicate the Project name, applicable Specifications Section and Paragraph, model number, and options.

D. Materials and Equipment Schedules

1. Within 30 Days of the commencement date in the Notice to Proceed, deliver to the ENGINEER a complete list of materials, equipment, apparatus, and fixtures that are proposed for use.

2. Include in the list the type, size, name of manufacturers, catalog number, and such other information as required to identify the item.

E. Technical Manuals

1. Submit complete information in accordance with the requirements of Section 01 33 00 – Submittal Requirements.

2. As-Built Drawings

a. Prepare as-built drawings, showing invert and top elevations and routing of duct banks and concealed below-grade electrical installations.

b. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00 –Submittal Procedures.

1.8 AREA DESIGNATIONS

A. General

1. Designations for raceway system enclosures shall comply with the requirements of Section 26 05 33 – Electrical Raceway Systems.

2. Designations for electrical WORK specifically indicated in other Sections shall comply with the requirements of those Sections unless indicated otherwise.

3. Designations for other electrical WORK not included in the above Paragraphs shall be as follows:

AREA	NEMA ENCLOSURE CLASSIFICATION					
	1	3R	4X	7	12	Notes
Headworks Building						
Wet Well				X		Class 1, Div 1
Dry Well Pump Room			X			
Coarse Screening Room				X		Class 1, Div 1
Grit Chambers – in classified zone				X		Class 1, Div 2
Grit Chambers – above classified zone						
Fine Screening Washpress Room			X			
Electrical Room	X					Gasketed
Fine Screening Room				X		Class 1, Div 1
MBR Blower Support Building						
Electrical Room	X					Gasketed
Chemical Room			X			Corrosive
Control Room	X					Gasketed
Blower Room			X			
Process Room			X			
BNR/MBR Basins						
Basins – in classified zone				X		Class 1, Div 1
Basins – above classified zone			4X			

UV Building						
Electrical Room	X					Gasketed
Process Area			X			

4. Designations for electrical WORK not included in the above Paragraphs shall be NEMA 4X.

5. Installations in hazardous locations shall conform strictly to the requirements of the indicated Class, Group, and Division.

B. Material Requirements

1. Construct NEMA 4X enclosures of Type 304 stainless steel.

2. Do not coat NEMA 4X enclosures.

3. Construct NEMA 7 enclosures of cast aluminum where used with aluminum conduit.

4. Do not coat NEMA 7 enclosures.

5. Construct NEMA 1, 3R, and 12 enclosures of steel, and prime and coat with American National Standards Institute (ANSI) 61 light grey paint.

1.9 TESTS

A. The CONTRACTOR shall be responsible for factory and field tests indicated in Division 26, as required by the ENGINEER, and as required by other authorities having jurisdiction.

B. Furnish necessary testing equipment.

C. Pay the costs of the tests, including replacement parts and labor, due to damage resulting from damaged equipment or from testing and correction of a faulty installation.

D. Reporting

1. Where test reporting is indicated, submit proof-of-design test reports for mass-produced equipment with the Shop Drawings.

2. Submit factory performance test reports for custom-manufactured equipment for approval prior to shipment.

3. Submit field test reports for review prior to Substantial Completion.

E. Remove and replace equipment or material that fails a test, or, if the ENGINEER approves, repair and retested for compliance.

F. Corrections to equipment or materials with a factory warranty shall be as recommended by the manufacturer and shall be performed in a manner that does not void the warranty.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Provide equipment and materials that are new and are the products of experienced and reputable manufacturers in the industry.

B. Provide equipment and materials listed by UL and bearing the UL label, where UL requirements apply.

C. Provide similar items in the WORK as products of the same manufacturer.

D. Provide equipment and materials of industrial grade standard of construction.

E. Where a NEMA enclosure type is indicated in a non-hazardous location, use that type of enclosure despite the fact that certain modifications such as cutouts for control devices may negate the NEMA rating.

F. On devices indicated to display dates, display the year as 4 digits.

G. Temperature Ratings of Equipment Terminations

1. Provide terminations and lugs rated for use with 75˚C conductors.

2. Wire sizes in the Contract Documents are based on NEC ampacity tables using the 75˚C ratings.

2.2 MOUNTING HARDWARE

A. Miscellaneous Hardware

1. Provide nuts, bolts, and washers constructed of stainless steel.

2. Provide threaded rods for trapeze supports constructed from continuous threaded galvanized steel, 3/8-inch diameter minimum.

3. Struts

a. Construct struts for mounting of conduits and equipment of 304 stainless steel.

b. Where contact with concrete or dissimilar metals may cause galvanic corrosion, use suitable non-metallic insulators in order to prevent such corrosion.

c. Do not use aluminum strut for free-standing support frames.

d. Strut Manufacturer, or Equal: **Unistrut**; **B-Line**

4. End Caps

a. Provide plastic protective end caps for all exposed strut ends below eight feet AFF.

b. End Caps Manufacturer, or Equal: **Unistrut, Model P2860**

5. Anchors

a. Provide stainless steel expansion anchors for attaching equipment to concrete walls, floors, and ceilings.

b. Wood plugs will not be accepted.

c. Anchor Manufacturer, or Equal: **"Power-Bolt"** or **"Power-Stud"** as manufactured by **Power Fasteners, Inc.**; similar by **Star**.

2.3 ELECTRICAL IDENTIFICATION

A. Nameplates

1. Fabricate nameplates from white-letter, black-face laminated plastic engraving stock, such as **Formica Type ES-1** or equal.

2. Securely fasten each nameplate, using fasteners constructed of brass, cadmium-plated steel, or stainless steel, and screwed into inserts or tapped holes as required.

3. Provide engraved characters of the block style, with no characters smaller than 1/8-inch top to bottom.

B. Conductor and Equipment Identification

1. Provide imprinted plastic-coated cloth marking devices, such as manufactured by Brady, Thomas & Betts, or equal.

2. Alternatively, provide heat-shrunk plastic tubing, imprinted split-sleeve markers cemented in place.

2.4 PROTECTIVE MATTING

A. Provide full-width, high-voltage switchboard matting in front of indoor switchgear, service equipment, panelboards and motor control centers.

B. For 600-volt equipment, provide matting that is 1/4 inch thick and 36 inches wide.

C. Matting Manufacturer, or Equal

1. W.H.Salisbury and Company; Mats, Inc.; Rhino.

PART 3 -- EXECUTION

3.1 GENERAL

A. Incidentals

1. Provide materials and incidentals required for a complete and operable system, even if not required explicitly by the Contract Documents.

2. Typical incidentals are terminal lugs not furnished with vendor-supplied equipment, compression connectors for cables, splices, junction and terminal boxes, and control wiring required by vendor-furnished equipment to connect with other equipment indicated in the Contract Documents.

B. Field Control of Location and Arrangement

1. The Drawings diagrammatically indicate the desired location and arrangement of outlets, conduit runs, equipment, and other items.

2. Exact locations shall be determined by the CONTRACTOR in the field, based on the physical size and arrangement of equipment, finished elevations, and other obstructions.

3. Follow the locations on the Drawings, however, as closely as possible.

4. Conduits

   a. Where conduit development drawings or "home runs" are indicated, route the conduits in accordance with those requirements.

   b. Provide exposed or encased routings as indicated, except conceal conduit in finished areas unless indicated otherwise.

   c. Size conduits encased in a slab for conduit OD not to exceed 1/3 of the slab thickness, and lay out and space as to not impede concrete flow.

5. Placement

   a. Install conduit and equipment in such a manner as to avoid obstructions, to preserve headroom, and to keep openings and passageways clear.

   b. Locate luminaires, switches, convenience outlets, and similar items within finished rooms as indicated.

   c. Where exact locations are not indicated, such locations will be determined by the ENGINEER.

   d. If equipment is installed without instruction and must be moved, the cost of moving shall be included as part of the WORK.

   e. Slightly adjust luminaire locations in order to avoid obstructions and to minimize shadows.

6. Circuits

   a. Wherever conduits and wiring for lighting and receptacles are not indicated, it shall be the CONTRACTOR'S responsibility to provide lighting and receptacle-related conduits

and wiring as required, based on the actual installed fixture layout and the circuit designations as indicated.

b. Provide No. 12 AWG minimum wiring, and 3/4-inch minimum conduits (exposed) and one-inch minimum conduits (encased).

c. Where circuits are combined in the same raceway, derate conductor ampacities in accordance with NEC requirements.

7. Workmanship

a. Install materials and equipment in strict accordance with the printed recommendations of the manufacturer, and using workers skilled in the WORK.

b. Coordinate installation in the field with other trades in order to avoid interferences.

8. Protection of Equipment and Materials

a. Fully protect materials and equipment against damage from any cause.

b. Cover materials and equipment, both in storage and during construction, in such a manner that no finished surfaces will be damaged, marred, or splattered with water, foam, plaster, or paint.

c. Keep moving parts clean and dry.

d. Replace or refinish damaged materials or equipment, including faceplates of panels and switchboard sections, as part of the WORK.

C. Provide incoming utility power equipment in conformance with the utility's requirements.

D. Provide starters in accordance with the requirements of Section 26 29 00 – Low Voltage Motor Control Center for starters in motor control centers (MCC's), and with Section 26 05 15 – Industrial Control Panels for starters not in MCC'S, except for starters in HVAC equipment which are indicated in Division 23 – HVAC.

3.2 CORE DRILLING

A. Perform core drilling as required for the installation of raceways through concrete walls and floors.

B. Base the locations of floor penetrations, as may be required, on field conditions.

C. Verify exact core drilling locations based on equipment actually furnished as well as exact field placement.

D. To the extent possible, identify the existence and locations of encased raceways and other piping in existing walls and floors with the OWNER prior to any core drilling activities.

E. Repair damage to encased conduits, wiring, and piping as part of the WORK.

3.3 CONCRETE HOUSEKEEPING PADS

A. Provide concrete housekeeping pads for indoor floor-standing electrical equipment.

B. Extend housekeeping pads for equipment, including future units, 3-1/2 inches above the surrounding finished floor or grade, and two inches larger in both dimensions than the equipment, unless otherwise indicated.

C. Provide concrete housekeeping curbs for conduit stub-ups in indoor locations that are not concealed by equipment enclosures.

D. Extend housekeeping curbs to three inches above the finished floor or grade.

3.4 EQUIPMENT ANCHORING

A. Floor-supported, wall, or ceiling-hung equipment and raceways shall be anchored in place by methods that will meet seismic requirements in the area where the Project is located. Refer to Section 01 73 24 – Design Requirements for Non-Structural Components and Non-Building Structures for support and anchorage requirements.

B. Provide wall-mounted panels that weigh more than 500 pounds or that are within 18 inches of the floor with fabricated steel support pedestals.

C. If the supported equipment is a panel or cabinet enclosed within removable side plates, match supported equipment in physical appearance and dimensions.

D. Provide transformers hung from 4-inch stud walls and weighing more than 300 pounds with auxiliary floor supports.

E. Provide leveling channels anchored to the concrete pad for MCC's, switchgear and other electrical equipment mounted on housekeeping pads.

F. Manufacturer's Recommendations

1. Anchoring methods and leveling criteria in the printed recommendations of the equipment manufacturers are a part of the WORK of this Contract.

2. Submit such recommendations as Shop Drawings as indicated.

3.5 EQUIPMENT IDENTIFICATION

A. Provide nameplates for panelboards, control and instrumentation panels, starters, switches, and pushbutton stations.

B. In addition to nameplates, equip control devices with standard collar-type legend plates.

C. Identify control devices within enclosures as indicated and similar to the subparagraph above.

D. Provide suitable inscribed finish plates for toggle switches that control loads out of sight of switches and for multi-switch locations of more than two switches.

E. Use equipment names and tag numbers, where indicated, on nameplates.

F. Provide typewritten circuit directories for panelboards, that accurately reflect the outlets connected to each circuit.

G. Terminal Blocks

1. Label termination points on terminal blocks by identifiers on the blocks.

2. Provide identifiers that have been preprinted by the terminal manufacturer or custom-printed.

3. Hand-lettered markers will not be accepted.

H. Provide arc-flash labels for all distribution equipment, stand-alone disconnects, starters, and variable frequency drives (VFDs). Fill in all values as required by NFPA 70E, and as calculated as part of the Protective Device Study. Verify that all settings as prescribed by the approved Protective Device Study have been implemented in the field.

3.6 CLEANING

A. Before final acceptance, thoroughly clean the electrical WORK of cement, plaster, and other materials.

B. Remove temporary tags, markings, stickers, and the like.

C. Remove oil and grease spots with a non-flammable cleaning solvent by carefully wiping and scraping cracks and corners.

D. Apply touch-up paint to scratches on panels and cabinets.

E. Vacuum clean electrical cabinets and enclosures. Do not use compressed air to clean cabinets.

F. Clean luminaires inside and out. Replace failed lamps.

G. Properly dispose cleaning debris and refuse off-site.

END OF SECTION

SECTION 26 01 26
ELECTRICAL TESTS

PART 1 -- GENERAL

1.1 THE SUMMARY

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

B. The WORK of this Section includes furnishing the labor, equipment, and power required to support the testing indicated in other Divisions of these Specifications. Electrical testing indicated herein and functional testing of power and controls not tested under Division 40 – Instrumentation, shall be completed before commencement of the 7-Day test of Section 01 75 16 – Starting Procedures. This scope may require the CONTRACTOR to activate circuits, shutdown circuits, run equipment, make electrical measurements, replace blown fuses, and install temporary jumpers, etc.

C. The requirements of Section 26 00 00 - Electrical Work, General, apply to the WORK of this Section.

D. Carry out tests indicated herein for individual items of materials and equipment in other Sections. Testing shall be done in accordance with the manufacturer's instructions, these Specifications, and applicable InterNational Electrical Testing Association (NETA) Acceptance Testing Specifications, National Electrical Manufacturers Association (NEMA), American National Standards Institute (ANSI), National Fire Protection Agency (NFPA), and ASTM International (ASTM) Standards.

1.2 REFERENCES

A. General

1. The publications listed below form a part of this specification to the extent referenced.

2. Where a date is given for reference standards, the edition of that date shall be used. Where no date is given for reference standards, the latest edition available on the date of the Notice Inviting Bids shall be used.

B. American National Standards Institute (ANSI)

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

D. IEEE 400-2001, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems

E. IEEE 576-2000, Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications

F. InterNational Electrical Testing Association (NETA)

G. NFPA 70, National Electrical Code (NEC)

1.3 SUBMITTALS

A. Submit in accordance with Section 01 33 00, Submittal Procedures.

B. Submit complete system test procedures for review. Test procedures shall include but not be limited to:

1. Detailed procedures in sufficient detail to verify conformance with these Specifications.
2. Incorporation of the Test Record Sheets included at the end of this Section.
3. Detailed comprehensive testing schedule including:
    a. Each major piece of electrical distribution equipment.
    b. Each major electrical subsystem.
    c. Duration of each test.
    d. Milestone test completion date.
    e. Ambient Conditions at time of test
    f. Date of test results submittals following completion of the tests.
    g. Names and qualifications of the individual(s) responsible for performing the testing.

C. Following completion of the test submit the completed test results to the Engineer for review. The results shall include a dedicated section with the “as-left” settings of all devices, relays, circuit breakers, etc.

D. Test result shall be submitted in one submittal

E. Test reports shall be based on NETA’s latest Acceptance Testing Specifications having a sign-off, pass/fail data filed for each line item covered by NETA’s Acceptance Testing Specifications latest edition.

1.4 COMMISSIONING

A. Commissioning during the 7-Day test in Section 01 75 16 shall not be attempted until all subsystems have been found to operate satisfactorily. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level

parameters or computer command, as applicable. Simulation of process parameters shall be considered only upon receipt of a written request by the CONTRACTOR.

B. Motor Current Tabulation

1. The motor current tabulation required by Section 26 05 73 – Protective Device Studies shall reflect the values occurring during commissioning.

2. Switchgear, motor control center (MCC) and switchboard ammeters and kilowattmeters shall be recorded every half-hour during the commissioning.

3. Motors which have current/power measurement capabilities shall have this data recorded every five minutes while operating during commissioning.

4. Power monitored amperes, voltage, and kilowatts for each phase shall be recorded every five minutes during commissioning.

PART 2 -- TESTING & REPORTS

2.1 PRE-ENERGIZATION AND OPERATING TESTS

A. The complete electrical system shall be performance tested when first installed on-site. Each protective, switching, and control circuit shall be adjusted in accordance with the recommendations of the protective device study and tested by actual operation using current injection or equivalent methods as necessary to ensure that each and every such circuit operates correctly to the satisfaction of the authority having jurisdiction.

1. Instrument Transformers. All instrument transformers shall be tested to verify correct polarity and burden.

2. Protective Relays. Each protective relay shall be demonstrated to operate by injecting current or voltage, or both, at the associated instrument transformer output terminal and observing that the associated switching and signaling functions occur correctly and in proper time and sequence to accomplish the protective function intended.

3. Switching Circuits. Each switching circuit shall be observed to operate the associated equipment being switched.

4. Control and Signal Circuits. Each control or signal circuit shall be observed to perform its proper control function or produce a correct signal output.

5. Metering Circuits. All metering circuits shall be verified to operate correctly from voltage and current sources, similarly to protective relay circuits.

6. Acceptance Tests. Complete acceptance tests shall be performed, after the station installation is completed, on all assemblies, equipment, conductors, and control and protective systems, as applicable, to verify the integrity of all the systems.

7. Relays and Metering Utilizing Phase Differences. All relays and metering that use phase differences for operation shall be verified by measuring phase angles at the relay under actual load conditions after operation commences.

B. Test Report. A test report covering the results of the tests required in the Pre-Energization and Operating Tests shall be delivered to the authority having jurisdiction prior to energization. Acceptance Testing shall be in accordance with NETA ATS-2017, *For Electrical Power Equipment and Systems*, published by the InterNational Electrical Testing Association.

2.2 TEST REQUIREMENTS

A. The following test requirements supplement test and acceptance criteria that may be stated elsewhere.

1. Lighting: Switching, include remote control, if present in system. Circuitry is in accordance with panel schedules. All interior and exterior lighting shall be checked for proper operation.

2. Power Instrumentation: Demonstrate that voltmeter and ammeter switches are functional. Demonstrate that kilowatt meters are within catalog accuracy as installed.

   a. Visual and Mechanical Inspection

      1) Compare equipment nameplate data with drawings and specifications.

      2) Inspect physical and mechanical condition.

      3) Verify tightness of electrical connections.

      4) Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case-shorting contacts, as applicable.

      5) Verify freedom of movement, end play, and alignment of rotating disk(s).

   b. Electrical Tests

      1) Verify accuracy of meters at all cardinal points.

      2) Calibrate watthour meters according to manufacturer's published data.

      3) Verify all instrument multipliers.

      4) Verify that current transformer and voltage transformer secondary circuits are intact.

3. Demonstrate mechanical and/or electrical interlocking by attempting to subvert the intended sequence.

4. Activate ground fault tripping by operating test features provided with ground current protective systems and by injecting a known and reasonable current in the ground current sensor circuit. In general, ground fault tripping should occur at a ground current equivalent to 20 percent of phase current. Current injection is not required of circuit 400 amperes or less.

5. Low Voltage Cables-600 volts Maximum

a. Visual and Mechanical Inspection

1) Compare cable data with drawings and specifications.

2) Inspect exposed sections of cables for physical damage and correct connection in accordance with single-line diagram.

3) Inspect bolted electrical connections for high resistance using one of the following methods:

a) Use of low-resistance ohmmeter

b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS- 2017, Table 100.12.

c) Perform thermographic survey in accordance with below Section Thermographic Survey.

4) Inspect compression-applied connectors for correct cable match and indentation.

5) Inspect for correct identification and arrangements.

6) Inspect cable jacket insulation and condition.

b. Electrical Tests

1) Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute.

a) Motor feeders tested with motors disconnected and controller open.

b) Motor control circuits tested and verified for proper operation with control stations and overcurrent devices connected.

c) Panelboard feeders tested with feeder breaker open and panel-board connected. If a lighting transformer is associated with the panelboard, it shall be connected and the test made for both primary and secondary sides.

d) Conductors of main lighting feeders, including lighting panel with branch circuits open.

e) Prior to performing insulation resistance tests on cables, verify that they are not connected to a solid state device.

f) Equipment which may be damaged during this test shall be disconnected.

g) The Engineer shall be consulted if minimum insulation values cannot be obtained.

2) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

3) Perform continuity test to insure correct cable connection.

c. Test Values – Visual and Mechanical

1) Compare bolted connection resistance to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Bolt-torque levels should be in accordance with NETA ATS-2017, Table 100.12 unless otherwise specified by the manufacturer.

3) Results of the thermographic survey shall be in accordance with the below Section Thermographic Survey.

d. Test Values – Electrical

1) Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Insulation-resistance values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS-2017 Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.

3) Cable shall exhibit continuity.

4) Deviations in resistance between parallel conductors shall be investigated.

6. Test ground interrupter (GFI) receptacles and circuit breakers for proper operation by methods sanctioned by the receptacle manufacturer.

7. A functional test and check of electrical components is required prior to performing subsystem testing and commissioning. Compartments and equipment shall be cleaned as required by other provisions of these Specifications before commencement of functional testing. Functional testing shall comprise:

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

b. Verification that electrical equipment has been labeled with Arc Flash protection boundary and PPE levels, as required by Section 26 05 73 – Protective Device Studies.

c. Setting of protective relays in conformance with results of the Short Circuit Study required by Section 26 05 73 – Protective Device Studies and testing of relays to assure that relays will trip at the current value and time required by the Study.

d. Circuit Breakers

1) Circuit breakers that have adjustable time or pick-up settings for ground current, instantaneous overcurrent, short-time overcurrent, or long-time overcurrent, shall be field-adjusted by a representative of the circuit breaker manufacturer.

2) Time and pickup setting shall correspond to the recommendations of the Short Circuit Study.

3) Setting shall be tabulated and proven for each circuit breaker in its installed position.

4) Test results shall be certified by the person performing the tests and shall be submitted to the ENGINEER.

8. Complete ground testing of grounding electrodes per requirements below prior to operating the equipment.

B. Subsystem testing shall occur after the proper operation of alarm and status contacts has been demonstrated or otherwise accepted by the ENGINEER and after process control devices have been adjusted as accurately as possible. Alarm conditions shall be simulated for each alarm point, and alarm indicators shall be checked for proper operation. It is intended that the CONTRACTOR will adjust limit switches and level switches to their operating points prior to testing and will set pressure switches, flow switches, and timing relays as dictated by operating results.

C. Metering and indication lights for motors and other devices shall be tested for proper operation.

D. All control circuits such as motor, interlock and remote shall be tested for proper operation.

E. After initial settings have been completed, each subsystem shall be operated in the manual mode and it shall be demonstrated that operation is in compliance with the Contract Documents. Once the manual mode of operation has been proven, automatic operation shall be demonstrated to verify such items as proper start and stop sequence of pumps, proper operation of valves, proper speed control, etc.

F. Motor operated valves shall be tested after having been phased and tested for correct motor rotation and after travel and torque limit switches have been adjusted by a

representative of the valve manufacturer. Tests shall verify status indication, proper valve travel, and correct command control from local and remote devices.

G. All lighting panels, circuits and fixtures; and power panels, circuits and receptacles shall be tested for proper operation.

H. Provide ground resistance tests on the main grounding electrode or system in the presence of the ENGINEER and submit results

1. Visual and Mechanical Inspection

a. Verify ground system is in compliance with drawings and specifications.

2. Electrical Tests

a. Perform fall-of-potential test or alternative in accordance with IEEE Standard 81 on the main grounding electrode or system.

b. The earth resistance of each ground electrode shall be measured and recorded before electrodes are connected to the grounding loop.

c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.

3. Test Values

a. The resistance between the main grounding electrode and ground shall be no greater than five ohms for commercial or industrial systems and one ohm or less for generating or transmission station grounds unless otherwise specified by the owner.

b. Investigate point-to-point resistance values which exceed 0.5 ohm.

I. Subsystems shall be defined as individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, etc.

2.3 THERMOGRAPHIC SURVEY

A. Visual and Mechanical Inspection

1. Inspect physical, electrical, and mechanical condition.

2. Remove all necessary covers prior to thermographic inspection. Utilize appropriate caution, safety devices, and personal protective equipment.

B. Equipment to be inspected shall include all 120 volt and higher current-carrying devices including all switchgear, switchboards, distribution panels, cable and bus connections, motor control centers and starters, disconnect switches, and other critical equipment. Testing of lighting luminaires, field instrumentation, supervisory control and data acquisition (SCADA) and Programmable Logic Controllers (PLCs) are not required.

C. Provide report including the following:

1. Description of equipment to be tested.
2. Discrepancies.
3. Temperature difference between the area of concern and the reference area.
4. Probable cause of temperature difference.
5. Areas inspected. Identify inaccessible and/or unobservable areas and/or equipment.
6. Identify load conditions at time of inspection.
7. Provide photographs and/or thermograms of the deficient area.
8. Recommended action.

D. Test Parameters

1. Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1°C at 30°C.
2. Equipment shall detect emitted radiation and convert detected radiation to visual signal.
3. Thermographic surveys should be performed during periods of maximum possible loading but not less than 40 percent of rated load of the electrical equipment being inspected. Refer to ANSI/NFPA 70B-2010, Section 11-17 (Infrared Inspection).

E. Test Values

1. Suggested actions based on temperature rise can be found in Table 100.18.

2.4 RE-INSPECTION

A. All items that are reported deficient in the thermography reports section of the inspection report shall be re-inspected after repairs have been made.

B. Original specification will apply to re-inspections.

C. Submit re-inspection reports and indicate that repairs have fixed the anomaly or indicate any remaining anomalies.

D. Perform a follow-up thermographic survey within 12 months of final acceptance by the owner.

2.5 TEST REPORTS

A. The test report shall include the following:

1. Summary of project.

2. Description of equipment tested.

3. Description of test.

4. Test data.

5. Analysis and recommendations.

B. Test data records shall include the following minimum requirements:

1. Identification of the testing organization.

2. Equipment identification.

3. Humidity, temperature, and other atmospheric conditions that may affect the results of the tests/calibrations.

4. Date of inspections, tests, maintenance, and/or calibrations.

5. Identification of the testing technician.

6. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.

7. Indication of expected results when calibrations are to be performed.

8. Indication of "as-found" and "as-left" results.

9. Sufficient spaces to allow all results and comments to be indicated.

C. The testing firm shall furnish a copy or copies of the complete report to the owner as required in the acceptance contract.

TABLE 100.18

THERMOGRAPHIC SURVEY
SUGGESTED ACTIONS BASED ON TEMPERATURE RISE

Temperature difference (ΔT) based on comparisons between similar components under similar loading.	Temperature difference (ΔT) based upon comparisons between component and ambient air temperatures.	Recommended Action
1ºC - 3ºC	1ºC - 10ºC	Possible deficiency; warrants investigation
4ºC - 15ºC	11ºC - 20ºC	Indicates probable deficiency; repair as time permits
- - - - - -	21ºC - 40ºC	Monitor until corrective measures can be accomplished
>15ºC	>40ºC	Major discrepancy; repair immediately

Temperature specifications vary depending on the exact type of equipment. Even in the same class of equipment (i.e., cables) there are various temperature ratings. Heating is generally related

to the square of the current; therefore, the load current will have a major impact on ΔT. In the absence of consensus standards for ΔT, the values in this table will provide reasonable guidelines.

An alternative method of evaluation is the standards-based temperature rating system as discussed in Chapter 8.9.2, Conducting an IR Thermographic Inspection, *Electrical Power Systems Maintenance and Testing*, by Paul Gill, PE, 1998.

It is a necessary and valid requirement that the person performing the electrical inspection be thoroughly trained and experienced concerning the apparatus and systems being evaluated as well as knowledgeable of thermographic methodology

PART 3 -- PART 3 EXECUTION

3.1 TEST RECORD SHEETS

A. Testing agency shall use NETA compliant forms to record all test data.

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SECTION 26 05 10
ELECTRIC MOTORS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. General: The SELLER shall provide electric motors, accessories, and appurtenances complete and operable, in conformance to the Contract Documents.

B. The provisions of this Section apply to low voltage three phase, AC squirrel cage induction motors throughout the Contract Documents, except as indicated otherwise.

C. The Construction Manager/General Contractor (CM/GC) shall assign to the equipment supplier the responsibility to select suitable electric motors for the equipment. The choice of motor manufacturer shall be subject to review by the ENGINEER. Such review will consider future availability of replacement parts and compatibility with driven equipment

1.2 CONTRACTOR SUBMITTALS

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

B. Complete motor data shall be submitted with the driven machinery Shop Drawings. Motor data shall include:

1. Machine name and specification number of driven machine
2. Motor manufacturer
3. Motor type or model and dimension drawing. Include motor weight.
4. Nominal horsepower
5. National Electrical Manufacturers Association (NEMA) design
6. Enclosure
7. Frame size
8. Winding insulation class and temperature rise class
9. Voltage, phase, and frequency ratings
10. Service factor
11. Full load current at rated horsepower for application voltage
12. Full load speed
13. Guaranteed minimum full load efficiency. Also nominal efficiencies at 1/2 and 3/4 load.
14. Type of thermal protection or overtemperature protection, where included

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

16. Bearing data. Include recommendation for lubricants of relubricatable type bearings.

17. If utilized with a variable frequency controller, verify motor is inverter duty type. Include minimum speed at which motor may be operated for the driven machinery. Provide shaft grounding details and information. Provide insulated bearing details and information.

18. Power factor at 1/2, 3/4 and full load.

19. Recommended size for power factor correction capacitors to improve power factor to 0.95 percent lagging when operated at full load.

C. If water cooling is required for motor thrust bearings, the Shop Drawing submittals shall indicate this requirement.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electric motors driving identical machines shall be identical.

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

C. Motor Capacity

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

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

   b. Size motors for minimum size indicated

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

   a. Ambient Temperature

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

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

b. Site Altitude: No derating is required for altitudes less than 3300 feet (1000 meters). Higher altitudes require the following derating factors:

Altitude	Derating Factor
3,300 to 5,000 ft	97 percent
5,001 to 6,600 ft	94 percent
6,601 to 8,300 ft	91 percent
8,301 to 9,900 ft	88 percent
9,901 to 11,500 ft	85 percent

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

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

2.2 DESIGN REQUIREMENTS

A. General: Electric motors shall comply with NEMA MG-1 - Motor and Generator. Motors used with adjustable frequency drives shall comply with NEMA MG-1, Part 31, and shall be clearly identified as “Inverter Duty.”

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

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

1. Motors below 1/2 HP shall be rated 115 volts, single phase, 60 Hz. Dual voltage motors rated 115/230 volts, 115/208 volts, or 120-240 volts are acceptable, provided leads are brought out to the conduit box.

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

D. Insulation: Three phase motors shall be provided with Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C and at the altitudes where the motors will be installed and operated, without exceeding Class B temperature rise limits stated in NEMA MG 1-12.44. Single phase motors shall have Class F insulation with temperature rise not to exceed the insulation class. Motors to be operated from

adjustable frequency drives shall be provided with insulation systems to withstand 1600 volt spikes, with dV/dT as defined in NEMA MG 1-31. The adjustable frequency drive manufacturer shall coordinate with the motor manufacturer to determine when additional dV/dT protection is required. Where required, it shall be furnished and installed as per the manufacturer's written instructions.

E. Motors 50 HP or smaller located in non-hazardous areas shall be totally enclosed, fan cooled (TEFC) with a Service Factor of 1.15 unless otherwise indicated.

F. Motors 50 HP and greater located in non-hazardous areas shall be ODP, with a service factor of 1.15.

G. Motors for use in hazardous locations shall have enclosures suitable for the classification indicated. Such motors shall be U.L. listed and be stamped as such.

H. Motors larger than 50 HP installed outdoors, in unheated areas or where indicated shall be provided with 120-volt AC space heaters, wired to a terminal strip in a low voltage motor junction box. If provided by the manufacturer when not specified, the manufacturer shall not require that they be connected or the CM/GC shall connect them at no extra cost to the BUYER, in order to keep the warranty in force.

I. NEMA Premium Efficiency Motors

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

2. Efficiency: Nominal efficiency and minimum efficiency shall be defined in accordance with the following tables. Both efficiencies shall be included in the Shop Drawing submittal.

OPEN DRIP-PROOF (ODP)

FULL-LOAD EFFICIENCIES OF NEMA PREMIUM EFFICIENCY MOTORS RATED 600 VOLTS OR LESS						
	2 POLE		4 POLE		6 POLE	
HP	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.
1	77.0	74.0	85.5	82.5	82.5	80.0
1.5	84.0	81.5	86.5	84.0	86.5	84.0
2	85.5	82.5	86.5	84.0	87.5	85.5
3	85.5	82.5	89.5	87.5	88.5	86.5
5	86.5	84.0	89.5	87.5	89.5	87.5
7.5	88.5	86.5	91.0	89.5	90.2	88.5
10	89.5	87.5	91.7	90.2	91.7	90.2
15	90.2	88.5	93.0	91.7	91.7	90.2
20	91.0	89.5	93.0	91.7	92.4	91.0
25	91.7	90.2	93.6	92.4	93.0	91.7
30	91.7	90.2	94.1	93.0	93.6	92.4
40	92.4	91.0	94.1	93.0	94.1	93.0
50	93.0	91.7	94.5	93.6	94.1	93.0
60	93.6	92.4	95.0	94.1	94.5	93.6
75	93.6	92.4	95.0	94.1	94.5	93.6
100	93.6	92.4	95.4	94.5	95.0	94.1
125	94.1	93.0	95.4	94.5	95.0	94.1
150	94.1	93.0	95.8	95.0	95.4	94.5
200	95.0	94.1	95.8	95.0	95.4	94.5
250	95.0	94.1	95.8	95.0	95.8	95.0
300	95.4	94.5	95.8	95.0	95.8	95.0
350	95.4	94.5	95.8	95.0	95.8	95.0
400	95.8	95.0	95.8	95.0	--	--
450	96.2	95.4	96.2	95.4	--	--
500	96.2	95.4	96.2	95.4	--	--

Source: NEMA MG1 - 2011, Table 12-12

TOTALLY ENCLOSED - FAN COOLED (TEFC)

FULL-LOAD EFFICIENCIES OF NEMA PREMIUM EFFICIENCY MOTORS RATED 600 VOLTS OR LESS						
	2 POLE		4 POLE		6 POLE	
HP	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.
1	77.0	74.0	85.5	82.5	82.5	80.0
1.5	84.0	81.5	86.5	84.0	87.5	85.5
2	85.5	82.5	86.5	84.0	88.5	86.5
3	86.5	84.0	89.5	87.5	89.5	87.5
5	88.5	86.5	89.5	87.5	89.5	87.5
7.5	89.5	87.5	91.7	90.2	91.0	89.5
10	90.2	88.5	91.7	90.2	91.0	89.5
15	91.0	89.5	92.4	91.0	91.7	90.2
20	91.0	89.5	93.0	91.7	91.7	90.2
25	91.7	90.2	93.6	92.4	93.0	91.7
30	91.7	90.2	93.6	92.4	93.0	91.7
40	92.4	91.0	94.1	93.0	94.1	93.0
50	93.0	91.7	94.5	93.6	94.1	93.0
60	93.6	92.4	95.0	94.1	94.5	93.6
75	93.6	92.4	95.4	94.5	94.5	93.6
100	94.1	93.0	95.4	94.5	95.0	94.1
125	95.0	94.1	95.4	94.5	95.0	94.1
150	95.0	94.1	95.8	95.0	95.8	95.0
200	95.4	94.5	96.2	95.4	95.8	95.0
250	95.8	95.0	96.2	95.4	95.8	95.0
300	95.8	95.0	96.2	95.4	95.8	95.0
350	95.8	95.0	96.2	95.4	95.8	95.0
400	95.8	95.0	96.2	95.4	--	--
450	95.8	95.0	96.2	95.4	--	--
500	95.8	95.0	96.2	95.4	--	--

Source: NEMA MG1 - 2011, Table 12-12

J. Two speed motors shall be of the 2-winding type.

2.3 ACCESSORY REQUIREMENTS

A. General: Horizontal motors three horsepower and larger and every vertical motor shall have split-type cast metal conduit boxes. Motors shall be provided with oversized conduit boxes. Where conduit sizes indicated do not match the motor terminal box, the CM/GC shall provide means to accommodate the motor requirements. Motor boxes other than open drip-proof shall be gasketed.

B. Lifting Devices: Motors weighing 265 pounds (120 Kg) or more shall have suitable lifting eyes for installation and removal.

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

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

E. Nameplate: Motors shall be fitted with permanent stainless-steel nameplates indelibly stamped or engraved with NEMA Standard motor data, in conformance with NEMA MG-1-10.40. Inverter duty motors shall be clearly identified as such.

F. Where motors are indicated by elementary schematics or specifications to have zero speed switches, the switches shall be factory mounted integral to the motors. Switches shall close the contacts when the motor is at zero speed.

G. Inverter duty motors shall be provided with shaft grounding rings. Rings shall be factory installed, and shall be manufactured by **Aegis**, or equal. The motor warranty shall include coverage against VFD-induced bearing damage or failure.

2.4 MOTOR THERMAL PROTECTION

A. Single Phase Motors: Single phase 120-, 208-, or 230-volt motors shall have integral thermal overload protection or shall be inherently current limited.

B. Thermostats: Where indicated or specified, winding thermostats shall be snap action, bi-metallic, temperature-actuated switch. Thermostats shall be provided with one normally closed contact. The thermostat switch point shall be precalibrated by the manufacturer. All inverter duty motors shall be provided with winding thermostats, unless RTDs are specified. All explosion-proof motors shall be provided with winding thermostats.

2.5 MOTOR BEARINGS

A. General: Bearings shall conform to Section 43 05 10 - Equipment General Provisions, except as indicated herein.

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

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

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

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

F. Water Cooled Motors: If water cooling is required for the thrust bearings, cooling water lines shall be provided complete with shut-off valve, strainer, solenoid valve, flow indicator, thermometer, throttling valve, and, (where subject to freezing), insulation with heat tracing.

G. Inverter Duty Motors: Provide an insulated bearing to prevent circulating bearing currents.

2.6 MANUFACTURERS, OR EQUAL

A. U.S. Motors/Nidec

B. Baldor

C. WEG

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Motor installation shall be performed in accordance with the motor manufacturer's written recommendations and the written requirements of the manufacturer of the driven equipment. Shaft grounding devices shall be connected to the grounding system in accordance with the manufacturer’s recommendations.

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

3.2 FACTORY TESTING

A. Motors rated 100 HP and larger shall be factory tested in conformance with IEEE 112, IEEE 43 - Recommended Practice for Testing Resistance of Rotating Machinery, and NEMA MG-2. Except where specific testing or witnessed shop tests are required by the

specifications for driven equipment, factory test reports may be copies of routine test reports of electrically duplicate motors. Test report shall indicate test procedure and instrumentation used to measure and record data. Test report shall be certified by the motor manufacturer's test personnel and be submitted to the ENGINEER.

3.3 FIELD TESTING

A. The CM/GC shall perform the following field tests (see also Section 26 01 26 – Electrical Tests):

1. Inspect each motor installation for any deviation from rated voltage, phase, frequency, and improper installation.
2. Visually check for proper phase and ground connections. Verify that multi-voltage motors are connected for proper voltage. Verify shaft grounding devices are properly grounded.
3. Check winding and bearing temperature detectors and space heaters for functional operation.
4. Test for proper rotation prior to connection to the driven equipment.
5. Visually check that motor overload heaters are properly sized and that MCP breaker settings are correct for the motor installed.
6. Test insulation (megger test) of new and re-used motors in accordance with NEMA MG-1. Test voltage shall be 1000 VAC plus twice the rated voltage of the motor.

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SECTION 26 05 15
INDUSTRIAL CONTROL PANELS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide complete industrial control panels and/or local control stations as indicated herein or in other Sections of the Specifications. The stations shall be designed to provide the sequence of operation in Section 40 91 00 – Process Control and Instrumentation Systems and the piping and instrumentation diagram (P&ID) Drawings.

B. This section also specifies miscellaneous electrical devices used throughout this project. These devices are not limited to use within industrial control panels or local control stations.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Industrial control panels and/or local control stations shall comply with the requirements of National Electrical Code (NEC) (including Article 409), National Electrical Manufacturers Association (NEMA) , and UL, LLC (UL).

1.3 CONTRACTOR SUBMITTALS

A. Furnish Shop Drawings in accordance with Sections 01 33 00 – Contractor Submittals and 26 00 00 – Electrical Work, General.

1. Ladder diagrams and written descriptions explaining ladder diagram operation and system operation.

2. Include catalog cuts of control equipment including enclosures, overcurrent devices, relays, pilot devices, terminations, and wire troughs.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall provide the equipment, panels and stations to satisfy the functional requirements in the relevant mechanical equipment and Instrumentation and Control specifications and the Electrical Elementary Schematics. Each panel and station shall be fabricated with UL labeled components. Equipment not specifically indicated as

being WORK of other Sections shall be provided under this Section. All equipment, panels and stations shall be wired under this Section.

B. The controls shall be 120 V maximum. Where the electrical power supply is 240 V, single phase or 480 V, three phase, the station shall be provided with a fused control power transformer. Control conductors shall be provided in accordance with Section 26 05 19 – Wire and Cabling.

C. Each panel and/or station shall be provided with identified terminal strips for the connection of external conductors. The CONTRACTOR shall provide sufficient terminal blocks to connect 25 percent additional conductors for future use. Termination points shall be identified in accordance with Shop Drawings. The panels and/or stations shall be the source of power for all 120 VAC solenoid valves interconnected with the panels and/or stations. Equipment associated with the panels and/or stations shall be ready for service after connection of conductors to equipment, controls, panels and/or stations.

D. Wiring to door-mounted devices shall be extra flexible and anchored to doors using wire anchors cemented in place. Exposed terminals of door-mounted devices shall be guarded to prevent accidental personnel contact with energized terminals.

E. Enclosures

1. In finished rooms, enclosures shall be NEMA 12 steel enclosures painted with ANSI 61 exterior and white interior.

2. In all other non-hazardous areas, enclosures shall be NEMA 4X stainless steel with brushed finish. Where possible, penetrations shall be made in such a manner to maintain the NEMA 4X rating. If this is not possible, the penetrations shall be made in such a manner to minimize entry of foreign materials into the enclosure, subject to approval by the ENGINEER.

3. In hazardous areas, enclosures shall be cast aluminum NEMA 7 and shall be UL listed for use in hazardous or classified locations.

4. In chemical areas for alum, sodium hypochlorite, etc., NEMA 4X fiberglass enclosures shall be used.

5. Enclosures shall be freestanding, pedestal-mounted, or equipment skid-mounted, as indicated. Internal control components shall be mounted on a removable mounting pan. Mounting pan shall be finished white.

6. Outdoor mounted enclosures shall be provided with thermostatically-controlled heaters. Heaters shall be operated at ½ rated voltage (240 volt heaters shall be sized and operated at 120 volts).

7. Provide screened weep holes for draining condensation.

F. Disconnect Devices

1. Disconnect Switches

a. Heavy duty, fusible, single throw switches shall be rated not less than 65 KA at 480 VAC for switches larger than 30A.

b. Heavy duty, non-fusible, single throw switches shall be rated not less than 14 KA at 480 VAC for switches 30A and smaller.

c. Horsepower rated

d. UL listed

e. Padlockable in "Off" position and door interlock

f. Enclosure per area classification in Section 26 00 00 – Electrical Work, General.

g. 480 V, 3-phase, 3-pole (6-pole when used with 2-speed motor).

h. Auxiliary control contact as applicable and where indicated.

i. As manufactured by **Eaton Electrical, Square D, ABB, or equal**.

2. Enclosed Circuit Breakers

a. Circuit breakers shall be service entrance rated where indicated with the neutral and ground busses permanently bonded .

b. Circuit breakers with a frame size of 600 amperes to 2,000 amperes shall be molded case with RMS sensing electronic trip with the following adjustments:

1) long-time setting (by changing the unit)

2) long-time delay

3) short-time setting

4) short-time delay

5) instantaneous setting

6) ground-fault setting

7) ground-fault delay

c. The interrupting capacity of the enclosed circuit breakers shall be a minimum of 65,000 RMS symmetrical amperes.

d. Service disconnects rated 1000 amps or greater shall provide for ground fault protection of the equipment.

e. Circuit breaker disconnect operators shall be capable of accommodating three padlocks for locking in the OPEN position.

f. As manufactured by **Eaton Electrical, Square D, ABB, or equal**.

3. Switch Rated Plugs & Receptacles

a. Plugs and receptacles must be listed to UL 2682 .

b. Plugs and receptacles must have constant pressure butt-contacts with solid silver-nickel tips. Pin and sleeve contacts are not permitted.

c. Receptacles must have dead front construction: live parts must be inaccessible to thin tool or wire.

d. Plugs and receptacles rated 100A and below must be able to close at least once into a conditional short-circuit current of up to 65,000A when protected by an RK1 fuse sized no greater than 400% of the highest full load motor current associated with the device.

e. Plugs and receptacles must incorporate an integral switching mechanism to ensure the load is broken before the plug is removed from the receptacle.

f. Plug and receptacle wire terminals must be spring-assisted to prevent loosening due to conductor yielding, shocks, vibrations or thermal cycling.

g. Ingress protection must be achieved automatically when the plug is fully inserted into the receptacles, without additional manual operation.

h. Plugs and receptacles must have a system of different keying positions in order to discriminate between circuits or incompatible operating voltages or frequencies.

i. Plugs and receptacles shall have 3 phase conductors and a ground as well as additional auxiliary contacts where required.

j. Plugs and receptacles installed in classified locations must be rated for the environment they are located in.

k. As manufactured by **MELTRIC** or equal.

G. Identification of panel-mounted devices, conductors, and electrical components shall be in accordance with Section 26 00 00 – Electrical Work, General.

H. Panel-mounted devices shall be mounted a minimum of three feet above finished floor elevation, but not higher than six feet six inches above finished floor, unless noted otherwise.

2.2 PANEL/STATION COMPONENTS

A. Pushbuttons, selector switches, and pilot lights shall be the heavy-duty, oil-tight type, sized to 30-mm. Miniature style devices are not acceptable. Devices shall be as manufactured by **General Electric, Eaton Electrical, Square D,** or equal.

1. Lens colors shall be green for "run," "open," or "on"; red for "stopped," "closed," or "off"; and amber for alarm.
2. Pilot lights shall be full voltage, push-to-test, LED cluster type.
3. Provide hazardous location type pilot devices in classified locations.

B. Relays shall be three PDT with 10 amp contacts, plug-in type with indicating light, rectangular blades and provided with sockets for screw-type termination and hold-down clips. Relays shall be as manufactured by **Square D, Potter Brumfield,** or equal.

C. Elapsed time meters shall be non-resettable type, read to a maximum of 99999.9 hours and shall be as manufactured by **General Electric, Eaton Electrical,** or equal.

D. Magnetic starters shall be:

1. NEMA rated, Size 1 minimum. International Electrotechnical Commission (IEC) or dual NEMA/IEC rated type are not acceptable.
2. Full voltage non reversing (FVNR) type unless indicated otherwise.
3. Combination starters with magnetic only instantaneous trip circuit breakers such as **Eaton Electrical HMCP, General Electric Mag-Break,** or equal. Breakers shall be rated 65 KA minimum.
4. Control transformers shall be provided with primary and secondary fuses, 120 V maximum control voltage. VA rating of transformer shall be based on devices on the control schematic.

E. Terminal strips shall be provided for every panel and shall be the flanged fork or ring lug type suitable for No. 12 AWG stranded wire minimum. Provide 25 percent spare terminals in each panel.

F. Time delay relays shall be combination on delay and off delay (selectable) with adjustable timing ranges. Provide socket with screw terminal connections and retaining strap. Time delay relays shall be **Square D, ATC, Eaton Electrical,** or equal.

2.3 FACTORY TESTING

A. Each panel/station shall be factory assembled and tested for sequence of operation prior to delivery.

2.4 SPARE PARTS

A. Provide a minimum of 10 percent spare lamps (minimum two) and one spare lens for each color pilot lamp in each panel.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Panels/stations shall be installed in accordance with in Section 26 00 00 – Electrical Work, General and in accordance with the manufacturer's recommendations.

B. Panels/stations shall be protected at the site from loss, damage, and the effects of weather. Panels/stations shall be stored in an indoor, dry location. Heating shall be provided in areas subject to corrosion and humidity.

C. Panels/station interiors and exteriors shall be cleaned, and coatings shall be touched up to match original finish upon completion of the WORK.

D. Conduit, conductors, and terminations shall be installed in accordance with Section 26 00 00 – Electrical Work, General.

3.2 FIELD TESTING

A. Each panel/station shall be tested again for functional operation in the field after the connection of external conductors and prior to equipment startup.

END OF SECTION

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SECTION 26 05 19
WIRE AND CABLING

PART 1 -- GENERAL

1.1 THE SUMMARY

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

B. In the event that motors provided are larger horsepower than the motors indicated, raceways, conductors, starters, overload elements, and branch circuit protectors shall be revised as necessary to control and protect the increased motor horsepower in accordance with Section 26 05 10 – Electric Motors. Revisions are part of the WORK of this Section.

1.2 ACTION SUBMITTALS

A. The CONTRACTOR shall submit Shop Drawings in accordance with Sections 01 33 00 – Contractor Submittals and 26 00 00 – Electrical Work, General. Submit cable test results in accordance with this Section as well as Section 26 01 26 – Electrical Tests.

1.3 DELIVERY, STORAGE AND HANDLING

A. The CONTRACTOR shall protect all cables from damage at all times.

B. Cable ends shall be protected from water entry in accordance with the manufacturer's recommended procedures. Cable ends shall not be left open in manholes or other locations subject to submergence. If the cable ends become submerged prior to splicing or termination, the cables shall be replaced in their entirety.

C. Cables shall be pulled into raceways in accordance with the manufacturer's requirements. Under no circumstances shall cable pulling tensions exceed the manufacturer's written instructions.

D. Pulling tensions on raceway cables shall be within the limits recommended by the cable manufacturer. Wire pulling lubricant, where needed, shall be UL approved.

PART 2 -- PRODUCTS

2.1 EQUIPMENT

A. Conductors, include grounding conductors, shall be stranded copper. Aluminum conductor and/or solid conductor wire and cable will not be permitted. Insulation shall bear the UL label, the manufacturer's trademark, and identify the type, voltage, and conductor size. Conductors except flexible cords and cables, fixture wires, and conductors that form an integral part of equipment such as motors and controllers shall conform to the requirements of Article 310 of the National Electric Code (NEC), latest edition, for current carrying capacity. Flexible cords and cables shall conform to Article

400, and fixture wires shall conform to Article 402. Wiring shall have wire markers at each end.

B. Low Voltage Power and Lighting Wire

1. Wire rated for 600 volts in duct or conduit for power and lighting circuits shall be single conductor, Class B Type XHHW or XHHW-2 cross-linked polyethylene conforming to UL-44 - UL Standard for Thermoset-Insulated Wires and Cables. THHN/THWN wire shall not be permitted to be used for any power or control wiring in this project, except as specifically permitted within control panels per Section 40 92 00 – Control Panels.

2. Conductors for feeders as defined in Article 100 of the NEC shall be sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.

3. Conductors for branch circuits as defined in Article 100 of the NEC shall be sized to prevent voltage drop exceeding 3 percent at the farthest connected load or combinations of such loads and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.

4. Wiring for 600 volt class power and lighting shall be as manufactured by **Okonite**, **General Cable**, **Southwire**, or equal.

C. Low Voltage Control Wire

1. Low voltage control wire in duct or conduit shall be the same type as power and lighting wire indicated above.

2. Control wiring shall be No.14 AWG.

3. Control wires inside panels and cabinets shall be machine tool grade type MTW, UL approved, rated for 90 degrees C at dry locations, and be as manufactured by **American, General Cable,** or equal.

D. Instrumentation Cable

1. Instrumentation cable shall be rated at 300 volts, minimum.

2. Individual conductors shall be No. 16 AWG stranded, tinned copper. Insulation shall be color coded polyethylene: black-clear for 2 conductor cable and black-red-clear for 3 conductor cable.

3. Instrumentation cables shall be composed of the individual conductors, an aluminum polyester foil shield, a No. 18 or larger AWG stranded, tinned copper drain wire, and a PVC outer jacket with a thickness of 0.047-inches.

4. Single pair, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 8719,** similar by **General Cable,** or equal.

5. Single triad, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 8618,** similar by **General Cable,** or equal.

E. VFD Power Cable

1. VFD power cable shall be three (3) conductor, stranded copper, PVC jacketed, shielded type, tray cable (TC) rated 600 volts with three (3) symmetrical ground conductors. The individual conductors shall be UL listed as Type XHHW-2 or RWH-2 rated for 90 degrees C at wet and dry locations, with XLPE insulation.

2. VFD Cables shall be as manufactured by **Belden, Alpha**, **General Cable,** or equal.

F. Medium Voltage -15 KV Cable

1. Individual conductors shall be copper, Class B, stranded.

2. Cable used in conduit or duct shall be composed of a single conductor, ethylene-propylene rubber (EPR) insulation rated at 105 degrees C, shield and black polyvinyl chloride (PVC) outer jacket. Insulation level shall be 133 percent. Shield shall be copper tape type, or corrugated drain wire type. Cable shall be UL Type MV-105 in accordance with UL 1072 and ICEA-S-93-639/NEMA-WC74 as manufactured by **Okonite, Southwire**, **General Cable,** or equal.

G. Cable Splices and Terminations

1. Where cable lugs are required for power cable terminations, utilize compression lugs – **3M** Scotchlok 30000 and 31100 Series, **Penn Union** HBBLU and BLU, **Burndy** Hylug, or equal. Utilize compression tools as recommended by the manufacturer. Pressure type, twist-on connectors (wire nuts) will not be acceptable.

2. Pre-insulated fork tongue lugs shall be **Thomas & Betts, Burndy**, or equal.

3. General purpose insulating tape shall be **Scotch No. 33**, **Plymouth Slip-knot**, or equal. High temperature tape shall be polyvinyl as manufactured by **Plymouth, 3M,** or equal.

4. Labels for coding 600 volt wiring shall be computer printable or pre-printed, self-laminating, self-sticking, as manufactured by **W.H. Brady, 3M**, or equal.

5. Stress cone material for make-up of medium voltage shielded cable shall be as manufactured by **Raychem, 3M**, or equal.

6. Shielded power cable shall be spliced using kits specifically designed to splice medium voltage, shielded power cables. Splice kits shall be designed for continuous submergence. Heat shrink splice kits shall be **Raychem "Type HVS"**, or equal. "Cold" shrink splice kits shall be **3M "5760 Series",** or equal. The CONTRACTOR's personnel shall be trained by the splice kit manufacturer for proper installation of the splices, and shall submit certification of training as a shop drawing. A certified trainee shall perform the splice work.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall provide, terminate and test all power, control, and instrumentation conductors.

B. The CONTRACTOR shall, as a minimum, provide the number of control wires listed in the conduit schedule or on the Contract Drawings. Excess wires shall be treated as spares for future use.

C. Conductors shall not be pulled into any raceway until raceway has been cleared of moisture and debris.

D. Instrumentation wire shall not be run in the same raceway with power and control wiring except where specifically indicated.

E. Wire in panels, cabinets, and wireways shall be neatly grouped using nylon tie straps, and shall be neatly fanned out to terminals.

F. Single conductor cable in cable trays shall be No. 1/0 or larger and shall be of a type listed and marked for use in cable trays. Tray cable smaller than 1/0 shall be multi-conductor, with outer jacket.

3.2 FIELD ASSEMBLY

A. General

1. Wire taps and splices shall be properly taped and insulated according to their respective classes.

2. In general, there shall be no cable splices in underground manholes or pullboxes. If splices are necessary, the cables shall be spliced using submersible cable splices, suitable for continuous submergence. Splices in underground manholes and pullboxes may be made only with the approval of the ENGINEER.

3. Stranded conductors shall be terminated directly on equipment box lugs making sure that conductor strands are confined within lug. Use forked-tongue lugs where equipment box lugs have not been provided.

4. Excess control and instrumentation wires shall be long enough to terminate at any terminal block in the enclosure, be properly taped, be identified with origin, and be neatly coiled.

B. Control Wire and Cable

1. Control conductors shall be spliced or terminated only at the locations indicated and only on terminal strips or terminal lugs of vendor furnished equipment.

2. In motor control centers, and control panels, control wire and spare wire shall be terminated to terminal strips.

3. The CONTRACTOR shall provide as a minimum the number of control wires listed in the conduit schedule or as indicated in the Contract Documents. Excess wires shall be treated as spares.

C. Instrumentation Wire and Cable

1. Shielded instrumentation cables shall be grounded at one end only, preferably the receiving end on a 4 - 20 mA system.

2. Two and 3 conductor shielded cables installed in conduit runs which exceed available standard cable lengths may be spliced in pullboxes with the prior approval of the ENGINEER. Such cable runs shall have only one splice per conductor.

D. Power Wire and Cable

1. 120/208-volt, 120/240-volt, and 480/277-volt branch circuit conductors may be spliced in suitable fittings at locations determined by the CONTRACTOR. Cables rated above 2,000 volts shall be spliced or terminated only at equipment terminals indicated.

2. Splices to motor leads in motor terminal boxes shall be wrapped with mastic material to form a mold and then shall be taped with a minimum of 2 layers of varnished cambric tape overtaped with a minimum of 2 layers of high temperature tape.

3. Shielded power cable shall be terminated with pre-assembled stress cones in a manner approved by the cable and terminal manufacturer. The CONTRACTOR shall submit the proposed termination procedure as a Shop Drawing.

4. VFD shielded power cables shall have the shield grounded at all locations where it is exposed.

E. Cable Identification

1. General: Wire and cable shall be identified for proper control of circuits and equipment and to reduce maintenance effort. Identification shall be installed at every termination point.

2. Identification Numbers: The CONTRACTOR shall assign to each control and instrumentation wire and cable a unique identification number. Numbers shall be assigned to conductors having common terminals and shall be shown on "as built" drawings. Identification numbers shall appear within 3-inches of conductor terminals. "Control and Instrumentation Conductors" shall be defined as any conductor used for control, interlock, alarm, annunciator, or signal purposes.

   a. Multiconductor cable shall be assigned a number which shall be attached to the cable at intermediate pull boxes and at stub-up locations beneath free-standing equipment. It is expected that the cable number shall form a part of the individual wire number. Individual control conductors and instrumentation cable shall be identified at pull points as described above. The instrumentation cable numbers shall incorporate the loop numbers assigned in the Contract Documents.

   b. 120/208-volt system feeder cables and branch circuit conductors shall be color coded as follows: Phase A - black, Phase B - red, Phase C - blue, and Neutral - white. The 120/240-volt system conductors shall be color coded as follows: Line 1 - Black, Line 2 - Red, and Neutral - White. The 480/277-volt system conductors shall be color coded as follows: Phase A - Brown, Phase B - Orange, Phase C - Yellow, and Neutral - Gray. Branch circuit switch shall be yellow. Insulated ground wire shall be green, and

neutral shall be gray. Color coding and phasing shall be consistent throughout the Site, but bars at panelboards, switchboards, and motor control centers shall be connected Phase A-B-C, top to bottom, or left to right, facing connecting lugs. Color coding tape shall be used where colored insulation is not available. Colored identification tape may be used on conductors between the local disconnect and the load, where permitted by the NEC. Any phase changes necessary for proper rotation shall be made at the driven equipment where colored insulation is used. Phase changes may be made on the load side of the local disconnect, where phase colors are identified using tape.

c. General purpose AC control cable shall be red. General purpose DC control cable shall be blue.

d. Spare cable shall be terminated on terminal screws and shall be identified with a unique number as well as with destination.

e. Terminal strips shall be identified by computer printable, cloth, self-sticking marker strips attached under the terminal strip.

3.3 FIELD QUALITY CONTROL

A. Cable Assembly and Testing: Cable assembly and testing shall comply with applicable requirements of ICEA Publication No. S-95-658/NEMA WC70 - Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy. Factory test results shall be submitted in accordance with Section 01 33 00 – Contractor Submittals, prior to shipment of cable. The following field tests (in addition to the tests specified in Section 26 01 26 – Electrical Tests) shall be the minimum requirements:

1. Insulation resistance testing, using a DC megohmeter, shall be performed on cables operating at more than 2,000 volts to ground. Time-resistance readings shall be taken and recorded at intervals of 30 seconds and one minute. Time-resistance voltage levels shall be per the cable manufacturer's recommendations.

2. Power cable rated at 600 volts shall be tested for insulation resistance between phases and from each phase to a ground using a megohmeter.

3. Field testing shall be done after cable is installed in the raceways.

4. Field tests shall be performed by a NETA-certified test organization. Test results shall be submitted to the ENGINEER for review and acceptance.

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

B. Continuity Test: Control and instrumentation cable shall be tested for continuity, polarity, undesirable ground, and origination. Such tests shall be performed after installation and prior to placing cable in service.

END OF SECTION

SECTION 26 05 26
GROUNDING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide the electrical grounding system, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 26 00 00 – Electrical Work, General apply to this Section.

C. Single Manufacturer

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

1.2 ACTION SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 –Submittal Procedures and Section 26 00 00 – Electrical Work, General.

1. Include with each submittal a copy of this specification section, with addenda updates included, and all referenced and applicable sections included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (√) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the CONTRACTOR, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The ENGINEER shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the CONTRACTOR with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

B. Shop Drawings

1. Submit manufacturer's product information for connectors, clamps, and all grounding system components, showing compliance with the requirements of this Section.

PART 2 -- PRODUCTS

2.1 EQUIPMENT

A. Components of the grounding electrode system shall be manufactured in accordance with UL 467 - Standard for Safety Grounding and Bonding Equipment, and shall conform to the applicable requirements of National Electrical Code Article 250 and local codes.

B. Grounding System

1. Grounding loop conductors shall be bare annealed copper conductors.
2. Conductors shall be No. 4/0 unless indicated otherwise.
3. Ground Rods
    a. Unless indicated otherwise, provide ground rods minimum of 3/4 inch in diameter, 10 feet long, and with a uniform covering of electrolytic copper metallically bonded to a rigid steel core.
    b. Provide corrosion-resistant copper-to-steel bond.
    c. The rods shall conform to UL 467.
    d. The rods shall be of the sectional type, joined by threaded copper alloy couplings.
4. Make buried, concrete-encased, or otherwise inaccessible cable-to-cable and cable-to-ground rod connections using exothermic welds by **Cadweld, Thermoweld,** or equal.
5. Exposed Connectors
    a. Exposed grounding connectors shall be of the compression type (connector-to-cable), constructed of high-copper alloy, and manufactured specifically for the particular grounding application.
    b. The connectors shall be **Burndy, O.Z. Gedney**, or equal.
6. Use grounding clamps to bond each separately-derived system to the grounding electrode conductors.
7. Equipment Grounding Circuit Conductors
    a. The conductors shall be the same type and insulation as the load circuit conductors.
    b. The minimum size shall be as indicated. Where not indicated, sizes shall conform to Table 250.122 of the National Electrical Code (NEC).
    c. Metallic conduit systems shall have an equipment grounding wires as well as being equipment grounding conductors themselves.
8. Grounding Materials Manufacturer, or Equal
    a. Copperweld
    b. Thermoweld

c. Burndy

d. Thomas and Betts

e. OZ Gedney

PART 3 -- EXECUTION

3.1 PREPARATION

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

B. Provide a separate grounding conductor for each motor and connect at motor box. Provide a supplemental ground connection for motor shaft grounding rings, where applicable.

C. Do not use bolts for securing the motor box to the frame or the cover for grounding connectors.

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

E. Route the conductors inside the raceway.

F. Provide a grounding-type bushing for secondary feeder conduits that originate from the secondary section of each motor control center (MCC) section, switchboard, or panelboard.

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

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

I. Provide a separate grounding conductor in each individual raceway for parallel feeders. Connect the parallel ground conductors together at each end of the parallel run, as required by the NEC.

J. Interconnect the secondary switchgear MCC or panelboard neutral bus to the ground bus in the secondary switchgear compartment only at the service entrance point. For wye connected, three phase, separately derived systems with three wire distribution, connect the transformer neutral to the grounding electrode system at the transformer. Connections shall be in accordance with the NEC.

K. Provide the duct bank ground system as indicated, including trenching, splices, ground rods, and connections to equipment and structures.

L. Measure ground impedance in accordance with Institute of Electrical and Electronics Engineers (IEEE) STD 81 after installation but before connecting the electrode to the

remaining grounding system. Provide additional grounding system testing in accordance with Section 26 01 26 – Electrical Tests.

M. Low Voltage Grounded System (600V or less)

1. A low-voltage grounded system is defined as a system where the local power supply is a transformer, with the transformer secondary grounded.

2. Grounding system connections for a premises-wired system supplied by a grounded AC service shall be provided with a grounding electrode connector connected to the grounded service conductor at each service, in accordance with the NEC.

3. The grounded circuit conductor shall not be used for grounding non-current-carrying parts of equipment, raceways, and other enclosures except where specifically listed and permitted by the NEC.

N. Embedded Ground Connections

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

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

3. Do not conceal or cover ground connections until the ENGINEER or an authorized representative has established that every grounding connection conforms to the requirements of the Contract Documents and has given the CONTRACTOR written confirmation.

O. Ground Ring

1. Furnish trenching and materials as necessary to install the ground ring as indicated.

2. The bonding conductor shall be in direct contact with the earth and of the indicated size.

3. Provide a minimum burial depth of 36 inches or as indicated on the Drawings, whichever is greater.

4. Re-compact disturbed soils to their original density in 6-inch lifts.

P. Duct Bank Ground

1. Embed a grounding conductor in every duct bank as indicated. The ground conductor shall be terminated at the ground grid at each end of the duct bank. Where no ground grid is installed, terminate at a suitable grounding electrode conductor near the end of the duct bank in accordance with the NEC.

Q. Ground Rods

1. Provide ground rods at the indicated locations.

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

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

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

R. Instrumentation Shield Grounding

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

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

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

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

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

END OF SECTION

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SECTION 26 05 33
ELECTRICAL RACEWAY SYSTEMS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide electrical raceway systems, complete and in place, as indicated in accordance with the Contract Documents.

B. In the event that individual equipment loads provided are larger than indicated in the Contract Documents, revise raceways, conductors, starters, overload elements, and branch circuit protectors as necessary in order to control and protect the increased connected load in conformance to NEC requirements as part of the WORK.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 –Submittal Proceduress, and Section 26 00 00 – Electrical Work, General.

B. Shop Drawings

1. Submit complete catalog cuts of raceways, fittings, boxes, supports, and mounting hardware, marked where applicable to show proposed materials and finishes.

2. Submit conduit routing drawings for all embedded conduits.

3. As-Built Drawings

a. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.

b. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Pull and junction boxes, fittings, and other indicated enclosures that are dedicated to the raceway system shall comply with the requirements of this Section.

2.2 CONDUIT

A. Rigid Aluminum (RAL) Conduits

1. Provide rigid aluminum conduit manufactured from 6063 alloy, temper T-1.

2. Provide rigid aluminum conduit manufactured in accordance with NEMA C80.5 – Electrical Rigid Aluminum Conduit, and UL-6A – Electrical Rigid Metal Conduit - Aluminum, Red Brass and Stainless Steel.

3. Manufacturer, or Equal

    a. **V.A.W. of America**

    b. **Alcoa**

B. Rigid Galvanized Steel (RGS) Conduit

1. Provide rigid steel conduit manufactured from mild steel, hot-dip galvanized inside and out.

2. Provide rigid steel conduit manufactured in accordance with NEMA C80.1 – Electrical Rigid Steel Conduit, and UL-6 – Electrical Rigid Metal Conduit - Steel.

3. Manufacturer, or Equal

    a. **Allied Tube & Conduit**

    b. **Triangle**

    c. **Wheatland Tube**

C. PVC Rigid Non-Metallic Conduit

1. Provide rigid non-metallic conduit manufactured from Schedule 40 PVC, as indicated, and sunlight-resistant.

2. Provide rigid non-metallic conduit manufactured in accordance with NEMA TC-2 - Electrical Plastic Tubing and Conduit, and UL-651 - Standard for Rigid Non-metallic Conduit.

3. Manufacturer, or Equal

    a. **Carlon**

    b. **Cantex**

D. Rigid PVC-Coated Galvanized Steel (RPGS) Conduit

1. The conduit shall meet the requirements for RGS conduit as indicated above.

2. Bond a PVC coating to the outer surface of the galvanized conduit.

3. Ensure that the bond between the coating and the conduit surface is greater than the tensile strength of the coating.

4. Provide the inside surfaces and threads of the conduit with a 2-mil urethane coating.

5. Provide a PVC coating thickness not less than 40 mils.

6. The PVC-coated RGS shall be manufactured in accordance with the following standards:

    a. UL-6

    b. ANSI C80.1

    c. NEMA RN1 - PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

7. Manufacturer, or Equal

    a. **Robroy Industries**

    b. **O'Kote**

    c. **Thomas & Betts**

E. Fiberglass Reinforced Plastic (FRP) Rigid Non-Metallic Conduit:

1. Provide FRP elbows, conduits and couplings when transitioning from concrete encased PVC to exposed aluminum in non-hazardous/non-classified areas. Thread adapters and PVC adapters shall be factory installed where factory elbows are utilized.

2. Provide iron pipe size (IPS) FRP conduits.

3. Provide suitable joint adhesive epoxy for the application.

4. FRP conduit shall be UL listed (UL 1684 - Standard for Safety for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings).

5. Manufacturer, or Equal

    a. **Champion Fiberglass**

F. Liquid-Tight Flexible Conduit

1. Provide liquid-tight flexible conduit constructed of a flexible galvanized metal core with a sunlight-resistant thermoplastic outer jacket.

2. Provide liquid-tight flexible conduit manufactured in accordance with the requirements of UL-360 - Steel Conduits, Liquid-Tight Flexible.

3. Manufacturer, or Equal

a. **Anaconda, Sealtite**

b. **Electriflex, Liquatite**

G. Electrical Metallic Tubing (EMT) or Intermediate conduit (IMC) will not be accepted.

2.3 FITTINGS AND BOXES

A. General

1. For use with metallic conduit, provide cast and malleable iron fittings of the threaded type with 5 full threads.

2. Fittings and Boxes

a. Provide fittings and boxes with neoprene gaskets and non-magnetic stainless steel screws.

b. Attach covers by means of holes tapped into the body of the fitting.

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

3. Provide boxes larger than standard cast or malleable types manufactured of Type 304 or Type 316 stainless steel, NEMA 4X.

4. Terminations

a. In outdoor areas, terminate conduit in rain-tight hubs as manufactured by Myers, O.Z. Gedney, Appleton, or equal.

b. In other than outdoor areas, provide sealed locknuts and bushings.

5. Hazardous Locations

a. In hazardous locations, provide conduit, fittings, and boxes suitable for the indicated Class and Division.

b. Provide conduits terminated in NEMA 7 boxes with a male bushing, **Adalet Type PEM**, or equal, inside the box.

B. Cast Aluminum Fittings and Boxes

1. Provide cast aluminum boxes and fittings with less than 0.40 percent copper content, and use with aluminum conduit.

2. Manufacturer, or Equal

   a. **O.Z. Gedney**

   b. **Appleton**

   c. **Crouse-Hinds**

C. Malleable Iron Fittings and Boxes

1. For use with galvanized steel conduit, provide fittings and boxes constructed of malleable iron or gray-iron alloy with zinc plating.

2. Manufacturer, or Equal

   a. **O.Z. Gedney**

   b. **Crouse-Hinds**

   c. **Appleton**

D. PVC Fittings and Boxes

1. For use with rigid non-metallic conduit, provide fittings manufactured of solvent-welded PVC.

2. Provide boxes manufactured of PVC or fiberglass reinforced polyester (FRP).

3. Manufacturer, or Equal

   a. **Carlon**

   b. **Crouse-Hinds**

   c. **Hoffman**

4. Provide welding solvent as required for the installation of non-metallic conduit and fittings.

E. PVC-Coated RGS Fittings

1. For use with PVC-coated RGS, provide PVC-coated coated that are the products of the same manufacturer as the conduit.

2. Provide male and female threads and internal surfaces with a 2-mil urethane coating.

F. Stainless Steel Boxes

1. Provide stainless steel boxes with PVC-coated RGS conduit and where indicated.

2. Provide NEMA 4X stainless steel boxes, constructed of Type 304 stainless steel.

3. Provide stainless steel of a minimum of 14-gauge thickness, with a brushed finish.

4. Door Hinges

a. Provide doors with full-length stainless steel piano hinges.

b. Non-hinged boxes will not be accepted.

5. Manufacturer, or Equal

a. **Hoffman**

b. **Rohn**

c. **Hammond**

G. Sheet Steel Boxes

1. Sheet steel boxes shall be galvanized steel outlet and switch boxes.

2. Manufacturer, or Equal

a. **Raco**

b. **Steel City**

c. **Appleton Electric**

2.4 WIREWAY

A. General

1. Provide wireway of the lay-in type and NEMA-rated for the area in which it is to be installed in accordance with the requirements of Section 26 00 00 – Electrical Work, General.

2. Separate power, control, signal and communications cables by grounded metallic dividers in wireways or run in separate wireways.

B. Fittings and Covers

1. Provide fittings and sections with non-magnetic stainless steel screws.

2. Attach covers by hinges and clamps to the bodies.

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

4. Provide covers and bodies constructed of aluminum or minimum 14-gauge steel.

C. Grounding

1. Ground the steel and aluminum wireway bodies.

2. Provide steel dividers with steel wireways or aluminum dividers with aluminum wireways, and ground by means of an individual grounding conductor.

3. Non-metallic dividers will not be accepted.

D. Terminations

1. In outdoor areas, terminate conduit in rain-tight hubs as manufactured by Myers, O.Z. Gedney, or equal.

2. In other than outdoor areas, provide sealed locknuts and bushings.

PART 3 -- EXECUTION

3.1 GENERAL

A. Run wiring in raceway unless indicated otherwise.

B. Install raceways between equipment as indicated.

C. Provide raceway systems that are electrically and mechanically complete before conductors are installed.

D. Bends and Offsets

1. Provide bends and offsets that are smooth and symmetrical, and accomplished with tools designed for this purpose.

2. Provide factory elbows wherever possible.

E. Combined Raceways

1. Raceways other than those containing power conductors may be combined in strict accordance with the NEC and with prior written permission from the ENGINEER.

2. In general, combine only raceways containing the same type (control, signal, and the like) and voltage of conductors/cables, or dedicated conduits from one source to one device/equipment, in accordance with the NEC.

3. Permission from the ENGINEER shall not relieve the CONTRACTOR of responsibility to meet national, state and local requirements.

4. Do not combine wiring for redundant systems into single raceways.

F. Routing

1. Where raceway routings are indicated, follow those routings to the extent possible.

2. Where raceways are indicated but routing is not indicated, such as home runs or on conduit developments and schedules, raceway routing shall be the CONTRACTOR's choice and provided in strict accordance with the NEC as well as customary installation practice.

3. Provide the raceway encased, exposed, concealed, or under-floor as indicated, except conceal conduit in finished areas unless specifically indicated otherwise.

4. Adjust routings in order to avoid obstructions.

G. Coordination

1. Coordinate between trades prior to installing the raceways.

2. The lack of such coordination shall not be justification for extra compensation, and any costs for removal and re-installation to resolve conflicts shall be part of the Contract Price.

H. Support rod attachment for ceiling-hung trapeze and cable tray installations shall meet the seismic requirements in the area where the Project is located.

I. Support wireways in accordance with the manufacturer's recommendations for the seismic requirements indicated in Section 26 00 00 – Electrical Work, General.

J. Install exposed raceways parallel or perpendicular to structural beams.

K. Expansion Fittings

1. Install expansion fittings with external bonding jumpers wherever exposed raceways cross building expansion joints.

2. Install expansion/deflection fittings where conduit movement is expected in more than one dimension, and where conduits transition out of structures in locations where differential settlement may occur.

3. Encased Expansion Fittings

a. Install encased expansion fittings wherever encased conduits cross building expansion joints.

b. Deflection type fittings shall not be required for encased conduits crossing an expansion joint within a single structure.

4. Provide expansion and expansion/deflection fittings constructed of the same material as the raceway to which they are installed.

L. Install expansion fittings with bonding jumpers wherever raceways cross building expansion joints.

M. Install exposed raceways at least 1/2 inch from walls or ceilings except that at locations above finished grade where damp conditions do not prevail, install exposed raceways at least 1/4 inch from the face of walls or ceilings by the use of clamp backs or struts.

N. Wherever contact with concrete or dissimilar metals can produce galvanic corrosion of equipment, provide a means of suitable insulation in order to prevent such corrosion.

3.2 CONDUIT

A. Provide exposed conduit manufactured of rigid aluminum, except as follows and unless indicated otherwise:

1. In areas with chlorine or sodium hypochlorite, provide Schedule 80 PVC conduit.

2. In Class I, Div I or Div II hazardous locations, provide rigid aluminum conduit.

3. For conduit containing only grounding system bonding conductors, provide Schedule 80 PVC conduit.

B. Power conduit encased in concrete shall be constructed of Schedule 40 PVC.

C. Analog control or instrumentation conduit shall be RGS.

D. Concrete Encasement

1. Where PVC or RGS conduit is stubbed up from a concrete encasement, provide a PVC-coated RGS elbow.

2. The conduit shall emerge from the concrete in a direction perpendicular to the surface whenever possible.

3. Do not encase conduit in the bottom floor slab below grade.

4. Do not encase conduits in the floor slabs of water bearing structures.

5. Do not encase conduits below equipment pads.

E. Size

1. Provide exposed conduit of 3/4-inch minimum trade size.

2. Provide encased conduit of one-inch minimum trade size.

F. Install supports at distances required by the NEC.

G. Concrete cover for conduit and fittings shall not be less than 1-1/2 inches for concrete exposed to earth or weather, or less than 3/4 inch for concrete not exposed to weather or in contact with the ground.

H. Penetrations

1. Provide conduit passing through walls or floors with plastic sleeves.

2. Perform core drilling in accordance with the requirements of Section 26 00 00 – Electrical Work, General.

3. Conduits passing through a slab, wall, or beam shall not significantly impair the strength of the construction.

I. Conduits embedded within a slab, wall, or beam (other than those merely passing through) shall meet the following requirements:

1. Conduits with their fittings embedded within a column shall not displace greater than 4 percent of the gross area of cross section;

2. Conduits shall not be larger in outside dimension than 1/3 the overall thickness of the slab, wall, or beam in which it is embedded; and,

3. Conduits shall not be spaced closer than 3 outside diameters on centers.

J. Place the conduit such that cutting, bending, or displacing reinforcement from its proper location will not be required.

K. Coat threads with a conductive lubricant before assembly.

L. Joints

1. Provide joints that are tight, thoroughly grounded, secure, and free of obstructions in the pipe.

2. Adequately ream the conduit in order to prevent damage to the wires and cables inside.

3. Use strap-wrenches and vises to install the conduit, in order to prevent wrench marks on the conduit.

4. Replace conduit with wrench marks.

5. Where installed in chemical or fuel containment areas, the conduit shall not have joints or fittings located below the top of the containment area to prevent entry of chemicals or fuel into the conduit system.

M. Slope

1. Wherever possible, slope the conduit runs to drain at one or both ends of the run.

2. Wherever conduit enters a substructure below grade, slope the conduit in order to drain water away from the structure.

3. Take extreme care in order to avoid pockets or depressions in the conduit.

N. Where conduits from duct banks enter building walls below grade, transition to PVC-coated RGS at least 12" outside the wall. Installation of PVC-coated rigid steel conduit though a core-drilled hole in an exterior wall below-grade shall utilize a sealing device as manufactured by **Link Seal**, or equal.

O. Connections

1. Make connections to lay-in-type grid lighting fixtures by using flexible metal conduit not exceeding 4 feet in length.

2. Make connections to motors and other equipment subject to vibration by using liquid-tight flexible conduit not exceeding 3 feet in length.

3. Provide equipment subject to vibration that is normally provided with wiring leads with a cast junction box for the make-up of connections.

P. Provide conduit seal fittings in hazardous classified locations, in strict accordance with the NEC.

Q. Provide conduit, fittings, and boxes required in hazardous classified areas that are suitably rated for the area, and provide in strict accordance with NEC requirements.

R. Duct sealant shall be foam duct sealant such as **Polywater FST or approved equal.** Provide duct sealant at the following locations:

1. Where required by NEC Article 300.7.

2. In areas where chlorine gas or fumes from sodium hypochlorite exist to prevent passage of gas through the raceway system.

S. Empty Conduits

1. Tag empty conduits at both ends to indicate the final destination.

2. Where it is not possible to tag the conduit, identify the destination by means of a durable marking on an adjacent surface.

3. Install a pull-cord in each empty conduit in floors, panels, manholes, equipment, and the like.

4. Install a removable plug on empty conduits that terminate below grade, in vaults, manholes, handholes, and junction or pullboxes.

T. Identification of Conduits

1. Identify conduits at ends and at pulling points.

2. Identification shall be the unique conduit number assigned in the Contract Documents.

3. Other than 120 VAC panelboard circuits, if a conduit has not been assigned a unique number in the Contract Documents, assign a unique number following the numbering scheme used in the Contract Documents.

4. Assign a unique number to 120 VAC panelboard circuits, similar to the cable numbering scheme used in the Contract Documents.

5. Provide conduit identification by a stamped or engraved non-corroding metal tag attached to the conduit bushing.

6. Provide an engraved phenolic nameplate in accordance with the requirements of Section 26 00 00 – Electrical Work, General, or a computer printed self-adhesive label attached to the equipment or enclosure inside which the conduit terminates.

7. Markings with a pen or paint will not be accepted.

U. Identification of Pullboxes and Junction Boxes

1. Identify pullboxes and junction boxes.

2. Identification shall be the unique conduit number assigned in the Contract Documents, or if not assigned a unique number the CONTRACTOR shall assign one following the numbering scheme used in the Contract Documents.

3. Provide box identification by a stamped or engraved non-corroding metal tag or an engraved phenolic nameplate, in accordance with the requirements of Section 26 00 00 – Electrical Work, General, and attached to the box or enclosure.

4. Markings with a pen or paint will not be accepted.

V. Provide conduit for data cables in accordance with the equipment manufacturer's recommendations, especially regarding separation from low- and medium-voltage power raceways.

END OF SECTION

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SECTION 26 05 36
WIRING DEVICES

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide wiring devices, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 26 00 00 – Electrical Work, General apply to this Section.

C. Single Manufacturer

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

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 –Submittal Procedures.

B. Shop Drawings

1. Submit complete catalog cuts of switches, receptacles, enclosures, covers and appurtenances, marked to clearly identify the proposed materials.

2. Submit documentation showing that the proposed materials comply with the requirements of NEC and U.L.

3. Submit documentation of the manufacturer's qualifications.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Devices shall carry the U.L. label, and shall be designed for use with stranded copper conductors.

B. Color

1. General purpose duplex receptacles and toggle switch handles shall be Brown everywhere except unless otherwise indicated.

2. Special purpose receptacles shall have a body color as indicated.

C. Receptacles and switches shall be of specification grade and shall conform to NEMA WD-1, Federal Specifications W-C-596E and W-S-896E, respectively.

2.2 LIGHTING SWITCHES

A. Toggle switches shall be AC only type switch.

1. 20A, 120/277V, Single, Double, 3-Way and 4-Way, Respectively

a. **Leviton**: 1221-2, 1222-2, 1223-2, 1224-2

b. **Hubbell:** HBL1221, HBL1222, HBL1223, HBL1224

c. **Pass and Seymour:** PS20AC1, PS20AC2, PS20AC3, PS20AC4

d. Or Equal

2. Hazardous Location Switches, shall be factory-sealed, 20A, 120-277VAC

a. **Appleton**: EDS

b. **Crouse-Hinds**: EDS

c. **Hubbell Killark**: FXS

d. Or Equal

2.3 GENERAL PURPOSE RECEPTACLES

A. Duplex receptacles shall be of the polarized 3-wire type for use with a 3-wire cord with grounded lead, and one designated stud shall be permanently grounded to the conduit system in accordance with NEC article 406.4.

B. Dry Areas

1. NEMA Configuration #5-20R: duplex receptacle rated 125V, 20A

a. **Leviton:** #5362

b. **Hubbell:** #HBL5362

c. **Pass and Seymour:** #5362A

d. Or Equal

C. Damp/Wet Areas

1. Receptacles for damp/wet locations shall be weather-resistant with extra duty, in-use listed covers in accordance with NEC Article 406.8.

D. GFCIs

1. Ground-fault circuit-interrupting receptacles (GFCIs) shall be installed at the indicated locations and as required by the NEC.

2. GFCIs shall be duplex receptacles, of specification grade, and tripping at 5 mA.

3. GFCI ratings shall be 125V, 20 amperes, NEMA WD-1, Configuration 5-20R, and capable of interrupting 5,000 amperes without damage.

4. GFCIs shall be weather resistant-listed in accordance with NEC Article 406.8.

5. Feed-through-type GFCIs serving standard receptacles will not be permitted.

   a. **Leviton:** G5362-WT

   b. **Hubbel:** GFR5362SG

   c. Or Equal

E. Hazardous Locations

1. Receptacles for hazardous locations shall be of the single-gang type with a spring door.

2. The receptacles shall be provided with a factory-sealed chamber.

3. The receptacles shall be provided with a delayed action feature requiring the plug to be inserted into the receptacle and rotated before the electrical connection is made.

4. The receptacle shall not work with non-hazardous rated plugs.

5. One plug shall be furnished with each receptacle.

6. The receptacles shall be rated for 20 amps at 125 VAC.

   a. **Appleton:** EFSB

   b. **Crouse-Hinds:** ENR

   c. **Hubbell Killark:** UGR

   d. Or Equal

7. Ground-Fault Protection: where indicated, hazardous location receptacles shall be provided with ground fault protection.

   a. **Appleton** EFSR-GFI

b. **Crouse-Hinds** GFS-1

c. **Hubbell Killark:** UGRGF

d. Or Equal

2.4 ENCLOSURES AND COVERS

A. Surface-mounted switches and receptacles shall be housed in FS or FD-type weatherproof conduit fittings.

B. Switch and receptacle covers on surface-mounted boxes shall be constructed of die-cast copper-free aluminum.

1. **Appleton**: FSK

2. **Crouse-Hinds**: DS185 and WLRD-1

3. **Hubbell Killark**: FZ and FC

4. Or Equal

C. In finished areas, switch and receptacle covers shall be constructed of stainless steel.

D. Wet Locations

1. Receptacles in wet locations shall be provided with a hinged non-metallic Clear cover/enclosure marked "Suitable for Wet Locations when in use" and "UL Listed."

2. Provide a gasket between the enclosure and the mounting surface, and between the hinged cover and mounting plate/base.

a. **Appleton**: WCIU

b. **Crouse-Hinds**: TP74

c. **Hubbell TayMac:** Extra Duty

d. Or Equal

2.5 NAMEPLATES

A. Provide nameplates or equivalent markings on the switch enclosures to indicate the ON and OFF positions of each switch.

B. ON and OFF for 3-way or 4-way switches will not be accepted.

C. Provide receptacles for special purposes with nameplates indicating their use.

D. Nameplates shall meet the requirements of Section 26 00 00 – Electrical Work, General.

PART 3 -- EXECUTION

3.1 GENERAL

A. Perform WORK in accordance with the requirements of the NEC.

3.2 CONNECTION

A. Rigidly attach wiring devices in accordance with the NEC and as indicated, avoiding interference with other equipment.

B. Securely fasten nameplates using screws, bolts, or rivets centered under or on the device, unless otherwise indicated.

C. Receptacles indicated to be powered by uninterruptible power supplies (UPS) shall have a nameplate installed directly above the receptacle that reads:

1. (first line) “UPS-POWERED”

2. (second line) “NO TOOLS”

D. Nameplates shall meet the requirements of Section 26 00 00 – Electrical Work, General, and shall consist of a red plate with white letters a minimum of 1/4 inch tall.

3.3 GROUNDING

A. Devices, including switches and receptacles, shall be grounded in accordance with NEC, Article 250, and Section 26 05 26 – Grounding.

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

C. Flush Receptacles

1. Flush receptacles and their metal plates shall be grounded through positive ground connections to the outlet box and grounding system.

2. Maintain the ground to each receptacle by a spring-loaded grounding contact to the mounting screw, or by a grounding jumper, each making a positive connection to the outlet box and grounding system at all times.

D. Receptacles served from an uninterruptible power supply shall be provided with an isolated grounding conductor from the serving power panelboard.

3.4 FIELD TESTING

A. Provide checkout, field, and functional testing of wiring devices in accordance with Section 26 00 00 – Electrical Work, General.

B. Test each receptacle for polarity and ground integrity, using a standard receptacle tester.

END OF SECTION

SECTION 26 05 43
UNDERGROUND RACEWAY SYSTEMS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide underground raceway systems, complete and in place, as indicated in accordance with the Contract Documents.

B. Manholes, pullboxes, and fittings that are dedicated to the underground raceway system shall comply with the requirements of this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals, and Section 26 00 00 – Electrical Work, General.

B. Shop Drawings

1. Submit complete catalog cuts of all raceways, fittings, pullboxes, and manholes, marked where applicable in order to show proposed materials and finishes.

C. As-Built Drawings

1. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.

2. Show routings, burial depths, manhole and handhole locations and sizes, and where applicable, connections to drainage systems.

3. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00 – Submittals Procedures.

PART 2 -- PRODUCTS

2.1 MANHOLES AND PULLBOXES

A. Frames and Covers

1. Provide traffic-type covers with an H-20 loading, except as otherwise indicated.

2. Identify manhole and pullbox covers as "ELECTRIC" by providing raised letters cast into the covers.

3. Provide frost-proof and water-tight grey iron frames and covers with solid lids and inner lids, and with 28-inch clear openings.

4. Bolt the covers and lids to cast-in-place steel frames using corrosion-resistant hardware.

5. Factory-prime the frames.

6. Provide covers constructed of cast-iron, and provide pick holes.

7. Provide frames with a 1/2-inch drilled and tapped hole and lug in order to accommodate a No. 4/0 AWG bare stranded copper conductor connected to a ground rod and the ground conductor of power cables passing through the manhole.

8. Manhole frames and covers shall be **Neenah Foundry No. NF-1755GT18** or equal.

B. Equip manholes and pullboxes with pulling-in irons, opposite and below each ductway entrance.

C. Provide manholes and pullboxes with closed bottoms; open-bottom manholes and pullboxes will not be accepted.

D. Provide PVC ductbank conduits with end bells.

E. Brackets

1. Provide non-metallic, non-conductive brackets and stanchions in manholes as required for racking wiring through the manholes. Attach to manhole walls using stainless steel anchors and hardware.

2. Brackets and stanchions: **Underground Devices, Inc.,** or equal.

F. Precast Manholes and Pullboxes Manufacturer, or Equal

1. **Jensen Precast**

2. **Mack**

3. **Quikset**

4. **U.S. Precast**

2.2 DUCTBANKS

A. Provide underground ducts constructed of Schedule 40 PVC.

B. Ductbanks

1. Ductbanks shall contain a No. 4/0 bare stranded copper ground wire.

2. The ground wire shall be continuous through the ductbank and terminate at power distribution equipment and the grounding grid.

C. Identification Tape

1. Provide continuous lengths of underground warning tapes located 12 inches above and parallel to the ductbanks.

2. Provide tape consisting of 6-inch wide polyethylene film, imprinted with "CAUTION - ELECTRIC UTILITIES BELOW."

3. Provide tape that contains a non-ferrous metal foil conductor sandwiched in the tape for detection purposes.

4. Tape Manufacturer, or Equal: **Brady**

PART 3 -- EXECUTION

3.1 GENERAL

A. Install underground raceways between manholes and pullboxes as indicated.

B. Raceway systems shall be electrically and mechanically complete before conductors are installed.

C. Provide bends and offsets that are smooth and symmetrical, and fabricated with tools designed for this purpose.

D. Use factory elbows wherever possible.

E. To the extent possible, follow the raceway routings as indicated on the Drawings.

F. Adjust the indicated routings as necessary in order to avoid obstructions.

G. Coordination with Other Trades

1. Coordinate with other trades prior to installation of raceways.

2. The lack of coordination shall not be justification for extra compensation.

3. Perform removal and re-installation to resolve conflicts as part of the WORK.

3.2 DUCTBANKS

A. Install ductbanks in accordance with the following criteria:

1. Assemble the duct using high-impact, non-metallic spacers and saddles in order to provide conduits with vertical and horizontal separation.

2. Set the plastic spacers every 5 feet.

3. Anchor the duct array every 5 feet in order to prevent movement during backfill.

4. Lay the duct on a grade line of at least 3 inches per 100 feet, sloping towards pullboxes or manholes.

5. Install the duct and adjust the pullbox and manhole depths such that the top of the highest conduits is a minimum of 24 inches below grade and a minimum of 30 inches below roadways.

6. Accomplish changes in direction of the duct envelope by more than 10 degrees horizontally or vertically by using bends with a minimum radius 24 times the duct diameter.

7. Stagger duct couplings a minimum of 6 inches.

8. Provide select backfill or sand for the the trench.

9. Cleaning

    a. Clean each bore of the completed ductbank by drawing through it a standard flexible mandrel, one foot long and 1/4 inch smaller than the nominal size of the duct.

    b. After passing the mandrel, draw through a wire brush and swab.

10. For spare raceways that are not indicated to contain conductors, provide a 1/8-inch polypropylene pull cord installed throughout the entire length of the raceway.

B. Grout duct entrances smooth, and terminate ducts with flush end bells.

C. Assemble sections of pre-fabricated manholes and pullboxes using waterproof mastic, and set on a 12-inch bed of gravel as recommended by the manufacturer or as required by field conditions.

D. Provide watertight ductbank penetrations through walls of manholes, pullboxes, and building walls below grade.

E. Where ducts enter buildings, provide duct sealant in every duct at the building-end of the duct run to prevent water or condensation entry from the duct bank into the building. Duct sealant shall be Polywater FST, Polywater FST-Mini, or equal.

F. When duct enters the building on a concrete slab on grade, transition to rigid steel PVC-coated conduits on stub-ups.

G. Sealing

1. Where an underground conduit enters a structure through a concrete roof or a membrane-waterproofed wall or floor, provide a **Link-Seal** or equal sealing device.

2. Use the sealing device with rigid steel conduit.

3. Transition from PVC to rigid steel conduit prior to building entry.

END OF SECTION

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SECTION 26 05 50
ELECTRIC HEAT TRACING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide electric heat tracing systems, complete and operable, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

ISA-S 5.1 Instrumentation Symbols and Identification.

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

B. Shop Drawings

1. Show the location of thermostats and interphasing with electric power supply.

2. Manufacturer's Data: Complete manufacturer's data of the electric heating cables and the thermostats.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Heat tracing shall consist of spiral wrapping with electrical heating cables as recommended by manufacturer under insulation with fiber glass sections, sealed and weatherproofed per Section 23 07 00 - Pipe and Equipment Insulation. The heating cables shall be controlled from thermostats installed in representative locations and accessible for adjustment. The heat tracing systems shall be installed complete, including heating elements, power connections, end seals, and controlling thermostats in accordance with the manufacturer's printed installation instructions. Heat tracing systems shall be 120v.

2.2 BASIC MATERIALS

A. Heating Cable: The electrical heat tracing system shall consist of a flat, flexible, low heat density, electrical heating strip of parallel construction, consisting of a continuous inner core of conductive material between 2 parallel copper bus strips. The electrical insulation of the heater strip shall be polyester rated for 140 degrees F temperature, and its width shall be a minimum of 1/2-inch. It shall be suitable for operation on 120 volts.

B. Thermostats: A thermostat with a range of 40 degrees to 120 degrees F shall be provided for each heated pipe. It shall be double-pole, single-throw, and be mounted in a weatherproof NEMA Type 4 enclosure. The capillary bulb shall be mounted on the pipe under the insulation. Heating strips for pipes over 2-inches in size shall be rated at 8 watts per foot; for pipes 2-inches and smaller they shall be rated at 4 watts per foot.

C. Manufacturers, or equal

1. **Briscoe Manufacturing Co.**

2. **Chromalox (Emerson Electric Co.)**

3. **Nelson Electric (A Unit of General Signal)**

4. **Raychem Corporation**

5. **Thermon Manufacturing Company**

6. For thermostats: **Honeywell, Chromalox**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. General

1. Pipes, valves, equipment and appurtenances shall be provided with heat tracing where indicated. Where not indicated, heat tracing shall be provided in all cases where items could be endangered by freezing.

2. The CONTRACTOR shall assemble and install equipment in strict accordance with the manufacturer's published instructions under the supervision of the manufacturer's representative. Installation shall be accomplished by competent craftsmen in a workmanlike manner. Heating strips shall be cut in the field and wrapped on the pipelines as required.

B. Contractor Coordination: The CONTRACTOR shall coordinate installation with the electrical WORK, to ascertain the correct location of electrical outlets.

C. Electrical Circuit: The CONTRACTOR shall provide heat tracing electric circuits in accordance with the National Electrical Code, NFPA 70, Article 427. Ground fault protection shall be provided for the heat tracing by a Class B GFCI circuit breaker with 30 mA trip. The GFCI circuit breaker may be installed in the panelboard feeding the circuit or in an enclosure by the heat traced equipment.

3.2 TESTING

A. The CONTRACTOR shall prepare the equipment for operational use in accordance with the manufacturer's printed instructions. Each system shall be tested for proper operation and the thermostats shall be set.

3.3 ACCEPTANCE

A. Final acceptance of the equipment is contingent on satisfactory appearance and operation.

END OF SECTION

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SECTION 26 05 73
PROTECTIVE DEVICE STUDIES

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall perform the indicated short circuit and protective device studies for the electrical power system in accordance with the Contract Documents.

B. The WORK of this Section shall include protection studies for motors with solid state overload and overcurrent protection devices.

C. It is the responsibility of the CONTRACTOR to obtain the information required from the electric utility and appropriate vendors.

1.2 QUALIFICATIONS

A. Short circuit studies, protective device evaluation studies, arc-flash hazard analysis studies, and protective device coordination studies shall be performed by a manufacturer who has been regularly engaged in short circuit and protective device coordination services for a period of at least 10 years.

B. The indicated studies shall be signed by the professional electrical engineer, registered in the State of Utah, responsible for the studies.

C. The studies shall utilize computer programs with proven reliability and accuracy for performing 3-phase fault-duty calculations.

1.3 CONTRACTOR SUBMITTALS

A. The indicated studies shall be submitted and approved by the ENGINEER prior to final approval of the distribution equipment Shop Drawings and release of equipment for manufacture.

B. An initial short circuit study shall be submitted and reviewed before the ENGINEER will approve the Shop Drawings for medium-voltage switchgear, transformers, or 480-volt distribution equipment.

C. Submit an initial protective device coordination study shall be submitted with 90 days after the approval of the initial short circuit study.

D. The short circuit, arc-flash hazard analysis, and protective device coordination studies shall be updated prior to Project Substantial Completion; utilize characteristics of as-installed equipment and materials.

E. The adequacy of the equipment "withstand" and interruption ratings shall be approved by the ENGINEER.

1.4 MANUFACTURERS' SERVICES

A. The low-voltage motor control center manufacturer shall furnish the services of a qualified field engineer and necessary tools and equipment in order to test, calibrate, and adjust the protective relays and circuit breaker trip devices as recommended in the power system coordination study.

B. The motor control center manufacturer shall furnish the services of a qualified field engineer to calibrate the MCPs as recommended in the power system study.

PART 2 -- PRODUCTS – NOT USED

PART 3 -- EXECUTION

3.1 GENERAL

A. The studies shall include development of single-line and impedance diagrams of the power system.

B. The diagrams shall identify components considered in the study and the ratings of power devices, including transformers, circuit breakers, relays, fuses, busses, and cables.

C. The resistances and reactances of cables shall be identified in the impedance diagram.

D. The studies shall contain written data from the electric utility company regarding maximum available short circuit current, voltage, and X/R ratio of the utility power system.

E. The studies shall include every protective device and feeder included or modified within the WORK.

F. The first upstream overcurrent device outside the WORK shall be used as a fixed reference.

G. The studies shall include all portions of the electrical distribution system for normal and standby power sources down to and including the 480-volt distribution system.

3.2 SHORT CIRCUIT STUDY

A. The short circuit study shall be performed with the aid of a digital computer program, and shall be in accordance with the following Standards:

ANSI/IEEE 141	Recommended Practice for Electrical Power Distribution for Industrial Plants ANSI/IEEE 242 Recommended Practice for Protection, and Coordination of Industrial, and Commercial Power Systems
ANSI/IEEE C 37.010	Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

ANSI/IEEE C 37.13 Low-Voltage AC Power Circuit Breakers Used in Enclosures

3.3 PROTECTIVE DEVICE EVALUATION STUDY

A. A protective device evaluation study shall be performed in order to determine the adequacy of circuit breakers, molded case switches, and fuses.

B. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the attention of the ENGINEER.

C. Do not utilize series-rated circuit breakers to meet short circuit requirements for this project.

D. Devices shall be fully rated to withstand available fault currents.

3.4 PROTECTIVE DEVICE EVALUATION STUDY

A. A protective device coordination study shall be performed in order to develop the necessary calculations to select power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low-voltage breaker trip characteristics and settings.

B. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the ENGINEER's attention.

3.5 TIME/CURRENT COORDINATION CURVES

A. As a minimum, the time/current coordination curves for the power distribution system shall include the following items plotted on 5-cycle log-log graph paper:

1. time/current curves for each protective relay, circuit breaker, or fuse demonstrating graphically that the settings will provide protection and selectivity within industry standards

2. Each curve shall be identified, and tap and time dial settings shall be specified.

3. Provide individual curves for each feeder unless identical to others.

4. Selectivity

a. Time/current curves for each device shall be positioned to provide the maximum selectivity to minimize system disturbances during fault clearing.

b. Where selectivity cannot be achieved, the ENGINEER shall be notified as to the cause.

c. Recommendations shall be included for alternate methods that would improve selectivity.

5. time/current curves and points for cable and equipment damage.

6. circuit interrupting device operating and interrupting times

7. Indicate maximum fault values on the graph.

8. sketch of bus and breaker arrangement

9. magnetizing inrush points of transformers

10. thermal limits of dry-type and liquid-insulated transformers (ANSI damage curve)

11. Every restriction of the ANSI and National Electrical Code shall be followed, and proper coordination intervals and separation of characteristics curves shall be maintained.

3.6 ARC FLASH STUDY

A. An arc flash study shall be performed with the aid of a digital computer program in order to determine the "Arc Flash Protection Boundary" and "Personal Protective Equipment" (PPE) levels for applicable electrical distribution equipment, stand-alone disconnects, starters, and VFDs in the power distribution system.

B. The arc flash study shall be performed in conjunction with short circuit calculations and protective device coordination.

C. The arc flash study shall be in accordance with the latest version of the following Standards:

1. NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces

2. IEEE 1584 IEEE guide for performing Arc Flash Hazard Calculations

3. OSHA (29 CFR PART 1910) Occupational Safety and Health Standards for General Industry

4. ANSI Z535.4 Product Safety Signs and Labels

D. The recommended values for the "Arc Flash Protection Boundary" and PPE levels, based on the arc flash study results, shall be tabulated in the study.

E. Labeling

1. The digital computer program shall provide the “Arc Flash Protection Boundary” and PPE values in a format that can be directly printed on to labels.

2. The CONTRACTOR shall provide these labels in accordance with Section 26 00 00 – Electrical Work, General.

3.7 FINAL SUMMARY REPORT

A. Summarize the results of the indicated power system studies in a final report.

B. The report shall include the following items:

1. single-line diagram
2. impedance diagram
3. tabulation of all protective devices identified on the single line diagram
4. time/current coordination curves
5. specific recommendations, if any
6. test instrumentation, condition, and connections, as applicable, for each study
7. computerized fault current calculations
8. any suggested changes to the protection scheme or equipment selection that will result in improved system reliability and safety
9. recommendations to minimize the arc flash energy

C. The report shall include information concerning the computer program used for the study, as well as a general discussion of the procedure, items, and data considered in the preparation of the study.

D. Submit eight bound copies of the report to the ENGINEER.

3.8 PROTECTIVE DEVICE TESTING, CALIBRATION, AND ADJUSTMENT

A. Test, calibrate, and adjust the protective relays and circuit breaker trip devices in accordance with the recommendations in the power system coordination study.

B. Calibrate the MCPs as in accordance with the recommendations in the power system study.

C. Adjustments shall be made prior to energizing any electrical equipment.

END OF SECTION

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SECTION 26 12 16
PANELBOARDS AND GENERAL PURPOSE DRY TYPE TRANSFORMERS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide panelboards and general purpose dry-type transformers, complete and operable, in accordance with the Contract Documents.

B. Single Manufacturer

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

2. The equipment specified under this section shall be provided by the same manufacturer as the equipment provided in the following sections:

a. Section 26 24 13 – 480V Switchboard

b. Section 26 29 00 – Low-Voltage Motor Control Centers

c. Section 26 29 13 - Solid-State Reduced Voltage Starting

1.2 CONTRACTOR SUBMITTALS

A. General: Submittals shall be in accordance with Section 01 33 00 – Submittal Procedures and Section 26 00 00 - Electrical Work, General.

B. Shop Drawings

1. Transformers

a. Dimension drawings

b. Technical certification sheets

c. Drawing of conduit entry/exit locations

d. Transformer ratings, including:

1) Voltage

2) Continuous current

3) Basic impulse level for equipment over 600 volts

4) KVA

e. Descriptive bulletins

f. Product sheets

2. Panelboards

a. Breaker layout drawings with dimensions and nameplate designations

b. Component list

c. Drawings of conduit entry/exit locations

d. Assembly ratings including:

1) Short circuit rating

2) Voltage

3) Continuous current

e. Cable terminal sizes

f. Descriptive bulletins

g. Product sheets

h. Installation information

i. Seismic certification and equipment anchorage details

PART 2 -- PRODUCTS

2.1 GENERAL

A. Transformers

1. The transformers shall be dry-type, designed, manufactured, and tested in accordance with the latest applicable standards of ANSI and NEMA.

2. Transformers shall be UL-listed and bear the UL label.

B. Panelboards

1. Panelboards shall be dead front factory assembled. Panelboards shall comply with NEMA PB-1-Panelboards, as well as the provisions of UL 50 - Safety Enclosures for Electrical Equipment and UL 67 - Safety Panelboards. Panelboards used for service equipment shall be UL labeled for such use. Lighting panelboards shall be rated for 120/208 volt, 3 phase operation or

120/240 volt for single phase operation as indicated. Power panelboards shall be rated for 480 volts, 3 phase, 3 wire operation, unless indicated otherwise.

2. The manufacturer of the panelboard shall be the manufacturer of the major components within the assembly, including circuit breakers.

2.2 TRANSFORMERS

A. Energy Efficiency: Standard dry-type transformers shall meet the energy efficiency requirements of the Department of Energy Code of Federal Regulations (10 CFR PART 431), DOE 2016 Efficiency Levels.

B. Ratings

1. KVA and voltage ratings shall be as indicated.

2. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96 - Guide for Loading Dry Type Distribution and Power Transformers

3. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:

Up to 9 kVA	40 dB
10 to 50 kVA	45 dB
51 to 150 kVA	50 dB

C. Construction

1. Insulation Systems

a. Transformers shall be insulated as follows:

1) 2 kVA and smaller: 150 deg C insulation system based upon 80 deg C rise.

2) 3 to 15 kVA: 185 deg C insulation system based upon 115 deg C rise.

3) 15 kVA and larger: 220 deg C insulation system based upon 150 deg C rise.

b. Required performance shall be obtained without exceeding the above indicated temperature rise in a 40 deg C maximum ambient.

c. Insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM D 635 - Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.

2. Transformer windings shall be copper.

3. Transformers shall have four 2-1/2 percent taps, 2 above and 2 below 480 volts.

4. Transformer shall include vibration dampeners between the core and the enclosure to minimize and isolate sound transmission.

2.3 MANUFACTURER, or equal:

A. **Eaton**

B. **ABB**

C. **Schneider Electric**

D. **Siemens**

2.4 PANELBOARDS

A. Ratings

1. Panelboards rated 240 VAC or less shall have short circuit ratings not less than 10,000 amperes RMS symmetrical or as indicated by the Short Circuit Study, whichever is greater.

2. Panelboards rated 480 VAC shall have short circuit ratings not less than 65,000 amperes RMS symmetrical or as indicated by the Protective Device Study, whichever is greater.

3. Panelboards shall be labeled with a UL short circuit rating. Series ratings are not acceptable.

B. Construction

1. Lighting and power distribution panels shall have tin-plated copper bus bars.

2. Breakers shall be one, 2, or 3 pole as indicated, with ampere trip ratings as required by the equipment. Breakers shall be quick-make and quick-break, inverse time trip characteristics, to trip free on overload or short circuit, and to indicate trip condition by the handle position.

3. The panels shall have hinged doors with combination catch and latch. The front panels shall be so arranged that when the plates are removed, the gutters, terminals and wiring will be exposed and accessible. The doors shall have inner

doors within the plates to have only the breaker operating mechanism exposed when they are opened. Live conductors and terminals shall be concealed behind the plates.

4. Panelboards shall be rated for the intended voltage.

5. Circuit breakers shall be interchangeable and capable of being operated in any position as well as being removable from the front of the panelboard without disturbing adjacent units. No plug-in circuit breakers will be acceptable.

6. Lighting and power distribution panels which are not part of a motor control center shall be constructed in accordance with Section 26 00 00 – Electrical Work, General. Panels shall have the necessary barriers, supports, and liberal wiring gutters. Trim screws shall be stainless steel. Panelboard parts of metal other than copper, aluminum, or stainless steel shall be cadmium plated.

7. Panelboards shall be UL listed except for special enclosures which are not available with UL listing.

8. Panelboards shall be suitable for use as service entrance where indicated.

C. Surge Protection Devices (SPD)

1. Provide integral SPDs. SPDs shall conform to Section 26 43 00 – Surge Protection Devices.

2. SPD units shall be rated for the voltage and phase service of the panel at 120 kA per phase.

2.5 MANUFACTURER, or equal:

A. **Eaton**

B. **ABB**

C. **Schneider Electric**

D. **Siemens**

PART 3 -- EXECUTION

3.1 GENERAL

A. WORK of this Section shall be installed as indicated in Section 26 00 00 – Electrical Work, General.

END OF SECTION

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SECTION 26 13 13
MEDIUM VOLTAGE METAL-CLAD SWITCHGEAR

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide medium voltage metal clad switchgear, complete and operable, in accordance with the Contract Documents.

B. The switchgear shall be provided by the manufacturer of the Standby Generation system to ensure proper coordination between generator and swithchgear.

C. The requirements of Section 26 00 00 - Electrical Work, General, apply to the WORK of this Section. Coordinate this equipment with the Generator supplied in Section 26 32 13 - Standby Power Generation.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

1. IEEE C37.6, Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Preferred Ratings and Related Capabilities for Voltages Above 1000 V

2. IEEE C37.04, Standard Rating Structure for AC High-Voltage Circuit Breakers (includes supplements C37.04A, C37.04BI)

3. IEEE C37.20.2, Standard for Metal-Clad Switchgear

4. IEEE C57.13, Standard Requirements for Instrument Transformers

5. IEEE C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus

B. Codes

1. ANSI/NFPA 70 National Electrical Code

2. NFPA 110 Standard for Emergency and Standby Power Systems

1.3 SYSTEM DESCRIPTION

A. Outdoor**,** protected aisle, metal clad switchgear intended for use on 12.47 KV, 3-phase 3 wire grounded, 60-Hz system. Switchgear shall be rated as indicated on drawings and have removable-element vacuum circuit breakers. Enclosures and circuit breaker(s), as a unit, shall have a basic impulse rating of 95 KV. Switchgear, including circuit breakers, meters, and relays, shall be factory tested.

B. Equipment shall be completely factory-built, assembled, wired, and tested. All equipment and components shall be of new construction.

1.4 CONTRACTOR SUBMITTALS

A. Submittals shall conform to the requirements of Section 26 00 00.

1. Engineering data to include voltage, current, and short-circuit ratings.

2. Outline dimensions to include available space for conduits, stress cone type cable terminations, and cable supports.

3. Certified copies of all Type (Design) and Verification Test Reports on a specified product.

4. Copies of installation, operation and maintenance procedures.

5. Operation and maintenance data based on factory and field testing, operation and maintenance of specified product.

6. Certified factory test reports

7. Final factory drawings shall be provided in an electronic format as well as hardcopy format. Provide electronic files in DXF CAD format.

1.5 QUALITY ASSURANCE

A. General: All materials shall be tested and inspected in accordance with Section 26 00 00 and the following requirements.

B. Manufacturer shall have specialized in the manufacture and assembly of medium voltage metal clad switchgear for a minimum of 25 years.

C. Manufacturer's Certificate of ISO 9002 Compliance.

D. Switchgear shall be qualified for use in seismic areas as defined on Sheet 00-S-001

1.6 PROJECT CONDITIONS (SITE ENVIRONMENTAL CONDITIONS)

A. The switchgear shall be designed for continuous duty service in the environmental conditions in Section 26 00 00.

B. Follow standard service conditions before, during and after switchgear installation.

1.7 MAINTENANCE AND GUARANTEE

A. The CONTRACTOR shall submit recommended spare part lists.

B. Special tools and equipment for system and equipment maintenance shall be furnished.

C. Manufacturer warrants equipment to be free from defects in materials and workmanship for 1 year from date of installation or 18 months from date of purchase, whichever occurs first.

D. The CONTRACTOR shall guarantee that the furnished equipment shall meet the requirements specified herein and specified elsewhere in the Contract Documents.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Switchgear shall consist of breakers, transfer controls, generator controls and auxiliary units, as indicated on drawings, assembled to form a rigid, self-supporting, metal-enclosed structure. The switchgear shall be provided in compliance with this Specification and with all applicable NEMA and ANSI standards. All major components shall be provided by **Eaton, Schneider, ABB,** or equal, establishing one source of responsibility for the equipment performance and assuring high standards in quality, coordination, reliability, and service.

B. Switchgear shall be **Eaton's VCP-W Metal- Clad Switchgear, Schneider's HVL Switchgear, ABB's Advance Medium Voltage Metal- Clad Switchgear,** or equal.

C. Switchgear assembly shall be UL listed and be labeled where possible.

D. The bus bar(s) shall be tin-plated copper and fully insulated; copper shall be silver plated at joints. A full-length tin-plated copper ground bus bar shall be provided at the bottom of the switchgear enclosure.

E. For rigidity during fault conditions all connections to roll-out potential transformer trays and control power transformer trays shall be rigid bus bars insulated to full voltage rating of switchgear assembly.

F. Circuit breaker compartments shall be designed to house 12.47KV removable-element circuit breakers. Stationary primary disconnect contacts shall be silver-plated copper. Grounded metal safety shutters shall isolate all primary connections in compartment when breaker is withdrawn from connected position.

2.2 SERVICE

A. The switchgear shall be suitable for operation at 12.47 kV, 3 phase, 60 Hz directly grounded system. The switchgear shall have an interrupting rating as indicated in drawings.

2.3 ENCLOSURE

A. The switchgear enclosure shall be an outdoor, weatherproof, NEMA 3R, walk-in, protected aisle type.

B. The switchgear shall be rodent-and bird-proof. Each section shall be equipped with a switched overhead lighting fixture and one convenience receptacle.

C. The floor-standing switchgear shall be shipped fully assembled and tested; if shipping breaks are imperative, the units shall be assembled and tested then broken down for shipping.

D. Energized bare parts mounted on doors shall be guarded where the door must be opened for maintenance of equipment or removal of drawout equipment.

E. Furnish full height hinged covers which can be bolted closed for each cable compartment.

F. Provide a mimic bus on front of the enclosure. Mimic bus shall be plastic and held in place with screws.

G. Protected Aisle Outdoor Enclosures

1. Outdoor protected aisle metal clad switchgear shall be enclosed in a weatherproof enclosure. An aisle space measuring a minimum of 75 inches from the exterior front to the breaker covers shall be provided.

2. Include suitable weatherproof aisle access doors with provision for padlocking. Interior of access doors shall be provided with panic style hardware.

3. Provide protected ventilation openings as required; interior lighting, utility outlets with protective devices; and equipment heaters with protective devices. Heaters are to remain energized with no switch or thermostat provided. In each unit, major primary circuit parts (breaker, buses, transformers) shall be completely enclosed by grounded metal barriers, including a front barrier as part of the circuit breaker.

2.4 DESIGN AND CONSTRUCTION FEATURES

A. The switchgear configuration shall be as indicated on drawings. Provide key interlocks where indicated.

B. Incoming and outgoing sections shall have ample space for stress-cone terminations, lightning arresters (if required). All terminals and lugs shall be of the solderless type suitable for copper cables of size indicated.

C. Main Bus

1. The main bus shall be tin plated copper and rated as indicated on drawings. Bus bars shall have a continuous current rating based on temperature rise and documented by design tests. All joints will be silver plated with at least 2 bolts per joint. Bus bars will be braced to withstand magnetic stresses developed by currents equal to main power circuit breaker close, carry, and interrupt ratings.

Access to bus bars shall be through removable front panels. The entire bus, except for terminations, shall be completely isolated with metal barriers and insulated as required by ANSI Standards. The bus supports shall be polyester glass (standard)

D. Ground Bus

1. A ground bus (1/4 by 2 inch copper) shall extend throughout assembly with connections to each breaker grounding contact and cable compartment ground terminal. Joints shall be made up as indicated in drawings. Station ground connection points shall be located in each end section.

E. Circuit Breakers

1. Circuit breakers shall be rated as indicated on drawings. Circuit breakers of equal rating shall be interchangeable. Circuit breakers shall be operated by an electrically charged, mechanically and electrically trip-free, stored-energy spring. A handle shall be used to manually charge the spring for slow closing of contacts for inspection or adjustment.

2. Circuit breakers shall be equipped with secondary disconnecting contacts which shall automatically engage in the connected position.

3. The circuit breakers shall be horizontal drawout type, capable of being withdrawn on rails. The breakers shall be operated by a motor-charged stored energy spring mechanism, charged normally by a universal electric motor and in an emergency by a manual handle. The primary disconnecting contacts shall be silver-plated copper.

4. Each circuit breaker shall contain three vacuum interrupters separately mounted in a self-contained, self-aligning pole unit, which can be removed easily. A contact wear gap indicator for each vacuum interrupter, which requires no tools to indicate available contact life, shall be easily visible when the breaker is removed from its compartment.

5. Each breaker compartment shall have a breaker rackout device. Using rackout device, a breaker will be self-aligning and will be held rigidly in the operating position. In the disconnect position, breaker shall be easily removable from compartment. Breaker racking shall be accomplished with door closed and latched. Insert handle through a hole in front door to operate rackout device.

6. An indicating tape shall show breaker position when racking breakers in or out of their connected positions

7. Interlocks shall prevent moving breaker to or from operating position unless main contacts are open. Operating springs shall be discharged automatically when breaker is rolled fully into connected or disconnected position. Rackout device shall have provisions to padlock in connected or disconnected position.

When locked in disconnected position, breaker shall be removable from compartment using portable lifting device. Padlock shall not interfere with breaker operation.

8. Automatic shutters shall cover primary disconnect stabs when breaker is withdrawn to test/disconnect position. Shutters shall be positively driven by linkages connected to racking mechanism. A stationary barrier shall be located in front of the shutters for additional safety.

9. Breaker control voltage shall be 125VDC.

10. Circuit breakers installed in the lower compartments shall be capable of being removed from their compartment without the use of a breaker dolly once they are moved to the disconnect position.

11. Each circuit breaker shall be provided with an auxiliary switch. Main breakers shall have 6-stage switch containing six “a” (normally open) and six “b” (normally closed) contacts. Feeder breakers shall have a 6-stage switch containing six “a” (normally open) and six “b” (normally closed) contacts. All spare contacts shall be wired to terminal boards.

12. Each circuit breaker shall be provided with a position switch indicating whether the circuit breaker is in the “Connect” or Disconnect” position. Main breakers shall have a 3-stage switch containing three “a” and three “b” contacts. Feeder breakers shall have a 3-stage switch containing three “a” and three “b” contacts. All spare contacts shall be wired to terminal boards.

13. Main breaker closing circuits shall be wired to prevent parallel connection of the utility source except during the short duration upon retransfer. Provide removeable cover plates over the mechanical "close" buttons on the front of the breaker to prevent inadvertent operation.

2.5 AUTOMATIC TRANSFER CONTROL

A. An automatic transfer control system shall be incorporated in the switchgear allowing it to operate as follows:

1. The switchgear shall consist of one (1) utility circuit breaker, , one (1) feeder circuit breaker, one (1) generator circuit breaker and one prepared space for a future generator breaker.

2. In normal operation the utility and feeder circuit breaker shall be closed and the generator circuit breakers shall be open.

B. Primary Feeder Failure

1. Failure of the utility source shall be detected by a 3-phase voltage sensor.

2. Activation of this relay shall cause the utility circuit breaker to open and the generator circuit breakers to close after an adjustable time delay.

3. The transfer controls shall provide a start signal for the generators.

4. After power has been restored on the utility source and monitored by the sensing relay for a predetermined time period, the paralleling controls shall adjust the generator frequency and voltage to match the utilities, the the utility circuit breaker shall close and then after a short time delay, the generator circuit breakers shall open.

5. If any breaker tripping has occurred, the lockout relay shall prevent closure of the circuit breaker until the fault has been cleared and the lockout has been reset.

2.6 AUTOMATIC PARALLELING CONTROLS

A. The automatic paralleling controls shall provide for complete, automatic synchronizing and paralleling of 2 generators rated 2500 KW, 12,470 VAC as described in Section 26 32 13 - Standby Power Generation. Controls shall also provide for short time paralleling of the generators to the utility allowing for a both a closed transfer of power from the utility and closed retransfer to utility power after power outage.

B. Equipment shall control all related equipment installed under this contract, and contain provisions for addition of future equipment as indicated.

1. Although system shall be designed and constructed to parallel 2 generators, only one generator will be installed at this time.

C. Materials and components utilized in the manufacture of the equipment shall be new, of latest available version, and shall be delivered with no prior service except as required for factory tests.

2.7 PROTECTIVE RELAYS

A. Each circuit breaker cubicle shall include a protective microprocessor-based relay. Protective relays shall be a **Schweitzer (SEL) 750, GE/MULTILIN 850**, **EATON EDR-5000**, or equal.

B. The protective relay shall provide the minimum functions listed below and their locations in the switchgear shall be as indicated on the drawings.

1. Phase overcurrent (Device 50/51)

2. Neutral Overcurrent (Device 50/51N)

3. Residual Time Overcurrent (Device 51G)

4. Synchronism Check (Device 25) - where indicated

C. All protective-type relays shall be suitable for operation at a frequency of 60 Hz with current transformers having 5 ampere secondary circuits and with potential transformers having 120 V secondary circuits.

2.8 METERING AND INSTRUMENTATION

A. Instrument Transformers:

1. Current transformer ratios are listed in each switchgear units specification paragraphs shall be as indicated on drawings. Current transformer accuracy shall be ANSI standard. Transformer mechanical ratings shall equal the momentary rating of the circuit breakers. Transformers, when mounted in switchgear assemblies, shall be rated for the full voltage of the switchgear.

2. Voltage transformers shall be drawout type, with current-limiting fuses and with BIL rating equal to the switchgear. Transformer ratios are listed on drawings.

B. Solid State Meters

1. Digital meters/monitors shall be **GE EPM 9700**, **EATON Power Xpert Meter 2000** or other approved equivalent devices.

2.9 CONTROL POWER AND WIRING

A. Provide control power transformers where indicated on drawings. Transformers shall be rated as indicated. Transformers rated 15kVA single phase and less shall be mounted on roll-out trays.

B. Secondary control wiring shall be No. 14, extra flexible, stranded, tinned-copper control wire, Type SIS cross-linked polyethylene, rated 600 volts, except for specific circuits requiring larger wire.

C. Crimp-type, uninsulated spade terminals shall be furnished on all wire ends, except where non-insulated ring terminals are used to connect to fuse blocks, instrument studs, or terminal block points with two or more wire connections

D. Secondary control wires shall be armored where they pass through primary compartments.

E. Short circuit style terminal blocks shall be installed in current transformer secondary wiring between the current transformer and all connected devices.

F. Provide marking sleeves on all switchgear control wiring, heat stamped with wire origin and / or destination information.

2.10 SURFACE PREPARATION, PAINTING AND CLEANLINESS

A. Cleanliness of the equipment furnished shall be such that it is smooth and free of all foreign matter such as scales, sand, blisters, weld splatters, metal chips and shavings, oil, grease, organic matter, and rust.

B. All metal enclosures shall be chemically cleaned and treated in a process which provides a phosphate coating, then be primed and finished with a corrosion resistant enamel paint.

1. The switchgear shall be painted with an electrostatically applied polyester powder with final baked on average thickness between 1.5 and 2.0 mils and meet ANSI requirements for outdoor equipment.

2. All exterior surfaces of the switchgear assembly shall be given final finish coats of ANSI 61 gray as standard.

3. Finish shall have a minimum pencil hardness of 2H as tested per ASTM D3363 and shall pass the SATM B117 Salt spray test for a minimum of 1000 hours.

C. The CONTRACTOR shall supply paint, matching each color used, for field "touch-up" after installation of the equipment. Two one-pint aerosol spray cans of each color shall be supplied per assembly.

2.11 ACCESSORIES

A. Provide two indicating lights (red and green) for each breaker and one indicating light (white) for each lockout relay, when provided. The indicating lights shall be **GE type ET-16** or equal.

B. Provide a hand-resetable lockout relay (device 86) where indicated on the drawings or where required. The lockout relay shall disable closing of the corresponding circuit breaker until the relay has been reset. The lockout relay shall be a **GE type HEA** or equal.

C. Provide intermediate class arresters where indicated on drawings. Arresters shall be gapless metal-oxide type with a nominal rating of 9kV and an MCOV of 7.65kV. The arrester shall be enclosed in a polymer housing. Arresters shall be designed and manufactured in accordance with the latest revision of ANSI/IEEE C62.11. Arresters shall be **GE type Tranquell, similar by Eaton,** or approved equal.

D. Non-drawout style protective relays shall be furnished with test switches to permit trip blocking, relay isolation and testing. Test switch shall be **GE Multilin type 515** or approved equal.

E. The switchgear manufacturer shall furnish one set of accessories for each line-up for test, inspection, maintenance and operation, including:

1. One maintenance tool for manually charging the breaker closing spring.

2. One levering crank for manually moving the breaker between the test and connected positions

3. One mobile lift for lifting the breaker on or off the rails

2.12 NAMEPLATES

A. Furnish nameplates for each device as indicated in drawings. Nameplates shall be black and white 1/8-inch thick lamicoid, with lettering engraved through the black surface exposing the white lamination beneath. Letter height shall be 1/8-inch minimum unless otherwise indicated. Nameplate shall be fastened using 2 matching screws; adhesive tape is not acceptable.

B. The switchgear shall carry a manufacturer's label stating switchgear ratings and catalog or shipping number as well as the name of the manufacturer.

2.13 SYSTEM OPERATION

A. General: It is the intention of these Specifications to describe a system of switchgear and associated equipment to provide an automatic and unattended back-up power system for the facility loads. Provisions shall be included for the addition of the indicated future equipment. These provisions shall be an integral part of the installed system.

B. Normal Mode: With utility power available, ac power will be distributed from the utility feed to the loads by means of the various switchgears and panels as indicated.

C. Standby Mode

1. Upon loss or unacceptable values of normal source voltage, the generator shall start and close into the main bus in the switchgear, and assume facility load. The generator shall remain on line unless normal source returns or the operator initiates manual operation.

2. Upon restoration of normal utility service and after a time delay to ensure it has stabilized, the transfer switch shall transfer to normal. When all load has been transferred, the engine generator shall be disconnected from the main bus and enter a cool-down period. The unit will then be shut down and the system will reset in preparation for the next operation. Should the normal utility source fail during the shutdown sequence, the system shall reverse the sequence at whatever point the system is at and assume the facility loads again.

a. If a portable generator is connected in lieu of the permanently installed generators, the retransfer to utility power shall be an open transition and there shall be no paralleling.

D. Manual Operation: It is the intent of this specification to provide automatic system operation. However, all major system functions shall be provided with a means of manual operation. These functions, shall include at least:

1. Circuit breaker open/close

2. Engine generator start/stop

3. Generator synchronizing/paralleling

4. Utility/auxiliary power transfer

5. Automatic load shed bypass-reset pushbutton control

2.14 FACTORY TESTS

A. General: The paralleling switchgear shall be completely assembled and adjusted at the factory and given the manufacturer's standard shop tests and other tests, including those indicated below. All tests herein shall be witnessed by the ENGINEER or the OWNER's representative unless waived in writing. The manufacturer shall notify the ENGINEER sufficiently in advance of test dates so arrangements can be made for witnessing tests.

B. The switchgear equipment and circuit breakers shall receive factory production test as listed below:

1. Equipment

   a. Low frequency dielectric test

   b. Grounding of instrument cases

   c. Control wiring and device functional test

   d. Polarity verification

   e. Sequence test

   f. Low frequency withstand voltage test on major insulation components

   g. Low frequency withstand test on secondary control wiring

2. Breakers

   a. Coil check test

   b. Clearance and mechanical adjustment

   c. 300 Electrical and mechanical operation test

d. Timing test

e. Conductivity of current path test

f. Hi-potential testing of breaker

g. Vacuum bottle integrity test

C. Relays: auxiliary and protective relays shall be checked for proper operating sequence per the drawings. Calibration of the protective relays shall be done by the switchgear manufacturer, utilizing the services of an independent testing agency.

D. Instruments: indicating and recording meters shall be checked for proper operation by injecting 3 phase current and voltage into the appropriate circuits.

E. Functional test

1. The paralleling switchgear in conjunction with the engine generator units shall be functionally tested after installation to verify compliance with the contract documents.

2. Various loading conditions shall be accomplished with load banks or site load, in accordance with section 26 32 13 - Standby Power Generation to verify operation of the automatic sequencing function. Fault conditions shall also be simulated to verify proper operation of the automatic prefault, fault, and recording networks.

3. Testing of the manual start, stop, and synchronizing controls shall be accomplished.

F. Manufacturer shall provide to the Engineer documents verifying completion of factory production tests.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall install the switchgear in accordance with the manufacturer's installation instructions and as indicated. The CONTRACTOR shall provide the floor channels and shall secure the switchgear to the channels by bolting or tack welding at the front and the rear. Prior to energizing, all equipment shall be cleaned, inspected for loose connections, checked out for electrical and mechanical operations and phase-sequence, and all circuits made free of any shorts or ground connections following field testing.

3.2 START-UP ASSISTANCE AND TRAINING

A. The manufacturer's representative shall furnish on-Site start-up assistance and shall inspect the installation prior to start-up to verify that equipment is installed in accordance with the manufacturer's requirements.

B. In addition, the manufacturer's representative shall provide on-Site training for operation and maintenance of all equipment included in this Section.

C. The following times shall be included, as a minimum, for the above tasks. A Day is defined as 8 hours on-Site, exclusive of meals and travel. Each task shall be considered a separate trip to the site. Dates and times for the trips shall be coordinated with the OWNER.

1. Inspection of the installation: 2 Days

2. Startup assistance: 3 Days

3. Operation and Maintenance Training: One Day

D. The manufacturer shall be responsible for activation and acceptance of switchgear

END OF SECTION

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SECTION 26 24 13
480V SWITCHBOARD

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide the 480V switchboard, complete and operable as indicated and in accordance with the Contract Documents.

B. The requirements of Section 26 00 00 – Electrical Work, General apply to the WORK of this Section.

C. UL Label

1. The switchboard assembly shall bear a UL label.

2. Furnish certified copies of design test reports demonstrating compliance with UL standards.

D. Single Manufacturer

1. The low voltage switchgear shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer's services.

2. The equipment specified under this section shall be provided by the same manufacturer as the equipment provided in the following sections:

a. Section 26 12 16 – Panelboards and General Purpose Dry Type Transformers

b. Section 26 29 00 – Low-Voltage Motor Control Centers

c. Section 26 29 13 - Solid-State Reduced Voltage Starting

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Codes

1. The indicated WORK shall conform to or exceed the applicable requirements of the National Electrical Code (NEC), provided that where a local code or ordinance is in conflict with the NEC, the provisions of the local code or ordinance shall take precedence.

B. Commercial Standards

ANSI/NFPA 70 National Electrical Code – 2017

UL 891 Dead-Front Switchboard

NEMA PB2 Dead-Front Distribution Switchboard

NEMA PB2.1 Proper Handling, Installation, Operation and Maintenance of Dead-front Switchboards Rated 600 volts or less.

1.3 CONTRACTOR SUBMITTALS

A. Submittals shall conform to the requirements of Section 26 00 00 – Electrical Work, General, and Section 01 33 00 – Submittals.

B. In addition, submit the following:

1. A complete list of special tools as may be required for the operation and maintenance of the unit.

2. Engineering data, including voltage, current, and short-circuit ratings.

3. Certified outline drawings complete with dimensions, available space for conduits, cable terminations, bus terminations, weights, and cable supports.

4. A complete one-line diagram showing protective devices and terminal numbers.

5. Interconnection diagrams.

6. Design certification of the anchoring systems for seismic requirements in conformance with the requirements of Section 26 00 00 – Electrical Work, General, for the indicated equipment.

7. Spare parts data, listing source and prices of recommended replacement parts and supplies.

8. Recommended maintenance procedures and intervals.

9. A certified factory design test report.

10. A material list and catalog data.

1.4 QUALITY ASSURANCE

A. General

1. Materials shall be tested and inspected in accordance with Section 26 00 00 – Electrical Work, General, and the requirements indicated in this Section.

B. Storage and Warranty

1. Switchboard shall be stored in a clean, dry space.

2. Factory wrapping shall be maintained or a heavy plastic cover shall be provided in order to protect units from dirt, water, construction debris, and traffic.

3. The storage space shall be heated.

4. Equipment furnished under this section shall be guaranteed against defective parts and workmanship under the terms of the manufacturers and suppliers standard warranty. In no event shall it be for a period of less than three (3) years after the date of acceptance of the system and shall include labor, materials and travel costs for necessary repairs at the job site.

C. Factory Tests

1. Submit a certification of design tests previously conducted on a circuit breaker and switchboard assembly of each rating similar to that indicated.

2. The design testing program shall conform to the requirements of ANSI/IEEE C37.20.1, and shall include the following tests:

a. dielectric

b. continuous current

c. withstand

d. endurance

3. After assembly, the complete switchboard shall be tested for operation under simulated service conditions in order to assure the accuracy of the wiring and the functionality of the equipment.

D. Environmental Conditions

1. The 480V switchboard shall be designed for continuous duty service in the environmental conditions indicated in Section 26 00 00 – Electrical Work, General.

PART 2 -- PRODUCTS

2.1 REQUIREMENTS

A. Switchboards shall be “fully-rated” for the available short circuit current of 65 KAIC. “Series-rated” equipment is not acceptable.

B. The switchboard shall be dead front construction, NEMA 1 gasketed enclosure, and consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.

C. All sections of the switchboard shall be rear aligned with depth as shown on the drawings. All protective devices shall be group mounted. Devices shall be front removable and load connections front accessible enabling the switchboard to be mounted against a wall.

D. The assembly shall be provided with adequate lifting means.

E. All exposed copper shall be tin-plated. Copper shall be tin-plated after all cutting, shearing, and drilling operations so that there is no exposed copper in the finished equipment.

F. Switchboards shall include Zone Selective Interlocking where indicated on the drawings.

2.2 BUS

A. All bus bars shall be tin-plated copper with silver plated joints. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on NEMA standard temperature rise criteria of 65°C over a 40°C ambient (outside the enclosure).

B. Provide a half capacity neutral bus where a neutral bus is indicated on the drawings.

C. A tin-plated copper ground bus (minimum ¼ inch by 2 inches), shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard.

D. All hardware used on conductors shall be high-tensile strength and zinc plated. All bus joints shall be provided with conical spring-type washers. Supports shall be high-impact, non-tracking insulating material.

2.3 WIRING/TERMINATIONS

A. Mechanical-type terminals shall be provided for all line and load terminations, suitable for copper cable rated for 75°C.

B. Lugs shall be provided within the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as required.

2.4 CIRCUIT BREAKERS

A. Product description: UL489, molded-case circuit breakers.

B. Circuit breakers with frame size 800A and 600A shall be provided with electronic trip units with adjustable current and time settings and zone selective interlock protection.

2.5 MANUFACTURER, or equal:

A. **Eaton**

B. **ABB**

C. **Schneider Electric**

D. **Siemens**

PART 3 -- EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall install switchboard in accordance with the manufacturer's published instructions.

B. Conduit installation shall be coordinated with the manufacturer's as-fabricated drawings.

C. Conduit shall be installed in the section that contains the devices to which conductors are terminated.

3.2 INSTALLATION

A. Switchboard shall be installed on 3-1/2-inch concrete pads and in accordance with the requirements of Section 26 00 00 – Electrical Work, General.

B. After leveling and shimming, the CONTRACTOR shall anchor switchboard to the concrete pads, and shall grout such that no space exists between the pad and support beams.

C. The CONTRACTOR shall:

1. Torque bus bar bolts to manufacturer's recommendations and tighten sheet metal and structure assembly bolts.

2. Touch up scratches after the equipment has been installed.

3. Verify that nameplates, and other identification is accurate.

4. Provide high-voltage switchboard matting in front of the switchboard, in accordance with the requirements of Section 26 00 00 – Electrical Work, General.

3.3 FIELD TESTS – (SEE ALSO SECTION 26 01 26 – ELECTRICAL TESTS)

A. Provide a visual and mechanical inspection after installation, as follows:

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

2. Check tightness of bolted connections.

B. Electrical Tests

1. Insulation Tests

a. Measure the insulation resistance of each bus section phase-to-phase and phase-to-ground for one minute.

b. The test voltage and minimum acceptable resistance shall be in accordance with manufacturer's recommendations.

c. The test voltage and minimum acceptable resistance shall be in accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 26 29 00
LOW-VOLTAGE MOTOR CONTROL CENTERS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide motor control centers (MCCs), complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 26 00 00 – Electrical Work, General, apply to the WORK of this Section.

C. In the event that provided motors are of greater horsepower than the indicated motors, revise the raceways, conductors, starters, overload elements, and branch circuit protectors as necessary in order to control and protect the increased motor horsepower in accordance with Section 26 05 10 – Electric Motors.

D. Single Manufacturer

1. The MCCs shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer's services.

2. This requirement, however, does not relieve the CONTRACTOR of overall responsibility for the WORK.

3. The equipment specified under this section shall be provided by the same manufacturer as the equipment provided in the following sections:

a. Section 26 12 16 – Panelboards and General Purpose Dry Type Transformers

b. Section 26 24 13 – 480V Switchboard

c. Section 26 29 13 - Solid-State Reduced Voltage Starters

E. Coordination

1. The equipment provided under this Section shall operate the electric motor driver with the driven equipment as indicated under other equipment Sections.

2. The MCC manufacturer shall be provided with the following information, at a minimum:

a. Section 43 05 10 – Equipment General Provisions

b. relevant Division 41 and Division 23 Sections for each piece of equipment driven by the MCC

c. Section 26 00 00 – Electrical Work, General

d. Section 26 05 10 – Electric Motors

e. Section 26 05 15 – Industrial Control Panels

f. Section 26 01 26 – Electrical Tests

g. The Electrical Contract Drawings

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 26 00 00 – Electrical Work, General.

B. Furnish the following equipment information in the Shop Drawings:

1. NEMA rating and color of enclosure

2. horizontal and vertical bus ampacities, voltage rating, interrupting capacity, and materials of construction

3. ground bus size and material of construction

4. conduit entrance provisions

5. main incoming line entry provision (top or bottom)

6. control unit nameplate schedule

7. circuit breaker types, frames, and settings

8. starter NEMA sizes, auxiliary contact provisions, and coil voltage

9. relays, timers, pilot devices, control transformer VA and fuse sizes

10. MCC Ladder Diagrams

    a. Furnish custom elementary schematic ladder diagrams for each compartment.

    b. The ladder diagrams shall include remote devices.

    c. Submittals not meeting these requirements will not be reviewed further and will be returned to the CONTRACTOR.

11. short circuit rating of the complete assembly

12. replacement parts lists and operation and maintenance procedures

13. seismic design certification of the anchoring system in accordance with Section 26 00 00 – Electrical Work, General

14. time-current curves for protective devices

15. RVSS and VFD Equipment Information

    a. name of starter and drive manufacturer

    b. type and complete model number

    c. assembly drawing and nomenclature, including enclosure dimensions, mounting and anchoring details, and internal layout

    d. detailed schematics, including external wiring connections

    e. maximum heat dissipation capacity in kW

    f. altitude de-rating information

16. factory test data certifying compliance with requirements of similar equipment from the same manufacturer

C. Furnish an Owner's Manual, including:

1. manufacturer's two-year warranty

2. field test report

D. Furnish the Manufacturer's Service Representative's resume, including the following documentation:

1. copy of the proposed representative's Factory Training Certificate

2. number of years experience servicing the manufacturer’s MCCs and VFDs

3. a statement that the individual is authorized to inspect, test and perform field service and repairs

E. Spare Parts List

1. Furnish spare parts information for parts required by this Section as well any other spare parts recommended by the MCC manufacturer.

F. Startup and Testing Report

1. Within 15 days after completion of startup and testing, the CONTRACTOR shall submit a report for the MCC.

2. The report shall contain the following documentation:

   a. the device name, serial number, rating, and complete model number of each MCC

   b. a complete listing of all tests performed and the results of each test

   c. a complete listing of all circuit breaker and overload settings, fuse ratings, settings, setpoints and configuration information for VFDs and equipment or devices with adjustable settings

   d. documentation for training that was provided to the OWNER's personnel, including topics covered, instructor's name and contact information, and a list of attendees

PART 2 -- PRODUCTS

2.1 GENERAL

A. The manufacturer of the low-voltage motor control center shall also be the manufacturer of at least the following:

   1. molded case circuit breakers, up to and including 1200 ampere frame size

   2. disconnect switches

   3. magnetic motor starters

   4. control and timing relays rated at 600 volts AC

   5. pushbuttons, lights and selector switches, including remote mounted control stations

   6. meters, including ammeter, voltmeter, and solid-state metering devices

   7. All VFDs located inside the MCC

   8. Solid State Reduced Voltage Starters located within the MCC

B. Single Manufacturer

   1. Devices of the same type shall be products of the same manufacturer.

   2. This requirement applies to control devices, custom-fabricated equipment, and insofar as practical to equipment manufactured on a production basis.

C. Lighting transformers and panelboards shall be in accordance with the requirements of Section 26 12 16 – Panelboards and General Purpose Dry-Type Transformers.

D. Motor control centers shall conform to the standards for NEMA Class IIS, Type B diagrams and wiring.

E. MCC Schedule

MCC DESIGNATION	LOCATION
10-MCC-01	Headworks building
35-MCC-01	MBR support building
35-MCC-02	MBR support building
50-MCC-01	UV building

2.2 DESIGN, CONSTRUCTION, AND MATERIAL REQUIREMENTS

A. The motor control centers shall be 600-volt class and suitable for operation on a 3-phase, 60-Hz system.

B. The system operating voltage and number of wires shall be as indicated.

C. Power

1. The motor control center shall receive power from a 3-phase, wye-connected 277/480-volt transformer with a grounded neutral.

2. Power distribution from the MCC shall be 480-volt, 3-phase, 3-wire.

D. Enclosure

1. The enclosure shall be of NEMA Type 1, gasketed.

2. The variable frequency drive (VFD) and solid-state soft starter (RVSS) compartments may be of NEMA Type 1, gasketed, provided that ventilation inlet openings are covered by externally replaceable dust filters.

3. Compartment doors shall be interlocked with compartment circuit breakers, fitted with a maintenance override.

4. Latches for panelboard compartments shall have butterfly heads or another hand operable method that does not require tools to operate.

E. Size and Arrangement

1. Motor control centers shall be configured as mechanical groupings of control center units, assembled into a lineup of control center sections.

2. Each control section shall be nominally 90 inches tall by a minimum of 20 inches deep.

3. MCCs shall be designed to not exceed the indicated spatial requirements, including spaces, spares, and future compartments.

4. MCCs shall be subject to rejection if they exceed the indicated lengths, where allotted space is critical.

5. Equipment within the MCC may be rearranged at the discretion of the manufacturer, providing that the MCC includes the spares, space, and future provisions as indicated.

6. Switches and circuit breakers used as switches shall be located such that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, will not be more than 6 feet, 7 inches above the floor, including the height of the concrete pad.

F. Components

1. Busses

a. Provide a continuous copper ground bus, full width of the motor control center line-up.

b. Horizontal Busses

1) The main horizontal bus shall be of tin-plated copper, and located within an isolated compartment.

2) The bus shall be rated for 600 amperes minimum, but in no case less than the main lug or main breaker frame size.

c. Vertical Busses

1) The vertical bus in each section shall consist of a single tin-plated copper conductor per phase, with a current capacity of not less than 300 amps.

2) The vertical bus shall be completely isolated and insulated, and shall extend the full height of the section wherever possible.

d. Power buses shall be braced to withstand 65,000 amperes, minimum.

2. Wireways

a. Provide a separate vertical wireway adjacent to each vertical unit, covered by a hinged door.

b. Each individual unit compartment shall be provided with a side barrier to permit pulling wire in the vertical wireway without disturbing adjacent unit components.

c. Full height (72-inch) compartments or sections are not required to have a separate wireway.

G. Cabinets

1. Structural members shall be fabricated of not less than 12-gauge steel, and side and top panels and doors shall be fabricated of not less than 14-gauge steel.

2. Spaces designated as SPACE or BLANK shall include blank hinged doors and vertical bus bars.

3. Control units inside compartments shall be clearly identified with tags or stencil markings.

4. Identification

a. Each control unit, including spares, spaces and blanks, lights, and devices shall be identified by an engraved nameplate.

b. Identification shall include the indicated circuit number.

c. Each motor control center shall be fitted with the manufacturer's nameplate which shall include the NEMA Standard electric rating and other pertinent data, including manufacturer, sales order number, date of manufacture, and place of manufacture.

5. Fans, heat exchangers, transformers, capacitors, junction boxes, and other devices shall not be mounted on the outside of the motor control center enclosure.

6. Protective Coating

a. The finish for motor control center shall be light grey: ANSI 61 or 49.

b. The panels shall be coated with 2 coats of primer inside and out, and 2 coats of enamel finish.

c. External colors other than ANSI 61 or 49 will not be accepted.

2.3 MAIN AND FEEDER CIRCUIT BREAKERS (480 V)

A. Circuit breakers having a frame size of 150 amperes or less shall be molded-case type with thermal magnetic non-interchangeable, trip-free, sealed trip units.

B. Circuit breakers with a frame size of 225 amperes to 1,200 amperes shall be molded case with RMS sensing electronic trip with the following adjustments:

1. long-time setting (by changing the unit)

2. long-time delay

3. short-time setting

4. short-time delay

5. instantaneous setting

6. ground-fault setting

7. ground-fault delay

C. The interrupting capacity of the main and feeder branch circuit breakers shall be a minimum of 65,000 RMS symmetrical amperes.

D. Service disconnects rated 1000 amps or greater shall provide for ground fault protection of the equipment.

E. Circuit breaker disconnect operators shall be capable of accommodating 3 padlocks for locking in the OPEN position.

F. Circuit breaker auxiliary contacts shall be furnished where indicated.

2.4 MOTOR STARTERS

A. Motor starters shall be mounted in standard motor control center assemblies, arranged as indicated.

B. Components

1. Each motor starter unit shall consist of a combination magnetic contactor and short circuit protective device, mounted in a completely enclosed cubicle.

2. The short circuit protective device shall be an instantaneous, magnetic only circuit breaker: **Cutler-Hammer Type HMCP, G.E. Mag-Break Motor Circuit Protector**, or equal.

3. Circuit breakers provided as part of a motor starter unit shall be capable of being padlocked in the OPEN position.

4. Resetting of thermal overload elements shall be possible with the unit door closed.

5. Provide 3-phase overload trip units to suit the full load current of the equipment installed, and the trip unit shall be adjusted as required for power factor correction capacitors.

C. Magnetic Starters

1. Magnetic starters shall have auxiliary contacts as indicated, including N-O and N-C contacts as indicated, plus one each spare N-O and N-C contact.

2. The combination motor starters shall be drawout-type for Size 5 and below.

3. The fixed-type unit assembly shall be constructed such that it can be easily removed from its panel after disconnecting the wires to the terminal block and withdrawing from the primary bus.

4. Removal of a unit assembly shall be possible without rear access and without disturbing any other unit in the motor control center.

D. Control Power Transformer

1. Each starter unit shall have its own control power transformer, with a 115-volt grounded secondary.

2. Provide one secondary fuse and 2 primary fuses.

3. Control power transformers shall be sized to accommodate the indicated control devices.

4. Local control devices shall be mounted independently of the cover door.

5. Starters shall have a local green RUN indicator, and a red OFF indicator to indicate the presence of control power when the motor is not energized.

6. Starters shall be provided with elapsed time meters, HAND-OFF-AUTO selector switches, and other devices as indicated.

7. Cubicle control wires shall be terminated at a pull-apart disconnecting terminal block located at the cubicle.

E. Identification

1. The motor control center manufacturer shall be responsible for identifying each control wire within each motor starter unit with wrap-around permanent plastic markers.

2. Each control wire shall be identified at both ends.

F. Full-Voltage Starters

1. Full-voltage motor starter units shall be NEMA Size 1 or larger.

2. Each combination starter shall be rated for a minimum 65,000 RMS symmetrical amperes.

G. NEMA Ratings

1. Motor starters shall be designed to NEMA ratings.

2. Starters designed to IEC ratings or with dual IEC/NEMA ratings will not be accepted, either as part of an MCC, as remote starters, or as part of an equipment package.

H. Solid-State Reduced-Voltage Starters

1. Solid-state reduced-voltage starters shall be in accordance with the requirements of Section 26 29 13 – Solid-State Reduced Voltage Starters.

2. Full-voltage bypass contactors, input contactors, output contactors and other components shall be provided where indicated.

I. Unless otherwise indicated, 2-speed starters shall be of the 2-winding type.

J. Variable Frequency Drives

1. Variable frequency drives (VFDs) shall be in accordance with the requirements of Section 26 29 23 – Variable Frequency Drives.

2. An externally mounted line reactor, cooling fan, and bypass contactor will not be accepted.

3. Full-voltage bypass contactors, input contactors, output contactors and other components shall be provided where indicated.

2.5 CONTROL DEVICES

A. Control devices shall be in accordance with the requirements of Section 26 05 15 – Industrial Control Panels.

B. Metering

1. Provide solid-state metering where indicated.

2. Include CTs and PTs of ratios as indicated or as recommended by the MCC manufacturer.

3. The CT leads shall terminate on shorting type terminal blocks, and the shorting bar shall be grounded to the MCC ground bus.

4. Solid-state metering shall be **G.E. "PQM", Cutler-Hammer "DP-4000," Square D "Power-Logic**," or equal.

2.6 FACTORY TESTS

A. Provide the manufacturer's standard electrical and mechanical production tests and inspections for motor control centers and their components.

B. The tests shall include electrical continuity check, dielectric tests for each circuit, and inspection for proper functioning of components including controls, protective devices, metering, and alarm devices.

2.7 SPARE PARTS

A. The CONTRACTOR shall furnish the following for each MCC:

1. Unit Control Transformer: one of each size furnished in magnetic starters installed

2. Bezels: 3 of each color installed for pilot indicators

3. Panel Lamps: one dozen of each type (form, voltage and current rating) installed

4. Control Fuses: one dozen of each type (form, voltage and current rating) installed

5. Relays: one of each type and size installed

B. Spare parts shall be identified by MCC number, type, size, and manufacturer.

2.8 MCC MANUFACTURER, OR EQUAL

A. **Eaton "2100" Series**

B. **ABB "ReliaGear"**

C. **Schneider Electric, “Model 6”**

D. **Siemens “Tiastar”**

PART 3 -- EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall install motor control centers in accordance with the manufacturer's published instructions.

B. Conduit installation shall be coordinated with the manufacturer's as-fabricated drawings such that conduit stub-ups are within the area allotted for conduit.

C. Conduit shall be stubbed up in the section that contains the devices to which conductors are terminated.

3.2 STORAGE AND HANDLING

A. If stored at the Site, motor control centers shall be stored in a clean, dry space.

B. Factory wrapping shall be maintained or an additional heavy plastic cover shall be provided to protect units from dirt, water, construction debris, and traffic.

C. The storage space shall be heated or the MCC space heaters shall be energized.

D. Motor control centers shall be handled carefully to avoid damage to motor control center components, enclosure, and finish.

E. Damage shall be repaired before installation.

3.3 MANUFACTURER'S SERVICES

A. General

1. An authorized Service Representative of the manufacturer shall be present at the Site for 4 Work Days in order to provide the services listed below.

2. For the purpose of this paragraph, a Work Day is defined as an 8-hour period, excluding travel time.

3. The service representative's resume shall be approved by the ENGINEER before training is scheduled.

B. Inspection, Startup, Field Adjustment

1. The Service Representative shall supervise the following items, and shall certify that the equipment and controls have been properly installed, aligned, and readied for operation:

a. installation of the equipment

b. inspection, checking, and adjusting of the equipment

c. startup and field testing for proper operation

d. performance of repairs to correct any discrepancies or problems revealed during startup and testing

e. performance of field adjustments to ensure that the equipment installation and operation comply with the indicated requirements

f. Preparation and submittal of a report covering startup and testing, including a listing of equipment settings and parameters at the end of startup and testing.

3.4 INSTALLATION

a. Motor control centers shall be installed on 3-1/2-inch concrete pads and in accordance with the requirements of Section 26 00 00 – Electrical Work, General.

B. After leveling and shimming, the CONTRACTOR shall anchor motor control centers to the concrete pads, and shall grout such that no space exists between the pad and support beams.

C. The CONTRACTOR shall:

1. torque bus bar bolts to manufacturer's recommendations, and tighten sheet metal and structure assembly bolts;

2. adjust motor circuit protector (MCP) devices to the instantaneous trip setting position recommended for the actual horsepower and full load amps of the motor;

3. verify that overload devices are proper for equipment installed;

4. make necessary changes in overload devices as required for motors having power factor correcting capacitors;

5. touch up scratches after the equipment has been installed;

6. verify that nameplate, and other identification is accurate; and

7. provide high-voltage switchboard matting in front of the MCC, in accordance with the requirements of Section 26 00 00 – Electrical Work, General.

3.5 FIELD TESTS

A. Provide a visual and mechanical inspection after installation, as follows:

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

2. Verify that the ratings of the thermal overload heaters match the motor full-load current nameplate data.

3. Check tightness of bolted connections.

B. Electrical Tests

1. Insulation Tests

a. Measure the insulation resistance of each bus section phase-to-phase and phase-to-ground for one minute.

b. The test voltage and minimum acceptable resistance shall be in accordance with manufacturer's recommendations.

c. Measure the insulation resistance of each starter section phase-to-phase and phase-to-ground with the starter contacts closed and the protective device open.

d. The test voltage and minimum acceptable resistance shall be in accordance with the manufacturer's recommendations.

e. Measure the insulation resistance of each control circuit with respect to ground.

2. Verify the proper operation of control logic in each mode of control.

END OF SECTION

SECTION 26 29 13
SOLID-STATE REDUCED VOLTAGE STARTING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. General: The CONTRACTOR shall provide solid-state reduced voltage motor starters, complete and operable, in accordance with the Contract Documents.

1. The MCCs shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer's services.
2. This requirement, however, does not relieve the CONTRACTOR of overall responsibility for the WORK.
3. The equipment specified under this section shall be provided by the same manufacturer as the equipment provided in the following sections:
    a. Section 26 12 16 – Panelboards and General Purpose Dry Type Transformers
    b. Section 26 24 13 – 480V Switchboard
    c. Section 26 29 00 – Low-Voltage Motor Control Centers

B. Coordination: Equipment provided under this Section shall operate the electric motor and the driven equipment indicated under other equipment specifications. The CONTRACTOR's attention is specifically directed to the need for proper coordination of the WORK under this Section with the WORK under the equipment section and with the WORK under Section 26 05 10 - Electric Motors.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals, except that Shop Drawing information for the drives shall be submitted as part of the information for the driven equipment.

B. Shop Drawings

1. Equipment information
    a. Name of drive manufacturer
    b. Type and model
    c. Assembly drawing and nomenclature
    d. Maximum heat dissipation capacity (KW)
2. Written description of ladder diagram operation. Custom schematics shall be furnished. Diagrams shall include remote devices.
3. System block diagram and interconnection diagrams.
4. Replacement parts list and operation and maintenance instructions.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall provide a total of 4 solid-state starters. Equipment to be operated through the starters includes the following:

Qty.	Equipment	Tag. No.	HP	Volt	RPM	Location
4	Fine Screens	10-SCR-4105 10-SCR-4305 10-SCR-4405 10-SCR-4605	2	480	1800	10-MCC-01

B. Solid-state reduced voltage starters (SSRV) shall be UL-listed and consist of a SCR-based power section, logic board, and internal paralleling bypass contactor.

C. Starters shall conform to the following:

1. The SCR-based power section shall consist of 6 back-to-back SCRs, 2 SCRs per phase, and shall be rated for a minimum peak inverse voltage rating of 2.5 times line voltage, 1200 PIV for 480 volts. Units using triacs or SCR/diode combinations shall not be acceptable. Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dv/dt characteristics of the electrical system.
2. Starters shall include the following logic and control functions:
    a. Adjustable maximum starting current from 200 percent to 500 percent
    b. Ramp time adjustment from 1 to 40 seconds
    c. Adjustable linear voltage deceleration
    d. Kick start
    e. Phase loss protection
    f. Undervoltage protection
    g. Current unbalance protection
    h. Phase rotation protection (prevents starting)
    i. Class 20 electronic overload protection. Heat sink overtemperature protection shall be provided.
    j. Dry contacts for remote indication of RUN and TRIP status
3. The paralleling bypass contactor shall energize when the motor reaches full speed. The contactor shall be an integral part of the reduced voltage starter and be connected directly across the power SCRs.
4. The starter shall be housed in a NEMA 1 enclosure. Heaters and cooling fans shall be provided if required to maintain the equipment within the manufacturer's environmental guidelines.

5. The starter shall be provided with a control power transformer sized to accommodate controls indicated on the Contract Drawings. An input power circuit breaker shall be provided. Lug termination of the incoming power conductors shall not be permitted. The starter and circuit breaker shall be rated for 65 KAIC RMS at 480 V.

6. The starter shall have door-mounted indication of run, phase rotation, phase loss, undervoltage, current unbalance, and current trip.

7. The starter shall be provided with the operator controls indicated. Operator interface controls shall be heavy duty, oil-tight, 30.5-mm.

2.2 MANUFACTURERS, OR EQUAL

A. Eaton

B. ABB

C. Schneider Electric

D. Siemens

PART 3 -- EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall install the solid-state reduced voltage starters in accordance with the manufacturer's published instructions.

B. The CONTRACTOR shall

1. Verify that the overload devices are properly adjusted for the equipment installed.

2. After the equipment is installed, touch up scratches and verify that nameplate and other identification is accurate.

C. Inspection, Startup, Field Adjustment: An authorized service representative of the manufacturer shall supervise the following and certify the equipment and controls have been properly installed, aligned, and readied for operation.

1. Installation of the equipment

2. Inspection, checking, and adjusting the equipment

3. Startup and field testing for proper operation

END OF SECTION

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SECTION 26 29 23
VARIABLE FREQUENCY DRIVE UNITS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. General

1. The CONTRACTOR shall provide variable frequency drive (VFD) units, complete and operable, as indicated in accordance with the Contract Documents.

2. It is the intent of this Section to require complete, reliable, and fully tested variable frequency drive systems suitable for attended or unattended operation.

B. The requirements of Section 26 00 00 – Electrical Work, General, apply to the WORK of this Section.

C. Single Manufacturer

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

a. VFDs installed in MCCs shall be the product of the MCC manufacturer.

b. VFDs not installed in MCCs shall be the product of a single manufacturer but do not have to be by the same manufacturer of the VFDs in the MCCs.

1) For VFDs not installed in MCCs, all components in the VFD enclosure including VFD, main breaker, pilot devices, line reactors, dV/dt filters, control power transformers, heaters, etc. shall be the product of, or supplied by, the VFD manufacturer and the entire assembly shall be assembled by the VFD manufacturer. VFDs consisting of components from multiple manufacturers assembled by a third party vendor will not be acceptable.

c. The VFD at the existing wastewater plant (area 70) for the sludge holding tank blower shall be the same manufacturer and model as the existing VFDs there.

2. This requirement, however, does not relieve the CONTRACTOR of overall responsibility for the WORK.

D. Coordination

1. Equipment provided under this Section shall operate the electric motor driver and the driven equipment as indicated under other equipment specification Sections.

2. The CONTRACTOR'S attention is specifically directed to the need for proper coordination of the WORK under this Section and the WORK under the equipment Section with the WORK under Section 26 29 00 – Electric Motors.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals, except that Shop Drawing information for the drives shall be submitted as part of the information for the driven equipment.

B. Shop Drawings: Include the following information:

1. Equipment Information
    a. name of drive manufacturer
    b. type and model
    c. assembly drawing and nomenclature
    d. maximum heat dissipation capacity in kW
2. conduit entrance provisions
3. circuit breaker type, frames, and settings
4. information related to relays, timers, pilot devices, control transformer VA, dV/dT devices, line reactors and fuse sizes, including catalog cuts
5. Ladder Diagram
    a. Submit the system schematic ladder diagram and interconnection diagrams.
    b. The schematic ladder diagram shall include remote devices.
    c. The ladder diagram shall incorporate the control logic on the corresponding elementary schematic as indicated.
    d. Submittals with drawings not meeting this requirement will not be reviewed further and will be returned to the CONTRACTOR stamped "REJECTED."
6. factory test data certifying compliance of similar equipment from the same manufacturer with requirements of this Section

C. The Technical Manual shall include the following documentation:

1. manufacturer's 2-year warranty
2. harmonic analysis report
3. field test report
4. programming procedure and program settings

D. Spare Parts List

1. Submit information for parts required by this Section plus any other spare parts recommended by the controller manufacturer.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall provide a total of 38 variable frequency drives.

B. Equipment to be operated through variable frequency drives shall include the following:

Quantity	Equipment	HP	Constant or Variable Torque (C/V)	RPM	Bypass (Y/N)	Enclosure Type
4	Influent Pumps	100			N	NEMA 1
2	Coarse Screens	3			N	10-MCC-01
1	Odor Control Fan	15			N	10-MCC-01
5	Air Scour Blowers	100	V	1800	N	NEMA 1
6	Permeate Pumps	40	V	1800	N	35-MCC-01
3	RAS Pumps	75	V	900	N	NEMA 1
4	MLR Pump	20	V	580	N	35-MCC-01
2	WAS Pumps	15	V	1800	N	35-MCC-01
2	Citric Acid Dosing Pumps	5	C	1800	N	35-MCC-01
2	Sodium Hypochlorite Dosing Pumps	3	C	1800	N	35-MCC-01
2	Plant Water Pumps	40	V	1800	N	NEMA 1
1	Plant Water Pump	10	V	1800	N	NEMA 1
2	Reaeration Blower	20	V	3600	N	NEMA 1
1	Sludge Holding Tank Blower	150				NEMA 1

2.2 EQUIPMENT

A. General

1. The power supply shall be an adjustable frequency inverter designed to convert incoming 3-phase, 480-volt, 60-Hertz power to a DC voltage and then to adjustable frequency AC by use of a 3-phase inverter.
2. Current-source inverters will not be accepted.
3. Inverters shall be sized to match the KVA and inrush characteristics of the motors actually provided.
4. The CONTRACTOR shall be responsible for matching the controller to the load (variable torque or constant torque) as well as the speed and current of the actual motor being controlled.
5. The CONTRACTOR shall provide "clean power" 18-pulse VFD's for VFDs that are operating motors greater than 50 HP.

B. Inverter

1. The inverter shall be of a voltage-source design, producing a pulse-width-modulated type output.
2. Six-step and current-source inverters will not be accepted.
3. Inverters shall be capable of delivering the nameplate horsepower exclusive of service factor without the need for mandatory thermostats or feedback tachometers.
4. The VFD shall vary both the AC voltage and frequency simultaneously in order to operate the motor at required speeds.

C. The minimum VFD inverter efficiency shall be 95 percent at 100 percent speed and load, and 85 percent efficiency at 50 percent speed and load.

D. Power Outage

1. The VFD shall shut down in an orderly manner when a power outage occurs on one or more phases.
2. Upon restoration of power and a START signal, the motor shall restart and run at the speed corresponding to the current process input signal.

E. The VFD shall be provided with the following features:

1. inrush current adjustment between 50 and 110 percent of motor full load current (factory set at 100 percent)
2. overload capability at 110 percent for 60 seconds for variable torque loads and 150 percent for constant torque loads.
3. adjustable acceleration and deceleration
4. input signal of 4 - 20 mA from process
5. output speed signal of 4 - 20 mA; Signals other than 4 - 20 mA will not be accepted.
6. Upon loss of input signal, the VFD shall operate at a preset speed.

7. a minimum of 2 selectable frequency jump points in order to avoid critical resonance frequency of the driven system.
8. additional devices and functions as indicated
9. Ethernet TCP/IP I/O communications to transmit VFD data to/from a plant PLC-based control system

F. The VFD shall be provided with, as a minimum, the following protection features:
1. input line protection with metal oxide varistor (MOV) and RC network
2. protection against single phasing
3. instantaneous overcurrent protection
4. electronic overcurrent protection
5. ground fault protection
6. overtemperature protection for electronics
7. protection against internal faults
8. ability to start into rotating motor (forward or reverse rotation)
9. additional protection and control as indicated and as required by the motor and driven equipment

G. The VFD shall be designed and constructed to satisfactorily operate within the following service conditions.
1. Elevation
   a. elevation to 3300 feet
   b. For elevation greater than 3300 feet, the VFD shall be derated in accordance with the manufacturer's recommendation
2. Ambient Temperature: 0 to 40 degrees C
3. Humidity: 0 to 95 percent, non-condensing
4. AC Line-Voltage Variation: plus 10 percent to minus 10 percent
5. AC Line-Frequency Variation: plus and minus 2 Hertz

H. Electrical equipment provided in addition to the adjustable frequency inverter for each drive shall include:
1. 2-1/2-percent (minimum) line reactor integral to the drive enclosure.
2. Provide a dV/dT filter device at the motor or VFD output per the manufacturer’s recommendation. Submit documentation demonstrating where such devices are required, along with mounting and cabling requirements.
3. fused 480-to-120-volt control transformer to provide system control power for the logic and pilot lamps.
4. Provide an input circuit breaker.

5. Heaters

   a. Provide overload heaters with auxiliary contacts in order to protect the motors in both VFD and bypass modes.

   b. Refer to the Elementary Schematics indicated on the Drawings.

   c. The heaters shall be sized for the motor actually being provided.

I. Inverter Signal Circuits

1. The inverter signal circuits shall be isolated from the power circuits and shall be designed to accept an isolated 4-20 mA signal in the automatic mode of operation.

2. The inverter shall follow the setting of a remote or local potentiometer control while in the manual mode.

3. Refer to the Elementary Schematic indicated on the Drawings for speed control and START/STOP methods.

4. Access to set-up and protective adjustments shall be protected by key-lockout.

5. The following operator monitoring and control devices for the inverter shall be provided on the face of the VFD enclosure, either as discrete devices or as part of a multi-function microprocessor-based keypad access device:

   a. AUTO/HAND selection from a remote logic relay or switch

   b. While in AUTO, the inverter shall operate from the remote 4-20 mA input, where applicable, and while in HAND control shall operate from a local or remote manually operated speed potentiometer; speed pot ratings shall be coordinated with the supplier of the Local Control Station.

   c. speed indicator calibrated in percent speed

   d. inverter fault trip pilot light and output alarm contacts

   e. trip reset pushbutton

   f. RUN and OFF indicating lights

   g. Provide other controls and readouts normally furnished as standard equipment, or as otherwise indicated on the Elementary Schematics indicated on the Drawings.

J. Properly identified screw type terminal boards shall be provided for interconnection to remote controls and instrumentation

K. Pilot devices, control relays, time delay relays, elapsed time meters, and indicators provided as a part of the VFD equipment package shall meet the applicable requirements of Section 26 05 15 – Local Control Stations and Miscellaneous Electrical Devices.

2.3 HARMONIC ANALYSIS FOR DRIVES

A. The CONTRACTOR shall perform a harmonic study of the facilities included in this Project.

B. The following assumptions shall be utilized for the harmonic analysis:

1. The distribution system is a "general" system as classified by IEEE 519 under low voltage systems.

2. Assume 90 percent of total plant operating load is motor load and 10 percent is resistive.

3. Assume a 70 percent plant diversity factor (i.e., 70 percent of the total plant load is operating), with motors other than VFDs operating at 90 percent of their nameplate horsepower.

4. Assume all VFDs are operating except:

a. One Influent Pump

b. One permeate pump

c. One RAS pump

d. One WAS pump

e. One air Scour pump

f. Two MLR pumps

g. One citric acid dosing pump

h. One sodium hypochlorite dosing pump

i. One Aeration blower skid

j. One Reaeration blower

5. Report

a. Results of the harmonic analysis shall be submitted prior to VFD shipment.

b. Excessive harmonic distortion shall be specifically denoted.

c. Corrective measures shall be submitted for action by the ENGINEER.

2.4 SPARE PARTS

A. The CONTRACTOR shall furnish the spare parts listed below, suitably packaged and labeled with the corresponding equipment number.

B. Modified Parts

1. At any time prior to Substantial Completion, the CONTRACTOR shall notify the ENGINEER in writing about any manufacturer's modification of spare part numbers, interchangeabilities, or model changes.

2. If the ENGINEER determines that the modified parts no longer apply to the equipment provided, the CONTRACTOR shall furnish other applicable parts as part of the WORK.

C. The following spare parts shall be furnished:

1. Provide one set of spare power fuses of each form, voltage, and current rating.
2. Provide 10 spare control and power fuses of each type and rating.
3. Provide 10 panel lamps of each type (form, voltage, and current rating).
4. Provide one of each type of circuit board, as applicable:
    a. control board
    b. power board
    c. diode bridge
    d. transistor module
5. Provide one of each size and type power diode and transistor.
6. Provide one set of any special tools required for maintenance of the VFD units

2.5 Manufacturers, or equal

A. **Eaton**

B. **Schneider**

C. **Rockwell Automation**

D. **Siemens**

E. VFD for sludge holding tank blower at existing wastewater plant shall be **ABB model xxx, no equal**

PART 3 -- EXECUTION

3.1 MANUFACTURER'S SERVICES

A. General

1. An authorized service representative of the manufacturer shall be present at the Site for 6 Days to furnish the services listed below.
2. For the purpose of this Paragraph, a Day is defined as an 8-hour period excluding travel time.

B. The authorized service representative shall supervise the following and shall certify that the equipment and controls have been properly installed, aligned, and readied for operation:

1. installation of the equipment

2. inspection, checking, and adjusting the equipment

3. startup and field testing for proper operation

4. performing field adjustments such that the equipment installation and operation comply with requirements

C. Instruction of OWNER's Personnel

1. The authorized representative shall instruct the OWNER's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with test equipment.

2. The instruction shall be specific to the VFD models provided.

3. Training shall be scheduled a minimum of 3 weeks in advance of the first session.

4. Training shall include individual sessions for 4 shifts of plant personnel.

5. Proposed training materials shall be submitted for review, and comments shall be incorporated.

6. Training materials shall remain with the trainees.

7. The OWNER may videotape the training for later use with the OWNER's personnel.

3.2 INSTALLATION

A. Conduit stub-ups for interconnected cables and remote cables shall be located and terminated in accordance with the drive manufacturer's recommendations.

B. Programming

1. The CONTRACTOR shall perform programming of drive parameters required for proper operation of the VFDs included in this project.

2. Submit records of programming data in the equipment Technical Manual, including setup and protective settings.

3.3 FIELD TESTING

A. Testing, checkout, and startup of the VFD equipment in the field shall be performed under the technical direction of the manufacturer's service engineer.

B. Under no circumstances shall any portion of the drive system be energized without authorization from the manufacturer's representative.

C. Verify proper operation of control logic in every mode of control.

D. Harmonic Analysis

1. The CONTRACTOR shall test the completed installation for actual harmonic distortion at the point of common coupling.

2. Harmonic analysis shall be performed in accordance with IEEE 519 - Harmonic Control and Reactive Compensation of Static Power Converters at unit full load using a harmonic analyzer by **Fluke**, or equal

3. Tests shall demonstrate that the harmonic voltage and current distortion levels at the point of common coupling do not exceed a magnitude of 5 percent of the fundamental, with the maximum number of drives, as permitted by the process, in operation and in conformance with the applicable requirements of IEEE-519.

4. Provide a report that shall include the following:

    a. expected harmonic voltage (THD) through the 35th harmonic, calculated with isolation transformers

    b. actual RMS value and measured percentage of the THD in the field

    c. suggested corrective action(s) where measured harmonics exceed the limits specified herein

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SECTION 26 32 13
STANDBY POWER GENERATION

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide an engine-driven standby electrical generating system, complete and operable, in accordance with the Contract Documents.

B. The CONTRACTOR shall be responsible for coordination of interface with other equipment and for any special construction necessary to complete the WORK of this Section in an acceptable manner.

C. The supplier of the generator set shall also be the manufacturer of the engine for the generator system; however, the CONTRACTOR shall be responsible to the OWNER for the WORK of this Section.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Materials shall conform with applicable requirements of the National Electrical Code (NEC), and any other State or Municipal codes which apply. Generator system shall meet applicable standards and codes, including IEEE, NEMA, ANSI, OSHA, and UL.

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

B. Shop Drawings

1. Detailed, dimensioned Shop Drawings and data demonstrating adherence to the requirements of these specifications shall be submitted and approved before fabrication, shipment, or other WORK under this Section begins. Include the manufacturer's certification that engine atmospheric emissions will comply with the limitations.

2. Certified custom drawings and custom wiring diagrams of each component in the system and a master wiring diagram showing the entire system on one sheet. This diagram shall include all AC and DC power control connections between the generator, engine, fuel tank system, batteries, and circuit breakers and shall be a custom drawing for this specific installation. A master drawing of the engine/generator set shall also be provided, showing general dimensions, bill of materials, location and size of all connections for fuel, cooling, exhaust, direct current connections, conduit locations, and connections for control and power wiring. Include wire and terminal numbers for all diagrams. Furnish KW output curves, fuel consumption curves, and certified air emission data sheets.

3. Outline drawings and connection diagrams shall be complete enough to enable the installation to be designed completely, and connection diagrams shall give both internal and external connections. Include foundation loading and clearances.

4. Five copies of complete and detailed instructions for the operation, lubrication, and maintenance of equipment in the system. The manuals shall be furnished after final approval of Shop and working drawings but prior to shipment of equipment. Manuals shall be complete with wiring diagrams, lubrication schedules and recommended lubricants, drawings, cuts, parts lists, and other necessary data. All parts shall be numbered or otherwise clearly identified to facilitate ordering of replacements. Descriptions of all operational control devices and their functions shall also be included.

1.4 QUALITY ASSURANCE

A. The engine/generator shall be the product of a manufacturer who has been regularly engaged in the design and production of similar engine/generator sets for a minimum of 10 years.

B. The supplier shall maintain a local parts and 24-hour service facility within the State of Utah. The supplier shall have factory trained and authorized service representatives to furnish necessary installation, test, and start-up supervision as well as operation and maintenance training necessary for final approval and acceptance.

PART 2 -- PRODUCTS

2.1 SYSTEM COMPONENTS

A. Provide one new diesel engine-powered electric generator set in an outdoor, waterproof, walk-in, sound attenuated enclosure. The engine generator shall have a nominal standby rating of 2500 KW, 3125 KVA, 0.8 power factor, 12,470 volts, three phase, four wire, grounded neutral, 60 Hertz. The equipment package shall include in general, and as applicable, engine and generator on a common vibration isolating base, with auxiliaries, accessories, and controls, including intake filters, discharge silencer, turbocharger, heat exchangers, foundation bolts, isolators, piping, flexible couplings, supports, complete exhaust piping, ring, and silencer, insulation, control panels, lubrication system, water jacket heaters, cooling system, fuel tank, batteries and battery rack, battery charger, spare parts, and all materials necessary to permit installation, testing and placing the system in successful operation.

B. Provide one 4,000 gallon fuel storage tank with double wall steel construction, integral with the base of the generator-set and generator-set enclosure.

C. The generator-set, enclosure, base-mounted fuel tank, and accessories shall be assembled and shipped to the Site as a complete, coordinated package, ready for installation. The engine generator base, cooling system, etc, shall be factory painted before installation in the enclosure.

2.2 SYSTEM OPERATION

A. The system shall operate as follows:

1. Automatic Control

a. A maintained remote contact closure from the automatic transfer switch shall cause the generator-set to start and run.

b. When the remote startup contact opens, the engine shall continue to operate for an adjustable cool-down time (typically 5 to 30 minutes).

2. Local Control: The generator-set shall be capable of manual initiation or stopping from the locally mounted generator control panel. The local generator control panel shall be provided as part of this Contract.

3. Emergency Stop Control: An emergency stop pushbutton shall be provided at the generator control panel that shall cause the unit to stop without any delay.

2.3 ENGINE

A. The CONTRACTOR shall provide a complete engine-powered standby electrical generating system of the type and capacity indicated.

B. The diesel engine shall be mounted on a common base with the generator and the direct connected radiator and shall be rated for standby service, continuously for the duration of the electric power interruption, with engine jacket water cooled by means of a direct mounted water-to-air radiator under SAE conditions at 85 degrees F, 4600 feet above sea level. It should be noted that this is the rating of the engine. The minimum generator rating shall be 2500 KW.

C. The diesel engine shall be four-cycle, turbocharged, aftercooled, 1800 rpm, with individual fuel pumps and injection valve for each cylinder. The generator-set shall be **Caterpillar, Cummins, MTU,** or equal**.**

D. The engine shall have a dry type air cleaner with service indicator, fuel oil filter, full pressure positive pump lubrication with full-flow oil filters, thermostatic regulated oil cooling system, and crankcase drain with valving to be able to drain the crankcase oil without reaching under the engine.

E. The engine shall also be equipped with two 120 volt, thermostatically controlled jacket water heaters. Power shall be derived from a suitably-rated dry-type transformer and panelboard, also provided as part of the generating system, and including facilities to provide power to the battery charger, fuel oil transfer pumps if required, and other generator-related facilities.

F. The diesel engine shall perform as indicated when operating on a commercial grade of non-premium distilled petroleum fuel oil such as No. 2 domestic burner oil and diesel fuel.

G. The engine shall be equipped with an electric 24-volt dc starting system of sufficient capacity to crank at a speed which will start the engine under conditions indicated. Include a charging alternator. The starting pinion shall disengage automatically when the engine starts. The starting system shall include relays for fully automatic operation from a remote signal.

H. The engine shall be provided with a speed control, **Woodward Type 2301** and electronic governor, **Woodward Type EG-3P,** or equal.

I. The engine shall minimize discharge of gaseous pollutants and shall comply with the discharge limitations of the Utah Division of Air Quality . The CONTRACTOR shall furnish a certification from the manufacturer that the proposed generator set will comply with the limitations.

J. Specific limitations applicable under all loads are:

Pollutant	Maximum Emission Rate (pounds per hour)
Nitrogen oxides	1.0
Carbon monoxide	1.0
Non-methane hydrocarbons	1.0

2.4 BATTERIES AND BATTERY CHARGER

A. Provide a lead-acid storage battery with sufficient capacity for three 30 second cranking cycles, allowing 10 seconds between cycles. Submit calculations verifying adequate capacity. The battery shall be on a plastic rack as close as practical to the starter motor. The CONTRACTOR shall provide vented, nonmetallic protective covers or red and black plastic or rubber boots covering all terminals to protect against an accidental short circuit as might be caused by laying a metallic object on the battery. Metallic racks and covers are not acceptable.

B. A unit-mounted battery charger for 120 V, single phase, 60 Hz input shall be provided. The battery charger shall be voltage regulated, with separate float and equalize charge voltage adjustment having a 10 amp rating. The battery charger shall include alarm relays to sense high and low dc voltage, zero current, and ac power failure, with individual output contacts wired to terminal strips for tie into remote alarms. Also, provide an ac “on” indicating pilot LED light and dc voltmeter and ammeter and annunciator. The battery charger shall be **LaMarche Model A46,** or equal.

2.5 EXHAUST SYSTEM

A. The engine shall be provided with an exhaust system consisting of flexible connection, exhaust silencer, steel piping, fittings, stainless steel hardware and supports, brackets, and rain collar.

B. The flexible connection shall be of the stainless steel bellows type with flanged ends. Flexible elements shall be stainless steel suitable for exhaust temperatures recommended by the engine manufacturer. The flexible connection shall be suitable for vibration isolation and for relieving stress caused by thermal expansion.

C. The exhaust silencer shall be a critical grade manufactured by **Maxim,** or equal.

D. The silencer shall be mounted and supported horizontally on the roof of the walk-in generator enclosure.

E. Exhaust piping shall be pitched upward from the engine and be provided with sufficient drains to eliminate condensation and rain water. Exhaust piping shall be welded steel pipe. Elbows shall be welding type, standard wall. Flanges shall be welding slip-on type, 125 pound, either forged or plate steel. Exhaust piping shall be supported independently of the silencer. The silencer and exhaust piping shall be insulated with a minimum of 2-1/2 inches of calcium silicate with a stainless steel jacket and shall be supported as required. The weight of the exhaust and silencer shall not be supported by the engine.

2.6 COOLING SYSTEM

A. The engine shall be equipped with a cooling system having sufficient capacity to effectively cool the engine when delivering full rated horsepower at the conditions stated above. A radiator and engine-driven fan of a type and capacity recommended by the engine manufacturer shall be included.

B. The radiator shall be sized in accordance with the engine manufacturer's recommendation for use with 50 percent aqueous ethylene glycol. Air flow shall be controlled by a power inlet damper and a gravity discharge damper, both provided as part of the walk-in outdoor enclosure. Design ambient air temperature shall be 100 degrees F at sea level.

C. The engine shall have an engine-driven, gear driven centrifugal type water circulating pump for circulating water through the cooling system.

2.7 GENERATOR

A. The generator shall be nominally rated 2500 KW at .8 PF, 12,470 V 3 phase, 60 Hz, 4 wire wye and shall be a brushless design with solid state permanent magnet generator (PMG) exciter. Other excitation methods are not acceptable. The voltage regulator shall be solid state, generator mounted. Provide radio-interference suppression meeting commercial standards.

B. If a line to neutral short circuit occurs, the generator shall be capable of supporting 300 percent rated current for 10 seconds without externally mounted devices.

C. Voltage Regulation Tolerance: Plus or minus 1 percent of any present value over the 3 phase load range. Instantaneous voltage dip or rise, when measured with an oscilloscope, shall not exceed 25 percent upon full load application or rejection, and shall return to preset value within 0.5 seconds.

D. Waveform: Deviation factor of output voltage shall not exceed 5 percent and the value of any individual harmonic shall not exceed 2 percent of the fundamental when operating with an unbalanced load.

E. Temperature Rise: Temperature rise of any component shall not exceed the rise permitted by NEMA standards. The voltage regulator shall be adjustable minus 25 percent to plus 10 percent.

F. Bearing: Double sealed ball bearing, lubricated for life.

2.8 VIBRATION ISOLATORS

A. The engine and generator shall be mounted on a common system base and shall be provided with vibration isolators of number and size as recommended by the engine supplier to support the engine, generator, radiator, and base. The isolation mountings shall consist of steel or cast iron top and bottom housings incorporating steel springs or "donut" style isolators, located between the genset and the base, and shall be provided with built-in leveling bolts and built-in resilient chocks to control isolation and withstand lateral forces in all directions.

B. The vibration isolators shall be **Korfund Dynamics Corporation Series L**, or equal.

2.9 LUBRICATION AND COOLING FLUIDS

A. The supplier shall furnish the engine fully charged with lubricating oil and grease as specified by the manufacturer for continuous service. The cooling system shall be furnished with a full charge of 50 percent ethylene glycol.

2.10 GENERATOR SYSTEM CONTROL PANEL

A. The engine shall provided with an integrally mounted instrument and control panel, vibration isolated, NEMA 12 compliant, dead front, constructed of 14-gauge steel and containing at least the following equipment:

Coolant temperature gauge
Oil pressure gauge
Four position selector switches marked for “auto,” “manual,” “stop,” and “stop/reset.”
Automatic starting controls (2 wire start/stop)

Coolant level pre-alarm
Coolant temperature pre-alarms (low and high)
Fuel pressure pre-alarm
Low dc voltage alarm to indicate loss of charge on battery
Electrical contacts and "push to test" pilot lights for shutting down the engine on low oil pressure, high oil temperature, overcrank, high coolant temperature, and overspeed condition
Individual electrical contacts for remote indication of any pre-alarm or alarm condition
Running Time Meter (Non Resettable)
Emergency stop switch
Voltmeter and switch, ammeter and switch, frequency meter

B. Wiring

1. Signal wiring shall be segregated from power wiring and be arranged neatly to facilitate tracing of circuits.

2. Plastic wiring wraps shall be used to bundle wires, except within wiring ducts. The bundles shall be securely fastened to the steel structure at suitable intervals not exceeding 12-inches in length. No open space hanging of wires will be permitted. Flexible stranded copper wiring shall be used throughout. No solid conductor wire shall be permitted.

3. Terminal blocks shall be provided for interconnections between remote devices and local control panel wiring. The terminal blocks shall be factory assembled on a mounting channel, and the channel shall be bolted to the inside of the panel. The terminals shall have a continuous marking strip using the nomenclature on the schematic diagrams. No more than 2 wires shall be terminated at any one terminal. Wire terminals shall have sleeve wire markers properly marked to match the schematic diagrams.

2.11 GENERATOR ENCLOSURE AND FUEL TANK

A. Generator Enclosure

1. A weatherproof, sound attenuated, walk-in type enclosure shall be provided to house the engine/generator and accessories. The following standards and codes shall be met at a minimum:

a. NEPA 70 (National Electric Code)

b. NFPA 30

c. NFPA 37

d. NFPA 110

e. UL 142

f. API 620

B. The enclosure shall be constructed with an aluminum diamond plate finished floor for mounting on a concrete pad. The enclosure shall conform to the following design criteria, and be constructed as manufactured by **Pritchard-Brown (Div. of Enviro Industries),** or equal**.**

Rigidity wind test equal to	150 MPH
Roof load equal to	50 lbs. per sq. ft.
Floor load equal to	200 lbs. per sq. ft.
Rain test equal to	4-inches per hour
Enclosure certified to meet	BOCA base building and mechanical codes

C. Test data on similar construction by the manufacturer shall be available to the ENGINEER upon request.

D. Enclosure shall consist of a roof, steel floor, fuel tank base, 2 side walls and 2 end walls, of stressed skin, semi-monocoque construction, sized as required to meet dimensional, sound attenuation, and code requirements for the actual generator provided.

E. The system shall include a cooling and combustion air inlet silencer section, an equipment enclosure section, and a cooling air discharge silencer section. It shall be designed to reduce source noise by an estimated average 25 dB(A) as measured at a distance of 7-meters from the enclosure. The enclosure shall also be bird- and rodent-proof with all openings screened.

F. Roof and walls shall be of one-piece semi-monocoque construction. Framing members shall be aluminum or aluminized steel. Skin material shall be minimum thickness 0.040-inch, prepainted earth bronze color, aluminum (roof shall be mill finish) or minimum thickness 18-gauge aluminized steel. Other materials of construction may be acceptable; however, the CONTRACTOR shall furnish data verifying that the proposed system is equivalent or better than that indicated. Alternative skin colors may be submitted to the ENGINEER for selection. Skin panels shall be hard-riveted to framing members on 3-inch centers maximum. Pop rivets and bolts are not acceptable fasteners to attach exterior skin to framing. Roof assembly shall be cambered to aid in rain runoff.

G. Insulation in walls and roof shall be semi-rigid, thermo acoustic, thickness as required to meet the noise criteria. Lining shall be perforated mill finish aluminum. Self-adhesive foam and loose or batt-type insulating materials will not be accepted.

H. Lifting provisions shall be provided at the enclosure base, with capacity suitable for rigging the entire assembly. Quality assurance procedures of the manufacturer shall include regular testing of the lift devices.

I. A minimum of 4 single personnel access doors shall be provided. A hinged access door for the load bank controls shall also be provided. Doors shall consist of an extruded frame with skin material matching enclosure. Doors shall be fully gasketed to form a weathertight perimeter seal and be padlockable. Hinges shall be stainless steel, and lock mechanisms shall be 3 point, with panic hardware to allow opening from inside even when padlocked. The door threshold, if needed, shall be aluminum. Stairs and handrails shall be aluminum and shall be manufactured to meet field-installed conditions.

J. Air handling shall be as follows: Air shall enter the enclosure through a removable hood. Motor-operated dampers shall be provided, wired to be spring operated to open upon engine startup. Radiator discharge shall be through a gravity-operated damper and into a hood. The system shall not exceed 0.5-inch wg total external static pressure to ensure adequate airflow for cooling and combustion.

K. A bolt-in-place removable end wall panel shall be provided for maintenance and/or equipment installation. Bolts, nuts, and washers shall be stainless steel.

L. Enclosure manufacturer shall provide all necessary hardware to externally mount the exhaust silencer and maintain the weatherproof integrity of the system. A bird screen shall be installed on exhaust outlet.

M. An electrical package shall include minimum four 60 watt incandescent lights, one battery-backed emergency light with two 25 watt heads, one light switch, and one duplex GFCI receptacle. These items, as well as the motor-operated air inlet damper, shall be factory wired to a 60A 120/240V Load Center. Input power to the load center shall be as indicated.

N. Fuel Tank

1. An integral UL listed underframe tank with floor and rupture basin shall be provided, consisting of the following: a rupture basin utilizing minimum 7-gauge steel channel perimeter walls and bottom, a UL listed above-ground rectangular fuel storage tank of minimum 12-gauge steel, 4000 gallon capacity, and a floor system consisting of fabricated or structural steel crossmembers on centers averaging 16-inches. The crossmembers shall be overlaid with O.S.B. board or plywood topped with 14-gauge steel diamond plate. This wood/steel combination shall be used for acoustic isolation of the generator set from the base. The tank shall have venting and emergency venting per UL 12 and NFPA 30; lockable fill, low-level, and high-level alarm contacts; and a dc electric analog fuel level gauge. The rupture basin shall include a float contact to indicate tank rupture. The crossmembers shall incorporate 3/8-inch thick steel tapping plates for gen-set mounting. The entire enclosure/fuel tank package shall be UL listed

for use with a diesel engine generator system and shall meet the previously indicated codes and standards.

2. Pipe and Fittings

   a. Pipe and fitting materials shall be new and the best of their respective classes. Pipe shall be clearly marked with the manufacturer's standard trade mark or identification mark. Pipe and fittings, unless otherwise indicated, shall meet the requirements of these specifications.

   b. Piping carrying fuel oil shall be copper type "L" with wrought copper fittings silver soldered. Flexible connections shall be provided between fuel lines and the engine.

3. Hangers, Supports, and Miscellaneous Metalwork: The CONTRACTOR shall provide all necessary hangers, supports, concrete inserts, anchors, and guides for the standby generator equipment.

4. Valves: The CONTRACTOR shall provide ball valves for installation at all required points and on at least each fuel supply line. Ball valves shall be stainless steel, rated 125 pounds working pressure and in every respect be suitable for the purpose intended.

2.12 SPARE PARTS

A. Four sets of the following spare parts shall be furnished:

1. Air filters

2. Oil filters

3. Fuel filters

PART 3 -- EXECUTION

3.1 FACTORY TESTING

A. The generator system shall be witness tested at the factory before shipment to the Site. The manufacturer's standard testing procedure shall be followed, and in the event the system does not satisfy the test criteria or the requirements of this Section, it shall be repaired, modified, or replaced until it conforms.

3.2 START-UP ASSISTANCE AND TRAINING

A. The manufacturer's representative shall furnish on-Site start-up assistance and shall inspect the installation prior to start-up to verify that equipment is installed in accordance with the manufacturer's requirements.

B. Upon completion of startup and after acceptance by the OWNER, the CONTRACTOR shall completely fill the fuel tank.

C. In addition, the manufacturer's representative shall provide on-Site training for operation and maintenance of all equipment included in this Section.

D. The following times shall be included, as a minimum, for the above tasks. A Day is defined as 8 hours on-Site, exclusive of meals and travel. Each task shall be considered a separate trip to the site. Dates and times for the trips shall be coordinated with the OWNER.

1. Inspection of the installation: 2 Days

2. Startup assistance: 3 Days

3. Operation and Maintenance Training: One Day

END OF SECTION

SECTION 26 33 53
UNINTERRUPTIBLE POWER, SINGLE PHASE

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide the single-phase uninterruptible power system (UPS) and all accessories required, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 26 00 00 - Electrical Work, General, apply to the WORK of this Section.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ANSI/IEEE 241	Electric Power Systems in Commercial Buildings, Recommended Practice for
ANSI/NEMA 250	Enclosures for Electrical Equipment
EIA	Electronic Industries Association Standards
IEEE-587	Standards for Surge with Stand Ability
NEC	National Electrical Code; Article 700 Emergency Systems
NEMA PB2	Panelboard
UL 1012	Underwriter's Laboratory Listing

1.3 CONTRACTOR SUBMITTALS

A. Furnish Shop Drawings and catalog data in accordance with Section 01 33 00 – Submittal Procedures. Submit sufficient information to indicate the scope and quality of the UPS system installation.

1. Block diagram showing system relationships of major components and quantities and interconnecting cable requirements.

2. Control console and panel arrangements, equipment outlet devices, and special mounting details.

3. Wiring diagrams showing terminal identification for field-installed wiring.

4. Catalog literature.

B. Instead of the Technical Manuals in Section 01 33 00 – Submittal Procedures, furnish 6 copies of the operating and service manuals for the system. The manuals shall be bound in flexible binders and all data contained therein shall be printed or typewritten. Each manual shall include all instruction necessary for proper operation and receiving of the system, and shall include a complete block diagram of the system, a complete circuit diagnosis of the system, and a wiring designation schedule for each amplifier as well as other major components, and a replacement parts list.

1.4 QUALITY ASSURANCE

A. Uninterruptible power system components shall be manufactured by firms that are regularly engaged in the production of UPS systems including auxiliary equipment similar to that required by this Contract and that have been in satisfactory service for at least 10 years.

B. Operation of the uninterruptible power system shall be demonstrated to the ENGINEER to prove that under normal conditions, UPS will provide power to the designated load without interruptions of functions and loss of stored information.

1.5 SERVICE DURING CORRECTION OF DEFECTS PERIOD

A. The CONTRACTOR shall respond to trouble calls with a competent repair person at the Site within 24 hours of notice. The CONTRACTOR shall also maintain a full inventory of replacement parts so that all routine repairs can be completed within 24 hours after the initial response.

PART 2 -- PRODUCTS

2.1 THE SYSTEM

A. The UPS shall be a continuous duty, on-line, solid-state system, utilizing line-interactive UPS topology and operating in conjunction with the plant electrical system to provide power conditioning, back-up, and distribution for critical equipment loads. The system shall consist of a solid-state inverter/charger, microprocessor controlled logic, a ferro-resonant transformer, a sealed maintenance-free battery, electromechanical bypass switch, and accessories as indicated.

B. In the line-interactive or single conversion UPS, utility power shall be fed directly to the critical load through an inductor transformer. Regulation and continuous power to the critical load shall be achieved through the use of inverter switching elements in combination with inverter magnetic components, such as inductors, linear transformers, or ferro-resonant transformers. The inverter shall interact with the transformer to provide plus or minus 3 percent load regulation under variations of line and load condition within the ratings of the UPS.

2.2 SYSTEM DESCRIPTION

A. The UPS system shall consist of the following major equipment:

1. Inverter/charger.

2. Electromechanical bypass switch.

3. Enclosed, sealed, maintenance-free battery. Battery cabinets for longer protection times.

4. Input, battery, and output breakers.

5. Microprocessor controlled logic and control panel.

6. Magnetics (ferro-resonant regulating transformer).

7. Control panel.

2.3 MODES OF OPERATION

A. The UPS shall operate as an on-line fully automatic system in the following modes:

1. Normal: For incoming utility voltage as low as 62 percent of nominal, based on the size of the load, the ferro-resonant regulating transformer shall provide regulated output voltage without drawing power from the batteries while supplying filtered ac power to the critical loads. In addition, simultaneous float-charging of the battery shall occur.

2. Emergency: Upon failure of the commercial ac power, the inverter shall continue to supply the critical load without any switching by obtaining its power from the storage battery. There shall be no interruption to the critical load upon failure or restoration of the commercial ac source.

3. Recharge: Upon restoration of the commercial ac source, the inverter/charger shall recharge the battery. This shall be an automatic function and cause no interruption to the critical load.

4. Bypass Mode: If the UPS must be taken out of service for overload, load fault, or internal failures, the bypass switch shall automatically transfer the load to the commercial ac power. Return from bypass mode to normal mode of operation shall be automatic, except for overload trip which requires manual reset. Transfer to bypass mode shall also be initiated manually by operating a key-controlled On/Off switch on the control panel.

2.4 PERFORMANCE CHARACTERISTICS

A. Power Ratings: 10 kVA/10 kW or 25 kVA/25 kW as indicated

B. Input

1. Nominal input voltage and frequency: 60 Hz models: 208 vac, 3ph.

2. Operating input voltage range: plus 15 percent to minus 20 percent of nominal without battery discharge.

3. Input power factor: 0.98 minimum at full load and nominal input voltage.

4. Output voltage THD: 5 percent maximum at rated kW load.

5. Input surge protection: 2000:1 spike attenuation using ANSI/IEEE C62.45 Category A and Category B tests.

C. Runtime (minutes): 15 min. under full load

D. Output

1. Nominal output voltage: 208 vac, 3ph.

2. Output voltage regulation: plus and minus 3 percent for input voltages of plus 15 percent to minus 20 percent.

3. Transient voltage response: Within plus and minus 8 percent from nominal peak voltage for a 100 percent load step.

4. Transient voltage recovery: 100 msec to within plus and minus 2 percent of nominal.

5. Frequency regulation: plus and minus 0.1 Hz.

6. Output voltage harmonic distortion: 5 percent or less TDH at rated kW load.

7. Output fully isolated from input and battery.

E. Environmental

1. Efficiency at full, unity power factor load and nominal input voltage: 90 percent

2. Elevation: The maximum operating ambient temperature drops 1 degree C per 300 meters (2 degrees F per 1000 feet) above sea level, with the maximum elevation being 3000 meters (10,000 feet).

3. Acoustical noise: 51 dBA at one meter (typical at 5.3 kVA but varies with UPS rating) (Measured at 25 degrees C

4. EMI suppression: Electromagnetic effects shall be minimized to ensure that computer systems or other similar electronic systems are neither adversely affecting to, nor are adversely affected by the UPS. The UPS shall be certified to

meet the requirements of Class A, Subpart J of Part 15 of the FCC Rules and Regulations.

F. Battery Pack

1. The battery shall consist of battery tray fully enclosed within the UPS

2. Batteries shall be sized to provide run times as indicated.

3. Battery Overcurrent Protection: A molded case breaker or fuse shall be provided for battery short circuit protection.

2.5 FUNCTIONAL DESCRIPTION

A. Inverter/Charger: The inverter shall be capable of providing the indicated quality output power while operating from the ac utility or dc source within the required operating range. In addition, the inverter shall simultaneously float charge the battery.

B. Electrical Protection

1. DC Input: DC fuse and battery charger fuse

2. Output Protection: The ferro-resonant transformer shall inherently limit current and provide overload protection. The UPS shall have high ac and low ac output voltage alarms, as well as an overload alarm. If the ac output voltage falls below the low ac output voltage alarm setpoint, the unit shall alarm after 5 seconds. If the ac output voltage falls below the low ac output shutdown setpoint, the unit shall alarm and shut down.

C. Electromechanical Bypass

1. An electromechanical bypass switch shall include transfer control logic which automatically transfers the load to bypass upon the following conditions:

a. Output overvoltage or undervoltage.

b. Overload condition of a duration longer than 10 minutes.

c. Overtemperature

d. Inverter failure

2. Return to UPS mode of operation upon restoration of normal operating conditions shall be automatic except for overload or inverter failure which requires a manual restart. Electromechanical transfers shall be break before make.

D. Microprocessor Controlled Logic: Fully automatic operation of the UPS shall be provided through the use of microprocessor controlled logic. All operating and

protection parameters shall be firmware controlled to eliminate the need for manual adjustment compensation for component tolerances. The logic shall include system and battery test capability to facilitate maintenance and troubleshooting. Start-up, transfers, and battery recharge shall be all automatic functions.

E. Control Panel

1. The UPS shall be equipped with a control panel that provides the monitoring and control functions

2. Four operating modes: Auto, Inverter On (Battery Power), Line Condition, and Off. Under normal conditions, selection of the appropriate operating mode shall be automatic, however the operating mode shall be manually selectable from the control panel.

3. Front panel lights

    a. AC LINE – White – Normal AC Input Power

    b. READY – Green – Battery backup power available

    c. CHARGING – Green – Battery is charging

    d. BATTERY POWER – Yellow – UPS is in the inverter mode with power provided from the batteries.

    e. ALARM – Red – Alarm condition

4. Alarm monitoring: The control panel shall display an error message identifying the alarm condition:

ALARM MESSAGE	ALARM CONDITION
Low Battery	The battery charge is low because the system was running on battery power or the DC Switch was not on.
Near Low Battery	The battery voltage has reached the Near Low Battery setpoint.
High Battery	There may be a problem with the charging circuit or parameter settings.
Low Runtime	The unit is running on battery power, and the battery runtime remaining is low.
Low AC Output	The output voltage is below a pre-programmed setpoint.
High AC Output	The output voltage is higher than the alarm setting.
Output Overload	Equipment is drawing more power than the UPS can provide. The unit shall continue to run with overloads as high as 125 percent for 10 minutes and then shut down.
Hi Ambient Temp	The temperature inside the unit is too high. If the temperature reaches a preset point, the unit shall shut down.
Hi Heatsink Temp	The inverter temperature is too high. If the temperature reaches a preset point, the UPS shall shut down.
User Test Alarm	The user is testing the alarm feature.
Hi Transformer Temp	The transformer temperature is too high. If the temperature reaches a preset point, the UPS shall shut down.
Check Charger	The UPS has detected a charger problem.
Check Battery	The batteries have failed the automatic system test.
Check Inverter	The inverter has failed the automatic system test.
Memory Check	Possible microprocessor problem.
Emergency Power Off	The Remote Shutdown feature has been activated at the RS232 port.
Hi PFM Res Temp	The Power Factor Module's temperature is too high. If the temperature reaches a preset point, the UPS shall shut down.
Probe Missing	A temperature probe is missing or damaged.
High AC Input	The input voltage is higher than the alarm setting.
Call Service	The UPS has detected a problem that requires service.
Fan Alarm	The fan has stopped.

F. Alarm Contact: A dry type summary alarm contact shall be provided for remote indication of alarm conditions.

2.6 ENCLOSURES

A. The UPS shall be housed in a free standing double dead front (safety shields behind front door) enclosure equipped with casters and leveling feet. Enclosures shall be designed for office or computer room applications. If system consists of more than one cabinet, the cabinets shall be shipped with joining hardware to be bolted together at time of installation.

B. Ventilation: Electronics cabinets shall be designed for natural convection cooling aided by a thermostatically controlled fan. Air inlets shall be in the lower front and rear; air outlets shall be in the upper rear. Battery cabinets shall be convection cooled.

C. Cable Entry: Units equipped with input cord and plug and output receptacles shall not require any installation. Hard-wired systems shall provide for conduit entry through knockouts located in the rear of the unit. Connection between UPS and battery cabinets shall consist of cables and power plugs.

D. Front Access: Major subassemblies shall be modular and shall be replaceable from the front of the unit.

2.7 MANUFACTURERS, OR EQUAL

A. **Schneider APC**

B. **Eaton “Ferrups**

C. **Vertiv “Liebert”**

PART 3 -- EXECUTION

3.1 GENERAL

A. The uninterruptible power system shall be installed as indicated and shall conform to Section 26 00 00 - Electrical Work, General and the equipment manufacturer's installation instructions.

1. The CONTRACTOR shall receive, store, and assemble all sections of the UPS to form complete units. The CONTRACTOR shall make all internal wiring interconnections as required for complete assembly of each UPS. Where wiring connectors are not supplied by the manufacturer, the CONTRACTOR shall furnish the connectors required to complete internal wiring terminations.

2. The CONTRACTOR shall take all necessary precautions to eliminate moisture and foreign material from the equipment at all times during storage and installation. Special care shall be taken to prevent corrosion of and damage to the UPS.

3. Each UPS shall be set level and plumb on its floor channels and be grouted in as indicated. The CONTRACTOR shall provide all shims necessary to accomplish these requirements.

END OF SECTION

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SECTION 26 35 26
ACTIVE HARMONIC FILTERS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide active harmonic filters, complete and operable, in accordance with the Contract Documents. It is the intent of this Section to require complete, fully tested active harmonic filters for unattended operation.

B. This Section defines the electrical and mechanical requirements for power correction systems in order to meet total demand distortion, total harmonic voltage distortion, and specific displacement power factor levels at selected points within the electrical system.

C. Power correction units shall be defined as a power electronic device consisting of power semiconductors that switch into the AC lines to modulate its output to cancel detrimental harmonic and/or reactive currents. A DC bus shall store power for power semiconductor switching. A microprocessor shall control the operation of the power converter.

D. Coordination: Equipment shall be sized to coordinate with the quantity and ratings of non-linear loads fed from the 480 volt distribution bus to be monitored by the Active Harmonic Filter.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

IEEE 519	Harmonic limits
IEEE C62.41	Surge Withstand Capacity
IP20 (NEMA 1)	Type of Enclosure
UL 508C	UL Requirements for Power Conversion Equipment

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

B. Shop Drawings

1. Equipment information

a. Name of manufacturer

b. Technical brochure detailing the standard and optional features of the power correction system

c. Type and model

d. Size and weights of shipping units to be handled by installer. Dimensional drawings with installed weight and heat dissipation for each size provided

e. Assembly drawing and nomenclature

f. Maximum heat dissipation capacity in kW

g. Information related to relays, timers, pilot devices, control transformer VA, and fuse sizes. Include catalog cuts.

2. Conduit entrance provisions.

3. Detailed installation drawings including terminal locations and remote CTs

4. Detailed layouts of customer power and control connections. Detailed installation drawings including terminal locations

5. System interconnection diagrams. The interconnection diagram shall include

a. System configuration in a single line diagram

b. Remote devices and control settings for matching CT ratios and system voltage

c. Factory test data certifying compliance of similar equipment from the same manufacturer with requirements of this Section.

C. Technical Manual: Include the following documentation:

1. Manufacturer's 2 year warranty.

2. Programming procedure and program settings.

3. Manuals shall include a functional description of equipment with block diagrams, safety precautions, installation instructions, start-up instructions, and troubleshooting guide.

D. Spare Parts List: Information for parts required by this Section plus any other spare parts recommended by the harmonic filter manufacturer.

1.4 SPECIAL CORRECTION OF DEFECTS REQUIREMENT

A. The power correction system manufacturer shall warrant products against defects in material and workmanship for a period of 2 years from date of shipment.

PART 2 -- PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Voltage: 480 volts, 3 phase, 3 wire plus ground or 480/277 volts, 3 phase, 4 wire plus ground as indicated on the drawings.

B. Output Load Capacity: Rated capacity shall be 480 volts, 3 phase, 3 or 4 wire and amp rating as indicated on the drawings.

C. Current Transducers: Split core type current transducers shall be furnished for installation by CONTRACTOR to monitor the current on 2 phases of the incoming feeds to the distribution switchgear for which the active harmonic filter is to provide harmonic mitigation.

1. Two current transducers per power correction system location shall be mounted on phases A & B.

2. Current ratings of the current transducers shall be as indicated on the drawings, corresponding to full load current of the feeds to the switchboards.

3. Current transducers rated for 400 Hertz shall be used.

2.2 MODES OF OPERATION

A. The power correction system shall be designed to electronically inject harmonic current to cancel load-produced harmonic current in the feeds to the power distribution switchgear monitored by the harmonic filter.

B. Displacement power factor correction shall be activated via a digital keypad/display mounted on the door of the enclosure. When reactive current compensation is activated, the power correction system shall first perform harmonic current correction and then use the remaining capacity to inject reactive current compensation to attain the level set forth herein.

C. Each unit shall be designed with a current limiting function to protect the semiconductors. When this level is attained, a message shall be displayed indicating the output capacity is at-maximum capacity and actuate the at-maximum capacity relay. Operation shall continue indefinitely at this level without trip off or destruction of the power correction unit.

D. Each unit shall incorporate an over-temperature output roll back that reduces the total output current in order to maintain maximum current correction within the electrical system.

E. Two distinct levels of faults shall be employed. Non-critical level faults shall provide automatic restart and a return to normal operation upon automatic fault clearance. Critical level faults shall stop the function of the unit and await operator action.

1. Faults such as AC line over-voltage, AC line under-voltage, AC line power loss, and AC line phase imbalance shall be automatically restarted. Upon removal of these fault conditions, the power correction system shall restart without user action. Automatic restart shall not occur if 5 faults have occurred in less than 5 minutes. During the fault condition, except line loss, the display shall state the type of fault and indicate that automatic restart will occur. The run relay and run LED shall be disabled. The fault relay shall not be enabled unless time-out occurs. Upon AC line loss, the power-on relay shall be disabled, and no display shall be provided.

2. Other types of faults shall be considered critical and shall stop the power correction system. The display shall indicate the fault condition and "stop." The run LED and relay shall be disabled, and the fault relay shall be enabled. User shall be required to initiate a power reset (turn power off and on) to restart the power correction system.

F. The logic of the power correction system shall monitor the load current by utilizing 2 current transducers (CTs) mounted on phases A and B to direct the function of the power electronic converter. The ratio of the CTs shall be entered into the logic via the digital keypad/display to calibrate the operation of the power correction system. The output of the current transducers shall be 5 amperes.

G. Up to 5 power correction units may be installed in parallel to inject current according to the information received from one set of CTs. The units shall function independently. If one unit is stopped or faulted, the remaining units shall adjust accordingly to maintain optimum harmonic cancellation levels up to the capacity of the remaining units.

2.3 PERFORMANCE REQUIREMENTS

A. Input Power

Voltage	Automatically adapted to 480 V, 3 phase plus ground
Voltage Tolerance	plus and minus 10 percent of nominal
Frequency	60 Hz, plus and minus 5 percent
Surge Withstand Capability, IEEE C62.41	Without damage
Input Fuses	Rated at 200,000 AIC amp interrupting capacity, Class T

B. Output Performance: Performance of the power correction system shall be independent of the impedance of the power source. Performance levels shall be attained whether on the utility service lines, backup generator, or output of UPS.

1. Harmonic Correction

a. Limit the 2nd through 50th order harmonic current to less than 5 percent TDD at each installed location. Harmonic levels for individual harmonic orders shall comply with respective levels established in IEEE 519, Table 10.3.

b. Limit the THD(V) added to the electrical system immediately upstream of the power correction system location(s) to less than or equal to 5 percent. The power correction system shall not correct for utility-supplied voltage distortion levels.

c. Reactive Current Compensation: Achieve 0.95 lagging displacement power factor. A leading power factor is not permitted.

C. Current Transducers

1. Current transducers shall be rated for 800 A or higher, corresponding to the total rated rms current of the total load at each installed location.

2. Two current transducers, mounted on phases A and B, shall be provided for each of 2 harmonic filters.

3. Each current transducer shall have a current output of 5 A. Current capacity of each current transducer shall be as indicated for the electrical system where installed.

4. Each current transducer shall be rated for 400 Hertz.

2.4 ENVIRONMENTAL CONDITIONS

A. The power correction system shall be able to withstand the following environmental conditions without damage or degradation of operating characteristics or shortening of useful life.

Operating Ambient Temperature	0 to 40 deg C (32 to 104 deg F)
Storage Temperature	-40 to 65 deg C (-40 to 149 deg F
Relative Humidity	0 to 95 percent, non-condensing
Altitude	Operating to 2000-m (6500-ft). Derated for higher elevations
Audible Noise	Generated by power correction system not to exceed 65 dbA measured 1-meter from surface of unit

2.5 OPERATOR CONTROLS AND INTERFACE

A. Units shall include a digital interface module (DIM) that includes an alphanumeric display consisting of 2 lines with 20 characters per line. Readout shall be in English. Display shall be easily viewed under lighting conditions, including sunlight, as found inside buildings.

B. Operators shall include run, stop, setup, enter, and up/down scroll.

C. The display shall provide operating data while functioning. Standard operating parameters available for display shall be AC line voltage, total rms load current, harmonic current of load, reactive current of load, output harmonic, and reactive current of power correction system. When the output of the power correction unit is at full-rated capacity, the display shall indicate at-maximum capacity and actuate an at-maximum capacity relay.

D. Fault conditions shall be displayed as they occur. Diagnostic information shall be presented in English, clearly indicating the nature of the fault

E. The Run pushbutton shall include a green LED that is lighted when unit is operating.

F. Contacts shall be provided for operator information for power on, run, fault, and at-maximum capacity conditions. Each contact shall be rated for 1 ampere at 120/240 volts. One form C contact shall be provided for each relay.

G. An RS 485 serial communication port shall be provided for remote control and diagnostic information.

2.6 FACTORY TESTING

A. Prior to shipment, the manufacturer shall fully test the performance at full current and voltage while functioning as a harmonic correction device to assure compliance with equipment specifications herein. A certified report shall be furnished to demonstrate successful completion of performance tests.

2.7 SPARE PARTS

A. Furnish the spare parts listed below, suitably packaged and labeled with the corresponding equipment number. At any time prior to Substantial Completion, the CONTRACTOR shall notify the ENGINEER in writing about any manufacturer's modification of spare part numbers, interchangeabilities, or model changes. If the ENGINEER determines that the modified parts no longer apply to the equipment provided, CONTRACTOR shall furnish other applicable parts as part of the WORK. The following spare parts shall be furnished:

1. Ten spare control and power fuses of each type and rating.

2. Five pilot lamps for replaceable incandescent lamps, as applicable.

3. One of each type of circuit board or modular assembly:

   a. Control board

   b. Power board

   c. Diode bridge

   d. Transistor/thyristor module

2.8 MANUFACTURERS, OR EQUAL

A. **AccuSine/Schneider Electric**

B. **Allied Motion/TCI**

C. **Eaton Electrical**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Each power correction unit shall be provided in NEMA 1 rated enclosure. Enclosures shall meet seismic requirements when installed according to manufacturer's requirements.

B. Units shall be either freestanding mounted to the floor with cable entry though the top or as part of a switchgear lineup as indicated.

C. Freestanding units shall include a door-interlocked disconnect that interrupts power when the door is opened. Disconnect shall be lockable in the power-off position. Wall mount units shall be disconnected from the power source by a disconnect device or circuit breaker contained in the power distribution center as required by codes for branch circuit protection.

D. Freestanding units shall include lifting provisions by forklift truck and lifting lugs. Wall mount units weighing more than 80 pounds shall have lifting lugs.

E. Units shall be provided with a grounding lug. Grounding by CONTRACTOR shall be according to local and national standards.

F. The paint shall be light grey - ANSI 61.

G. The authorized service representative of the manufacturer shall perform programming of parameters required for proper coordination with the operation of the VFDs deriving their operating power from the bus current and voltage monitored by the harmonic filter. Submit records of programming data in the Technical Manual, including setup and protective settings.

3.2 SERVICES OF MANUFACTURER

A. Inspections and Tests: CONTRACTOR shall arrange for the following services to be performed by factory-trained field service personnel. An authorized service representative of the manufacturer shall be present at the Site for 2 Days for each harmonic filter, to furnish the services listed below. For the purpose of this paragraph, a Day is defined as an 8 hour period excluding travel time

1. Visual Inspection

    a. Inspect equipment for signs of damage.

    b. Verify installation per drawings.

    c. Verify ground conductors are properly sized and configured.

    d. Verify current transducer orientation and wiring to power correction system.

    e. Verify logic setup corresponds to performance specifications defined herein.

2. Mechanical Inspection

    a. Check control wiring connections for tightness.

    b. Check power wiring connections for tightness.

    c. Check terminal screws, nuts, and/or spade lugs for tightness.

3. Electrical Inspection

    a. Check fuses for continuity

    b. Confirm input voltage and verify unit match.

    c. Check current transducers for proper phasing, location and orientation.

B. Startup and Field Adjustment: The authorized service representative shall supervise the following and certify the equipment and controls have been properly installed, aligned, and readied for operation.

1. Startup and field testing for proper operation

2. Performing field adjustments such that the equipment installation and operation comply with requirements.

C. The manufacturer shall provide field test personnel to initialize all equipment. A 3 phase harmonic analyzer shall be used to measure TDD and THD(V) levels to verify performance to requirements. Test reports shall be prepared for each point of test.

Test reports shall be documented, signed, and dated, and be submitted to the ENGINEER.

D. Instruction of OWNER's Personnel: The authorized representative shall instruct the OWNER's personnel in the operation and maintenance of the equipment, including step by step troubleshooting with test equipment. Instruction shall be specific to the harmonic filter model provided. Training shall be scheduled a minimum of 3 weeks in advance of the first session. Training shall include individual sessions for each shift of plant personnel. Proposed training materials shall be submitted for review, and comments shall be incorporated. Training materials shall remain with the trainees. The OWNER may videotape the training for later use with the OWNER's personnel.

3.3 FIELD TESTING

A. Testing, checkout, and energization of the harmonic filter equipment in the field shall be performed under the technical direction of the manufacturer's service engineer. Under no circumstances shall any portion of the system be energized without authorization from the manufacturer's representative. Equipment related to pump operation, specifically VFD's, shall not be energized or de-energized except by authorized plant personnel.

B. The representative of the manufacturer shall test the completed installation for actual harmonic distortion at the point of common coupling. Harmonic analysis shall be performed in accordance with IEEE 519 at unit full load using a harmonic analyzer by **Hewlett Packard**, or equal.

C. Tests shall demonstrate that the harmonic voltage distortion at the 480 volt distribution bus of the switchgear serving the VFD's is limited to a magnitude of 5 percent of the fundamental with the maximum number of drives, as permitted by the process, in operation and in conformance with the applicable requirements of IEEE 519. The report shall include the following:

1. Expected harmonic voltage (THD) through the 35th harmonic, calculated with isolation transformers

2. Actual RMS value and measured percentage of the THD in the field.

END OF SECTION

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SECTION 26 41 23
LIGHTNING PROTECTION SYSTEM

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR, through a qualified Subcontractor, shall design and provide a lightning protection system, complete and operable, as indicated in accordance with the Contract Documents.

B. The lightning protection Subcontractor shall be certified by the Lightning Protection Institute (LPI), for both the design and the installation of the lightning protection system.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes

NFPA 780	Standard for the Installation of Lightning Protection Systems
NFPA 70	National Electric Code
UL 96A	Lightning Protection Components
LPI-175	Lightning Protection Institute Installation Code

1.3 CONTRACTOR SUBMITTALS

A. Furnish Shop Drawings in accordance with the requirements of Sections 01 33 00 – Submittal Procedures and 26 00 00 – Electrical Work, General.

1. Products: Furnish manufacturer’s catalog data for all materials.

2. Drawings

a. Furnish a scaled drawing of the facility showing the lightning protection system.

b. The drawing shall show, at a minimum:

1) the location of air terminals

2) the routing of conductors

3) connections to the electrical grounding system and ground rods

4) details of air terminal mounting and bonding to vents, chimneys, antennas, and other metallic structures

3. Cross-reference the materials provided with the manufacturer's catalog numbers and cuts.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Products shall be UL-listed for use in lightning protection systems.

B. Products shall be Class I for structures not greater than 75 feet high and Class II for structures higher than 75 feet.

C. Air terminals for aluminum roofs or structures shall be of aluminum construction.

D. Air Terminals

1. Air terminals shall project a minimum of 10 inches above the objects protected, and shall be located at intervals not exceeding 20 feet along ridges and around the perimeter of flat roof or gently sloping roofs.

2. Flat or gently sloping roofs exceeding 50 feet in width shall be provided with additional air terminals at intervals not exceeding 50 feet on the flat or gently sloping area.

3. Locate air terminals within 24 inches of the roof edge and outside corners of the protected area.

4. Provide air terminals for metal stacks, flues, and mechanical equipment having a metal thickness of less than 3/16 inch and not within a zone of protection of an air terminal.

5. Equipment with a metal thickness 3/16 inch or greater shall be bonded in accordance with code requirements.

6. Air terminals shall be No. A71, 1/2-inch by 12-inch (or longer, as required), constructed of solid aluminum, and shall use air terminal bases of cast aluminum construction for aluminum roofs.

7. Air terminals shall be No. 71, 1/2-inch by 12-inch (or longer, as required), constructed of solid copper, and shall use air terminal bases of cast bronze construction for non-aluminum roofs.

E. Conductors

1. Structures Less than 75 Feet High

a. With Aluminum Roofs

1) Main size conductors on the roof shall be No. A28, Class I aluminum lightning conductor, consisting of 28 strands of 14 AWG aluminum wire weighing 115 lbs. per 1000 feet.

2) Secondary bonding conductors shall be No. A10, secondary bonding conductor, consisting of 10 strands of 14 AWG aluminum wire.

3) Down Conductors

a) Down conductors shall be No. 29, Class I copper lightning conductor.

b) Conceal down conductors in exterior wall construction.

c) Use bimetallic connectors for the transition from aluminum roof conductors to copper down conductors.

4) Provide buildings over 60 feet high with a conductor counterpoise cable constructed of 29/17 copper in conformance with NFPA code requirements.

b. With Non-Aluminum Roofs

1) Main size conductors on the roof shall be No. 29, Class I copper lightning conductor, consisting of 29 strands of 17 AWG copper wire weighing 190 lbs. per 1000 feet.

2) Secondary bonding conductors shall be No. 14, secondary bonding conductor, consisting of 14 strands of 17 AWG copper wire.

3) Down Conductors

a) Down conductors shall be No. 29, Class I copper lightning conductor.

b) Conceal down conductors in exterior wall construction.

4) Provide buildings over 60 feet high with a conductor counterpoise cable constructed of 29/17 copper in conformance with NFPA code requirements.

2. Structures Higher than 75 Feet

a. With Aluminum Roofs

1) Main size conductors on the roof shall be No. A37, Class II aluminum lightning conductor, consisting of 37 strands of 13 AWG aluminum wire weighing 190 lbs. per 1000 feet.

2) Secondary bonding conductors shall be No. A10, secondary bonding conductor, consisting of 10 strands of 14 AWG aluminum wire.

3) Down Conductors

a) Down conductors shall be No. 28, Class II copper lightning conductor.

b) Conceal down conductors in exterior wall construction.

c) Use bimetallic connectors for the transition from aluminum roof conductors to copper down conductors.

4) Provide buildings over 60 feet high with a conductor counterpoise cable constructed of 28/14 copper in conformance with NFPA code requirements.

b. With Non-Aluminum Roofs

1) Main size conductors on the roof shall be No. 28, Class II copper lightning conductor, consisting of 28 strands of 14 AWG copper wire weighing 375 lbs. per 1000 feet.

2) Secondary bonding conductors shall be No. 14, secondary bonding conductor, consisting of 14 strands of 17 AWG copper wire.

3) Down Conductors

a) Down conductors shall be No. 28, Class II copper lightning conductor.

b) Conceal down conductors in exterior wall construction.

4) Provide buildings over 60 feet high with a conductor counterpoise cable constructed of 28/14 copper in conformance with NFPA code requirements.

F. Miscellaneous Hardware

1. Provide miscellaneous hardware as may be required for the installation of the lightning protection system.

2. The hardware shall be compatible with the indicated air terminal and conductor materials.

3. Nuts, bolts, and other fasteners shall be constructed of stainless steel.

G. Corrosion Protection

1. Provide corrosion protection at the junctions of dissimilar metals and at locations where the components of the lighting protection system may be subjected to corrosion.

2. Use bimetallic connectors and fittings for splicing and bonding dissimilar metals.

3. Bimetallic connectors shall be located not less than 18 inches above grade.

4. Copper components within 24 inches of a chimney or vent emitting corrosive gases shall be protected by a hot-dipped lead coating or by another method as approved by the ENGINEER.

H. Grounding Materials

1. Ground rods and ground conductors shall conform to the requirements of Section 26 05 26 – Grounding.

2. Down conductors shall be connected to the ground rods using exothermic weld connections.

I. Structural Steel System

1. Structural steel may be substituted for down conductors.

2. The main steel columns shall be grounded an average maximum distance of 60 feet using Class II material.

3. Roof penetrations from steel to perimeter cables shall be at intervals not exceeding 100 feet in accordance with the requirements of UL 96A, LPI 175, and NFPA 780.

4. Use exothermic welds for steel connections.

PART 3 -- EXECUTION

3.1 GENERAL

A. The lightning protection system shall be installed in accordance with applicable code requirements by a Subcontractor certified in the following organizations:

1. NFPA

2. LPI

3. UL

B. Bends in conductors shall be gradual, utilizing a radius of 8-inches or greater and forming an angle of at least 90 degrees.

3.2 ROOF PENETRATIONS

A. Roof penetrations shall be made using a conduit sleeve passing through a pitch pocket.

B. The CONTRACTOR shall construct the pitch pockets in such a way as to maintain the roofing warranty required under Section 07 54 19 PVC Membrane Roofing in full force.

3.3 INTERCONNECTIONS OF METALS

A. Metal bodies within 6 feet of the conductor shall be bonded to the system with approved fittings and conductor.

B. Bonding of metallic objects and systems at roof levels and elsewhere on the structure shall be complete.

C. The primary bonds for metal bodies of conductance, which shall include the following items, shall be bonded with appropriate fittings and full-size conductor:

1. roof exhaust fans

2. HVAC units with related piping ductwork

3. exhaust vents and other roof piping systems

4. cooling towers and rail systems

5. window-washing tracks

6. antenna masts for TV, radio, or microwave

7. flag poles

8. roof handrails

9. decorative screens

10. roof ladders

11. skylights

12. metal plumbing stacks

D. Exterior architectural metal fascia, curtain walls, or mullions, which extend the full height of the structure, shall be bonded, if not inherently bonded through the building frame.

E. Metal Bodies of Conductance

1. Metal bodies of inductance located within 6 feet of a conductor or object with secondary bonds shall be bonded with secondary cable and fittings.

2. Typical of these are:

a. roof flashings

b. parapet coping

c. gravel guards

d. isolated metal building panels or siding

e. roof drains and down spouts

f. roof insulation vents

g. other sizeable miscellaneous metal fabrications

3.4 INSPECTION AND ACCEPTANCE

A. The lightning protection system shall be inspected, tested, and certified.

B. The CONTRACTOR shall retain the services of an independent inspector.

C. An LPI/UL Certificate of Inspection shall be furnished to the ENGINEER.

END OF SECTION

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SECTION 26 43 00
SURGE PROTECTION DEVICES (SPD)

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install surge protective devices (SPD).

B. SPDs furnished under this Section shall be ANSI/UL 1449 Type 2 integrating both surge suppression and high-frequency noise filtering suitable for use on low-voltage distribution systems.

C. The requirements of Section 26 00 00 – Electrical Work, General, apply to the WORK of this Section

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Standards:

1. ANSI/UL 1449, Fourth Edition, Safety Surge Protective Devices

2. IEEE C62.41.1, Guide on the Surge Environment in Low-Voltage (1000V and Less) AC Power Circuits

3. IEEE C62.45, Recommended Practice on Surge Testing for Equipment Connect to Low-Voltage (1000V and Less) AC Power Circuits

4. UL 1283, Safety Electromagnetic Interference Filters

5. NFPA 70, National Electric Code

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 26 00 00 – Electrical Work, General.

B. Shop Drawings:

1. Electrical and mechanical drawings for each type of unit, showing electrical ratings, dimensions, mounting provisions, connection details, and layout diagrams.

C. Product Data:

1. Manufacturer’s technical information, including catalog information.

2. Manufacturer's technical specifications with assembly and component ratings.

D. Certifications: Certification that SPD devices comply with standards referenced in this Section.

1.4 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: Shall have at least five (5) years' experience manufacturing and servicing products substantially similar to those required and shall be able to submit documentation of at least 5 installations in satisfactory operation for at least five (5) years each.

B. Component Supply and Compatibility:

1. Obtain all products included in this Section regardless of component manufacturer from a single SPD manufacturer.

2. SPD manufacturer shall review and approve or prepare all Shop Drawings and other submittals for all components furnished under this Section.

3. Components shall be suitable for the specified service conditions and shall be integrated into overall assembly by SPD manufacturer.

PART 2 -- PRODUCTS

2.1 GENERAL

A. SPD shall be modular, high-energy, parallel design with fast-acting transient voltage suppression using metal oxide varistors. Equipment shall provide noise attenuation with electromagnetic interference filter.

B. SPD shall be suitable for operation under the following environmental conditions:

1. Relative Humidity: Zero to 95%, non-condensing

2. Frequency: 47 to 63 Hz

3. Temperature: Zero to 149°F

4. SPD operating voltage shall be suitable for the associated SPD location(s).

5. SPD shall be suitable for internal and external mounting. SPD shall be factory-mounted and integrated into distribution equipment specified under the following Sections:

a. Section 26 00 00 – Electrical Work, General

b. Section 26 12 16 – Panelboards and General Purpose Dry Type Transformers

c. Section 26 29 00 – Low Voltage Motor Control Centers

d. Section 26 24 13 – 480V Switchboard

C. SPD shall include a surge suppression path for each mode as required for the system configuration. Each mode shall be individually fused and equipped with thermal cutouts. SPD short-circuit current rating shall be 200 kA. Protection modes shall include, to the extent applicable, the following:

1. Line-to-line

2. Line-to-neutral

3. Line-to-ground

4. Neutral-to-ground

D. SPD shall include electromagnetic interference/radio frequency interference (EMI/RFI) noise rejection filter with attenuation up to 30 dB from 10 kHz to 100 MHz.

E. SPDs and components in the operating path shall have maximum continuous operating voltage greater than 115% of nominal system operating voltage.

F. ANSI/UL 1449 minimum withstand rating shall be 20 kA per pole, and ANSI/UL 1449 voltage protection rating for SPD shall not exceed the following:

Modes	208Y/120	480Y/277
L-N,L-G, N-G	800	1200
L-L	1200	2000

G. SPD surge capacity based upon IEEE C62.41 location category shall, as a minimum, be the following:

Category	Application	Per Phase	Per Mode
C	Service entrance	240 kA	120 kA
B	High exposure locations (distribution equipment)	160 kA	80 kA
A	Branch locations	120 kA	60 kA

H. Provide SPD equipped with the following accessories:

1. Surge counter with display for indicating the number of surges detected.

2. LED indicators for monitoring device status.

3. Audible alarm and silence switch for indicating an inoperative condition.

4. Dry contacts, “form C”, for remote annunciation of unit status.

I. Source Quality Control: Perform manufacturer’s standard factory tests on equipment. Tests shall be in accordance with ANSI/UL 1449.

J. Manufacturers, or equal:

1. Eaton

2. Schneider Electric

3. ABB

4. Siemens

PART 3 -- EXECUTION

3.1 GENERAL

A. Install SPD in accordance with equipment manufacturer’s written recommendations and instructions and the Contract Documents.

B. Where an SPD cannot be installed integral with the equipment to which it is connected, conductor length between suppressor and connection point shall be as short and as straight as possible.

END OF SECTION

SECTION 26 50 00
LIGHTING

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. Provide luminaires and accessories, complete and operable, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Codes

NFPA 70 National Electric Code

NEMA 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)

UL-595 Standard for Safety Marine-Type Electric Lighting Fixtures

UL-924 Standard for Safety Emergency Lighting and Power Equipment

1.3 CONTRACTOR SUBMITTALS

A. Furnish the following product information in accordance with the requirements of Section 01 33 00 –Submittal Procedures.

B. Furnish the following information:

1. Interior Luminaires

a. Catalog data sheets and photos

b. Luminaire finish and metal gauge

c. Lens material, pattern, and thickness

1) Candlepower distribution curves in 2 or more planes

d. Candlepower chart, 0 to 90 degrees

e. Lumen output chart

f. Average maximum brightness data in foot-lamberts

g. Coefficients of utilization for zonal cavity calculations

h. Mounting or suspension details

i. Heat exchange and air handling data

2. Exterior Luminaires

a. Catalog data sheets and photos

b. Luminaire finish and metal gauge

c. Lens material, pattern, and thickness

d. IES lighting classification and isolux diagram

e. Fastening details to wall

3. Lamps

a. Voltages

b. Colors

c. Approximate life (in hours)

d. Approximate initial lumens

e. Lumen maintenance curve

f. Lamp type

4. Photocells

a. Voltage and power consumption

b. Capacity

c. Contacts and time delay

d. Operating levels

e. Enclosure type and dimensions

f. Temperature range

PART 2 -- PRODUCTS

2.1 LUMINAIRES

A. General

1. Additional Work requirements are indicated in the Luminaire Schedule on the Drawings.

2. Where normal use lighting is provided with integral emergency battery option, provide additional hot (unswitched) wire to the luminaire.

B. Provide minimum 18 AWG wire leads with fused inputs.

C. Provide components that are accessible and replaceable without removing the luminaire from the ceiling.

D. Exterior Installations

1. Installations shall be UL-labeled as "Suitable for Wet Locations."

2. When factory-installed photocells are provided, the entire assembly shall be UL-labeled.

E. Emergency Lighting

1. Power Pack

a. Self-contained

b. 120/277 V

c. Battery as per luminaire schedule

d. Indicator switch in accordance with the requirements of UL 924

2. Lighted, push-to-test pushbutton and indicator

3. Capability of providing full illumination for 1-1/2 hours in emergency mode

4. Capability of full recharge in 24 hours, automatically initiated upon resumption of normal line voltage

5. Capability of protecting against excess charging and discharging

6. Solid state charger

7. Normal and emergency led indicating lights

8. Mounting stand (as applicable)

9. Provide NEMA-rated enclosures in accordance with the area classifications in which they are installed.

F. Exit Signs

1. Internally illuminated

2. Universal mounting type

3. Battery as per luminaire schedule

4. Battery charger

5. LED-type emergency and normal indicating lights

6. Press-to-test button

7. Directional arrows

2.2 LAMPS

A. See Luminaire Schedule

2.3 LIGHTING CONTROL

A. Photocell

1. Photo Control: automatic ON-OFF switch

2. Housing: self-contained; die-cast aluminum; unaffected by moisture, vibration, or temperature changes

3. Settings: ON at dusk; OFF at dawn

4. Provide a time delay feature in order to prevent false switching.

5. Field-adjustable to control operating levels

6. Manufacturer, or Equal

a. **Tork**

b. **Paragon**

PART 3 -- EXECUTION

3.1 LUMINAIRES

A. General

1. Install in accordance with the manufacturer's recommendations.

2. Provide necessary hangers, pendants, canopies, and other accessories.

3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to the building as required to safely mount the luminaire.

4. Install the luminaire plumb and level.

5. The mounting heights indicated for wall-mounted or pendant-mounted luminaires are from the bottom of the luminaire to finished floor or finished grade, whichever is applicable.

6. Install each luminaire outlet box with a galvanized stud.

B. Pendant Mounting

1. Provide swivel-type hangers and canopies to match the luminaires, unless otherwise indicated.

2. Space single-stem hangers on continuous-row fluorescent luminaires 48 inches apart.

3. Provide twin-stem hangers on single luminaires.

C. Unfinished Areas

1. Locate the luminaires to avoid conflicts with other building systems and blockage of the luminaire light output.

2. Luminaire Suspension

a. Provide 3/8-inch threaded galvanized steel hanger rods.

b. Scissor-type hangers will not be accepted.

3. For attachments to steel beams, provide flanged beam clips and straight or angled hangers.

3.2 LAMPS

A. Within each luminaire, provide the number and type for which the luminaire is designed, unless otherwise indicated.

3.3 CLEANUP

A. Remove labels and other markings, except the UL listing mark.

B. Wipe the luminaires inside and out in order to remove construction dust.

C. Clean the luminaire plastic lenses with an antistatic cleaner only.

D. Touch up painted surfaces of the luminaires and the poles with matching paint provided by the manufacturer.

E. Replace defective lamps at the Date of Substantial Completion.

END OF SECTION