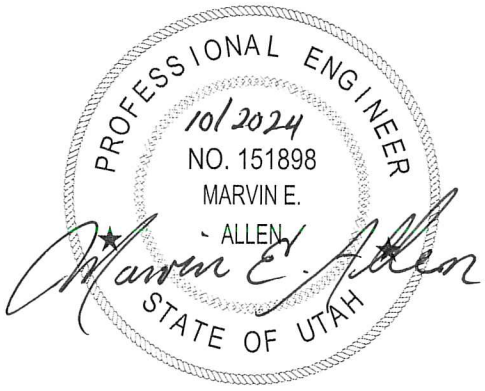
JORDAN VALLEY WATER
CONSERVANCY DISTRICT

WELL PUMP STATION CONSTRUCTION

700 EAST (7618 S 700 E, SANDY CITY)
1000 EAST (7750 S 1000 E, MIDVALE CITY)



BIDDING DOCUMENTS

OCTOBER 2024

CONTRACT DOCUMENTS FOR THE

700 E & 1000 E WELL PUMP STATION CONSTRUCTION
AT
7618 SOUTH 700 EAST
7750 SOUTH 1000 EAST

PROJECT #: 4280

NOVEMBER 2024

BID DOCUMENTS & SPECIFICATIONS

OWNER
Jordan Valley Water Conservancy District
8215 South 1300 West
West Jordan, Utah
(801) 565-4300

ENGINEER
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ELECTRICAL GENERAL REQUIREMENTS

PART 1 GENERAL

1.1 DESCRIPTION

A. It is the intent of this part of the Contract Documents to cover all work and materials necessary for erecting complete, ready for continuous use, a tested and working electrical system, substantially as indicated on the Plans and as hereinafter specified.

1.2 GENERAL PROVISIONS

A. Minimum sizes of equipment, electric devices, etc., are indicated but it is not intended to show every offset and fitting, nor every structural or mechanical difficulty that will be encountered during the installation of the work.

B. All work indicated on the Plans is approximately to scale, but actual dimensions and detailed drawings should be followed as closely as field conditions permit. Field verification of scale dimensions on Plans is directed since actual locations, distances, levels, etc. will be governed by field conditions.

C. Discrepancies indicated on different Plans, between Plans and actual field conditions, or between Plans and Contract Documents shall be promptly brought to the attention of ENGINEER for a decision.

D. The alignment of equipment and conduit shall be varied due to architectural changes, or to avoid work of other trades, without extra expense to OWNER.

E. CONTRACTOR shall furnish and install all parts and pieces necessary to the installation of equipment in accordance with the best practice of the trade and in conformance with the requirements of these Contract Documents.

F. All items not specifically mentioned in these Contract Documents or noted on the Plans or accepted shop drawings, but which are obviously necessary to make a complete working installation, shall be deemed to be included herein.

G. CONTRACTOR shall lay out and install electrical work prior to placing floors and walls. He shall furnish and install all sleeves and openings through floors and walls required for passage of all conduits. Sleeves shall be rigidly supported and suitably packed or sealed to prevent ingress of wet concrete.

H. CONTRACTOR shall furnish and install all inserts and hangers required to support conduits and other electrical equipment. If the inserts, hangers, sleeves, etc. are improperly placed or installed, CONTRACTOR shall do all necessary work, at his own expense, to rectify the errors.

I. All electrical equipment shall be capable of operating successfully at full-rated load, without failure, at an ambient air temperature of 40 degrees C, and specifically rated for an altitude of 4500 feet.

J. CONTRACTOR shall submit shop drawings, data and details to ENGINEER on all controls, fixtures, wireing, electrical equipment, conduit, etc. for review and acceptance prior to use of any components in the work.

K. All materials, equipment, and parts comprising any unit or part thereof specified or indicated on the Plans shall be new and unused, of current manufacturer, and of highest tgrade consistent to the state of the art. Damaged materials, equipment and parts are not considered to be new and unused and will not be accepted.

1.3 REGULATIONS AND CODES

A. Electrical work, including connection to electrical equipment integral with mechanical equipment, shall be performed in accordance with the latest published regulations of each of the following as well as all State and local codes.

1. NATIONAL ELECTRICAL CODE (NEC)
2. NATIONAL ELECTRICAL SAFETY CODE (NESC)
3. INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)
4. AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
5. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
6. INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)
7. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
8. NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)
9. FEDERAL OCCUPATIONAL SAFETY AND HEALTH ACT (OSHA)
10. UNDERWRITERS' LABORATORIES, INC. (UL).

1.4 COORDINATION OF THE ELECTRICAL SYSTEM

A. CONTRACTOR shall verify all actual equipment and motor full-load and locked-rotor current ratings. The necessary minimum equipment, wire, and conduit sizes are indicated on the Plans. If CONTRACTOR furnishes equipment of different ratings, CONTRACTOR shall coordinate the actual current rating of equipment furnished with the branch circuit conductor size, the overcurrent protection, the controller size, the motor starter, and the branch circuit overcurrent protection. The branch circuit conductors shall have a carrying capacity of not less than 125 percent of the actual full-load current rating. The size of the branch circuit conductors shall be such that the voltage drop from the overcurrent protection devices up to the equipment shall not be greater than 2 percent when the equipment is running at full-load and rated voltage.

1.5 TEST

A. The electrical work shall be free from improper grounds and from short circuits. The correctness of the wiring shall be verified first by visual comparison of the conductor connections with connection diagrams. Individual circuit continuity checks shall next be made by using electrical circuit testers. Last, the correctness of the wiring shall be verified by the actual electrical operation of the electrical and mechanical devices. Any deviation from the wiring indicated on the Plans or accepted drawings shall be corrected and indicated on the Plans.

1.6 CONFORMS TO RECORD DOCUMENTS DRAWINGS

A. Prior to completion of the Contract, CONTRACTOR shall furnish ENGINEER with a set of electrical plans marked with any changes, deviations or additions to any part of the electrical work.

B. Each conductor shall be identified as required by the Contract Documents. This identification shall be indicated on the record documents drawings to enable rapid and accurate circuit tracing by maintenance personnel.

1.7 SUBMITTALS

A. Submittals shall be in accordance with Section 01 33 00, SUBMITTAL PROCEDURES.

PART 2 PRODUCTS

2.1 NAMEPLATES

A. Where indicated on the Plans and where required by applicable codes, CONTRACTOR shall furnish and install nameplates which shall be black lamicoid with white letters. The nameplates shall be fastened to the various devices with round head brass screws. Each disconnect means for service, feeder, branch, or equipment conductors shall have nameplates indicating its purpose. All nameplates shall have 3/8-inch high lettering.

2.2 AUTOMATIC EQUIPMENT WARNING SIGNS

A. Permanent warning signs shall be mounted at all mechanical equipment which may be started automatically or from remote locations. Signs shall be in accordance with OSHA regulations and shall be suitable for exterior use. The warning signs shall be fastened with round head brass screws or bolts, located and mounted in a manner acceptable to ENGINEER.

B. Warning signs shall be 7 inches high by 10 inches wide, colored yellow and black, on not less than 18 gauge vitreous enameling stock. Sign shall read:

CAUTION
THIS EQUIPMENT STARTS
AUTOMATICALLY
BY REMOTE CONTROL

PART 3 EXECUTION - Not Used

- END OF SECTION -

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SECTION 26 05 05
ELECTRICAL EQUIPMENT

PART 1 GENERAL

1.1 DESCRIPTION

A. This section includes general electrical equipment used to complete the electrical system.

B. Related work includes but is not limited to,

1. Section 01 33 00 - Submittal Procedures
2. Section 01 60 00 - Product Requirements
3. Section 26 05 00 - Electrical General Requirements
4. Section 26 05 13 - Conductors and Cables
5. Section 26 05 33 - Conduit and Raceways
6. Section 26 05 34 - Electrical Boxes and Fittings

1.2 SUBMITTALS

A. Submittals will be required for all electrical equipment and shall be made in accordance with Section 01 33 00 - Submittal Procedures.

PART 2 MATERIALS

2.1 LIGHTING SWITCHES

A. Manufacturers:

1. Hubbell 1221W (white)
2. P&S 20AC1W (white)
3. Leviton 1221-2W (white)
4. Or approved equal

B. Specification Grade: Snap switches shall have the number of poles as indicated on the drawings, white, rated at 20 ampere.

C. Device Cover Plates:

1. Indoor Industrial Areas: Stainless steel cover plates shall be utilized.
2. Outdoor: Weatherproof cover plates.
3. Indoor in fluoride and hypochlorite rooms: White plastic cover plates.

2.2 SENSOR SWITCH

A. Manufacturers

1. Lutron, Maestro Series
2. Or Equal.

B. Switch shall include passive infrared occupancy or vacancy sensor. The unit shall detect heat from within the area and control the light fixtures.

C. Field of View: 180 degrees.

D. Distance: up to 30-ft x 30-ft

E. Operation: Auto-On / Auto-Off

F. Adjustable timeout 1, 5, 15 or 30 minutes.

G. Suitable for LED fixtures.

2.3 RECEPTACLES

A. Manufacturers:

1. Hubbell IG5352W (white)
2. P&S No. 5352-W (white)
3. Leviton 8300-W (white)
4. Or approved equal
5. Specification Grade: Outlets shall be duplex white receptacles and shall be 2-pole, 3-wire grounded, 125 volts, industrial, rated at 20 amperes.

B. Special receptacles, covers, etc. shall be as specified herein or as indicated on the Plans.

C. Device Cover Plates:

1. Indoor Industrial Areas: Stainless steel cover plates shall be utilized.
2. Outdoor: Weatherproof cover plates which also protect outlet when in use.
3. Indoor in Fluoride and Hypochlorite rooms: White plastic cover plates.

D. Ground Fault Interrupter Receptacles (GFI): GFI outlets shall be duplex ivory GFI receptacles, 2-pole, 3-wire grounded, 125 volts AC, rated at 20 amperes.

1. Manufacturers:
   a. Hubbell No. GF5262W (white)
   b. General Electric,
   c. P&S 2091-W (white)
   d. Leviton 5362-WGI (white)
   e. Or approved equal.

2.4 ENCLOSURES

A. Manufacturers:

1. Hammond Manufacturing,
2. Nvent Hoffman, Inc.
3. Rittal North America, LLC
4. Or approved equal.

B. This specification includes enclosures to house electrical controls, instruments, terminal blocks, etc. If not indicated otherwise they shall be NEMA 12 for indoor and NEMA 3R for outdoor installations.

C. A rolled lip shall be provided around three sides of the door and around all sides of the enclosure opening. The gasket shall be attached with oil-resistant adhesive and held in place with steel retaining strips. Exterior hardware, such as clamps, screws, and hinge pins, shall be of stainless steel for outdoor installations. A hasp and staple shall be provided for padlocking. Each enclosure shall have a print pocket.

D. Enclosures shall be from 14 gauge steel with seams that are continuously welded. Doors shall have full length piano hinges with the door removable by pulling the hinge pin.

E. Finish - Steel: Finish shall be white enamel interior, light grey enamel, ANSI 61 exterior, over phosphatized surfaces. Special finishes and colors shall be furnished for wet locations. Plans should be checked for special conditions.

2.5 DISCONNECT SWITCHES (INDIVIDUAL)

A. Manufacturers:

1. Eaton.
2. General Electric Co.
3. Siemens, Inc.
4. Square D Co.
5. Or approved equal.

B. Disconnect switches shall be heavy-duty safety switches with a quick-make, quick-break operating mechanism, full cover interlock and indicator handle. The disconnect switches shall be furnished with fuses of the size indicated on the Plans. One set of spare fuses shall be furnished for each fused disconnect switch.

2.6 CIRCUIT BREAKERS - LOW VOLTAGE (INDIVIDUAL)

A. All circuit breaker frame and trip ratings shall be as indicated on the Plans, except that they shall be coordinated with the ratings of the equipment actually furnished and shall be modified where necessary to suit this equipment. Circuit breakers to be used in motor control centers shall be as indicated on the Plans. When no indication of type is given on the Plans, the following shall govern:

1. Circuit breakers protecting motors rated 7.5 horsepower or less shall be motor circuit protectors, all other circuit breakers shall be molded case circuit breakers.

B. Manufacturers:

1. Eaton
2. General Electric
3. Siemens
4. Square D Company

5. Or approved equal.

2.7 FULL-VOLTAGE, NON-REVERSING MOTOR CONTROLLERS

A. GENERAL

1. Provide each motor with a suitable controller and devices that will function as specified for the respective motors and meeting NEMA ICS 2, the NEC, and UL.
2. Provide each motor controller with thermal overload protection in all ungrounded phases. Use protection consisting of thermal overload relays meeting NEMA ICS 2 which are sensitive to motor current and mounted within the motor controller, or a combination of thermal protectors embedded within the motor windings and controller-mounted overload relays, as indicated. Use overload protection devices of the inverse-time-limit type.
3. Provide controller-mounted overload relays of the manual-reset type with externally operated reset button when used without motor thermal protectors; when used in conjunction with thermal protectors, provide the automatic reset type. Select and install overload relay heaters after the actual nameplate full-load current rating of the motor has been determined.
4. Install and connect any required thermal protector monitoring relay provided by motor manufacturer in motor-control circuit and provide manual reset function. Fuse thermal-protector circuits according to the manufacturer's recommendations.
5. The Booster Pump controller shall be provided with two sets of thermal overload devices, rated for the full load current of the existing motors. The controller shall have a selection switch on the front selecting which thermal overload will be in service.

B. FULL VOLTAGE MAGNETIC STARTERS

1. Provide starters meeting NEMA ICA 2, Class A, with the rating and enclosure shown.
2. Supply individual control power transformers where indicated. The transformers shall have sufficient capacity to serve the connected load and limit voltage regulation to 10-percent during contact or pickup. Fuse one side of the secondary winding and ground the other side. Provide primary, current limiting fuses on all control power transformers.
3. For nonhazardous, indoor, dry locations, provide heavy-duty, LED indicating lights, selector switches, and stations. Utilize General Electric Type CR 104P, or equivalent by Square D, Cutler-Hammer, or other acceptable manufacturer. The use of other manufacturer's names referenced to materials herein, shall indicate the quality of material to be provided.

2.8 FUSES, 0-600 VOLTS

A. Provide a complete set of current-limiting fuses wherever fuses are indicated. Supply a set of six spare fuses of each type and each current rating installed. Utilize fuses that fit mountings specified with switches and which provide features rejecting Class H fuses. Provide the following types:

1. For 0- to 600-volt motor and transformer circuits, 0- to 600 amps, UL Class RK-1 with time delay, Bussmann Type LPS-RK, Shawmut Type A6D, or equal.
2. For 0- to 250-volt motor and transformer circuits, 0- to 600 amps, UL Class RK-1 with time delay, Bussmann Type LPN-RK, Shawmut Type A2D-R, or equal.
3. For 0- to 600-volt feeder and service circuits, 0 to 600 amps, UL Class RK-1, Bussmann Type KTS-R Shawmut Type A6K-R, or equal.
4. For 0- to 250-volt feeder and service circuits, 0 to 600 amps, UL Class RK-1, Bussmann Type KTN-R, Shawmut Type A2K-R, or equal.

2.9 MODULAR OVERLOAD RELAYS

A. Where called for on the Plans, modular overload relays shall be provided with the motor starters. The modular overload relays shall be 3-pole solid state devices set by one plug-in heater and shall protect all 3 phase of the motor in ambient temperatures ranging from -20 degrees to +70 degrees C.

B. The jam modules shall plug in the modular overload relays and shall provide for instantaneous trip of the overload relay should the current exceed a preset value at any time after the motor has accelerated. The modules shall be adjustable to any value between 150 percent and 400 percent of the motor full-load current.

C. The underload modules shall plug in the MOR and shall provide for overload relay trip whenever the current falls below a set value after the motor has accelerated. The modules shall be adjustable between 50 percent and 90 percent of the full load value of the motor full load current.

2.10 LIGHTING

A. Lighting fixtures shall be as described below and as indicated on the Plans.

B. Fixtures shall include lamps, ballasts, poles, mounting hardware, etc. to provide complete operating units.

C. Fixtures shall be LED type.

D. Catalog data including applicable coefficients of utilization tables, isolux chart of illumination on a horizontal plane, beam efficiency, horizontal and vertical beam spread, and beam lumens shall be submitted to the ENGINEER for review and acceptance for all fixtures before fixtures are manufactured. Substitutions will be permitted only if acceptable to the ENGINEER.

E. Light Emitting Diode(LED) Lighting

1. The LED Fixture shall consist of a LED Luminaire Assembly, LED Driver and mounting hardware.
2. LED Fixture requirements are as described below:
   a. The input to the LED Lighting Fixture shall be 120 to 277VAC (±10%), 60HZ or as indicated in the Contract Document.
   b. Correlated Color Temperature (CCT) shall be minimum 4000K or as indicated in the Contract Document.

c. Color Rendering Index (CRI) shall be 70.
d. A minimum of 50,000 operating hours before reaching the L70 lumen output degradations point without catastrophic failure, or as indicated in the Contract Document.
e. Conform with UL 8750.
f. Compliance to FCC CFR Section 15.

3. LED Luminaire Assembly
   a. Definition: Luminaire Assembly is the LED assembly without LED driver.
   b. Input voltage shall be 24VDC, 36VDC or as indicated in the Contract Document.
   c. CCT, CRI, Minimum life and UL conformity requirements are as defined in above article LED Lighting Fixture.
4. LED Driver
   a. Must operate input voltage between 120VAC to 277VAC (±10%).
   b. Operating frequency must be 60Hz.
   c. Must be rated to operate between -40ºC to +50ºC.
   d. Must have a minimum efficiency of 85%.
   e. Self protected including short circuit protection.
   f. Compliance to FCC CFR Section 15.
   g. Driver must have a Power Factor (PF) of 0.90.

F. Types and ratings: As shown on "Lighting Fixture Schedule" on Drawings.

2.11 CONTROL PANELS

A. Enclosure Manufacturers:

1. Hammond Manufacturing,
2. Nvent Hoffman, Inc.
3. Rittal North America, LLC
4. Or approved equal.

B. ENCLOSURES:

1. This specification includes enclosures to house electrical controls, instruments, terminal blocks, etc. If not indicated otherwise they shall be NEMA 12 for indoor and NEMA 3R for outdoor installations.
2. A rolled lip shall be provided around three sides of the door and around all sides of the enclosure opening. The gasket shall be attached with oil-resistant adhesive and held in place with steel retaining strips. Exterior hardware, such as clamps, screws, and hinge pins, shall be of stainless steel for outdoor installations. A hasp and staple shall be provided for padlocking. Each enclosure shall have a print pocket.
3. Enclosures shall be from 14 gauge steel with seams that are continuously welded. Doors shall have full length piano hinges with the door removable by pulling the hinge pin.
4. Finish - Steel: Finish shall be white enamel interior, light grey enamel, ANSI 61 exterior, over phosphatized surfaces. Special finishes and colors shall be furnished for wet locations. Plans should be checked for special conditions.

C. PILOT DEVICES:

1. Manufacturers:
    a. Allen-Bradley, Bulletin 800T, 30 mm
    b. Eaton
    c. Square D, Type K, 30 mm - Class 9001
    d. Or equal.
2. Indicating lights, pushbuttons and selector switches shall be miniature oiltight units. Contact blocks in control circuits shall be NEMA ICS, B150, rated 5 amperes inductive at 120 volts AC. Contact blocks for signal circuits shall be rated 0.06 amperes at 30 volts AC or DC and shall be hermetically sealed and reed switches. Pilot lights for 120 volt AC circuits shall be LED type. Where group lamp test circuits are not specified, individual pilot light assemblies shall be "push-to-test" type. Pilot lights shall be capable of being changed from the front of the panel without special tools.

D. TERMINAL BLOCKS:

1. Manufacturers:
    a. Allen-Bradley
    b. Buchanan
    c. Eaton
    d. Entrelec (ABB) M4/6
    e. Square D Co.
    f. Weidmuller
    g. Or equal
2. Terminal blocks shall be of the size required for conductors therein and a minimum of 50 percent spares shall be provided in each terminal box.

E. FUSE BLOCKS:

1. Manufacturers:
    a. Entrelec (ABB), M10/13.SF2
    b. Or approved equal.
2. DIN rail mounted.
3. Terminals shall accommodate 22-10 AWG solid or stranded wires.
4. Provide terminals rated for 600 VAC/VDC and 15 amperes.
5. Device shall be UL listed.

F. TIMING RELAYS:

1. Manufacturer:
    a. Allen-Bradley,
    b. Square D Company
    c. Approved equal.
2. Timing relays shall be heavy-duty industrial 600 volt, 10 amperes.

G. CONTROL RELAYS:

1. Manufacturer:
    a. Allen-Bradley
    b. Idec RH series

c. Or equal.
2. Control relays shall be general purpose “midget” relays, 10 ampere contact rating, with 1, 2, 3 or 4 Form C contacts as shown on the drawings.
3. Relay shall be provided with blade style terminals.
4. Provide LED indicator light with relay.
5. Provide a standard DIN rail mount relay socket.
6. Relay life expectancy shall be in excess of 500,000 operations at 120 VAC.
7. Device shall be UL listed.

H. TIME CLOCK

1. Manufacturer/Model:
   a. Tork/8009A
   b. No Equal.
2. 24-hr time duty cycle time switch.
3. Flexible Scheduling: Minimum ON and OFF cycle of 15 minutes (minimum), with 1 to 48 ON/OFF operations per day.
4. Duty Cycle: Adjustable from 1/2, 1, 2, 3, 4, 5, 6, 12 and 24 hours.
5. Power: 120 VAC, 1-phase.
6. Switch: SPDT.
7. Contact Ratings: 20 Amp, 125/250/480 VAC.

I. DIN RAIL CIRCUIT BREAKERS

1. Manufacturer/Model:
   a. Eaton/FAZ-NA
   b. LS Electric
   c. Approved Equal.
2. DIN Rail mounted.
3. Trip Characteristics: UL C or D.
4. UL Listed under UL 489.
5. Dual rated for AC or DC applications.
6. Single-pole, two-pole or three-pole models.
7. Current limiting design.
8. Thermal-magnetic overcurrent protection.
9. Trip-free design.

J. DIN-RAIL DUPLEX RECEPTACLE

1. Manufacturer/Model:
   a. Phoenix Contact/EM-DUO
   b. Approved Equal.
2. Color: Ivory.
3. UL: 508
4. Voltage: 125 VAC
5. Amps: 15A.
6. Mounting: Din rail.

2.12 PROCESS SWITCHES

A. LEVEL SWITCH - FLOAT

1. Manufacturer/Model:
    a. IMO Industries, Inc. Gems Sensors Division, LS-270.
    b. No Equals.
2. Stem: 316 Stainless steel
3. Float: Buna N
4. Operating Temperature:
    a. Water: to 180-degrees F.
5. Minimum Liquid Specific Gravity: .65
6. Pressure (MAX): 150 PSI
7. Switch Rating: 20 VA
8. Electrical Termination: No. 22 AWG, 24-inches long, Polymeric Lead Wires.
9. Selectable Normally Open (NO) or Normally Closed (NC) by inverting float on unit stem.

B. ELECTRO-OPTIC LIQUID LEVEL SWITCH

1. Manufacturer/Model:
    a. Gems ELS Series Level switches w/Opto-Pak Controller
    b. Approved Equal.
2. Switch shall be small size with no moving parts. Unit to be installed in the inner spatial space in the storage tank. Unit shall offer ±1mm repeatability.
3. Unit shall operate with an infrared LED light source and receiver.
4. Unit shall provide TTL signal to an Electro-Optic Converter.
5. The Opto-Pak controller shall convert 120 VAC to the power requirement for the optical sensor. The unit shall have a SPDT, 5 amp relay output. Unit shall be supplied with a self-contained NEMA 4X enclosure.
6. Install optical sensor in tank inner spatial space. Install optical relay in the control panel and/or RTU enclosure.

C. PRESSURE SWITCH

1. Manufacturer:
    a. Mercoid: Model DAW-23-8S: 0-200 PSIG
    b. Ashcroft B424B.
    c. Or approved equal.
2. Stainless steel bourdon tube material
3. Pressure: 10-200 psig
4. Minimum Deadband (psig): 8.
5. Switch: SPDT, closes on increase pressure, 10A, 120 VAC, Adjustable Deadband.
6. Application:
    a. PSH-1: Pump High Discharge Pressure.

D. FLOW SWITCH

1. Manufacturer:
    a. Gems FS-200
    b. Approved Equal.
2. Housing Material: Bronze
3. Setting Type: Adjustable, Range; 1.0 - 6.0 gpm

4. Port Size: 1-inch
5. Shuttle: Teflon
6. Spring: Stainless steel
7. Pressure Rating:
    a. Operating: 400 psig
    b. Proof: 800 psig
8. Operating Temperature: -20-deg F to 200 deg F
9. Repeatability: 1% Maximum
10. Set Point Accuracy: ±10-percent
11. Switch: SPDT, 20 VA
12. Electrical Termination: No. 18 AWG, 24" long (NC: Red, Common: Black, NO: Orange)

2.13 MISCELLANEOUS

A. HATCH POSITION SWITCH

1. Manufacturer:
    a. Square D Company
    b. Or approved equal.
2. Heavy duty turret head lever arm type switch. Provide a offset type lever arm with sufficient length to contact hatch lid.
3. Rated NEMA 6P
4. Rated: 120 VAC, 6 amps.
5. Application:
    a. Roof Hatches

B. MAGNETIC DOOR SWITCH (MAN-DOOR)

1. Manufacturer
    a. Ademco, 7939GY
    b. Edwards, Model 60
    c. Substitutions: Refer to Section 01600 - Product Requirements
2. Provide a gray Normally Open (NO) magnetic door switch, where the switch closes when the magnet engages. Provide appropriate hardware to install on door.

C. TEMPERATURE INDICATING TRANSMITTER

1. Manufacturer/Model:
    a. Devar Inc./d-RTTI.
    b. No Equal.
2. Loop powered two-wire temperature sensor/transmitter that mounts on a single-gang outlet box.
3. Voltage: Operates on 24VDC.
4. Output: Provide 4-20 mA DC output.
5. Indication: Four digit LED with 0.4" high red characters.
6. Range: -40 to +180 deg F., Accuracy: ±1 Deg, C or ±2 Deg F.

D. POWER AND ENERGY MONITOR

1. Manufacturer/Model:
    a. Electro Industries/Gauge Tech, Shark 250
    b. No Equal
2. Basic Features:
    a. 0.2% class revenue certifiable Energy and Demand metering
    b. Meets ANSI C1202 and IEC 687
    c. Multifunction Measurement
    d. 3 line 0.56" LED display
    e. % of Load Bar for analog perception
    f. Standard RS485 Modbus.
    g. IrDA port for PDA Read
3. Unit shall measure the following parameters:
    a. Voltage L-N.
    b. Voltage L-L.
    c. Current.
    d. +/- Watts
    e. +/- Wh
    f. +/- VARs
    g. +/- VARh
    h. VA
    i. VAh
    j. PF
    k. Frequency
    l. %THD
    m. %Load Bar
4. Communications: unit shall include 100BaseT Ethernet Capability.
5. Unit shall include V-Switch Pack: Power Quality Harmonics.
6. Provide two units to JVWCD. When installed in RTU Enclosure, it will be installed by the Owner. When not installed in the RTU Enclosure, install in the VFD enclosure or in a separate enclosure adjacent to the RTU.

PART 3 INSTALLATION

A. Installation shall be per manufacturers specifications.

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SECTION 26 05 13
MEDIUM-VOLTAGE CABLES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section includes specifications for medium-voltage cables, grounding conductors, cable connectors, termination and splice kits, lugs and markers and pulling compound.

B. Related Work includes but is not limited to:

1. Section 26 05 26 - Grounding and Bonding for Electrical Systems
2. Section 26 05 33 - Conduit and Raceway
3. Section 26 05 34 - Electrical Boxes and Fittings
4. Section 26 12 19 - Pad-Mounted, Medium Voltage Transformers
5. Section 26 13 00 - Medium-Voltage Switchgear
6. Section 31 23 15 - Excavation and Backfill for Buried Pipelines
7. Section 32 12 16 - Hot-Mix Asphalt Concrete Paving
8. Section 32 91 13 - Finish Grading and Soil Preparation

1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE 48 – Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations 2.5kV through 765kV.
2. IEEE 386 – Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
3. IEEE 404 – Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2.5kV through 500kV.
4. ANSI/IEEE C2 – National Electrical Safety Code

B. National Fire Protection Association (NFPA)

1. ANSI/NFPA 70 – National Electrical Code

C. Underwriters Laboratories (UL)

1. UL 44 – Thermoset-Insulated Wires and Cables
2. UL 486A-486B – Wire Connectors
3. UL 486C – Standard for Splicing Wire Connections
4. UL 1072 – Standard for Medium-Voltage Power Cables

D. National Electrical Manufacturers Association (NEMA)

1. NEMA 250 – Enclosures for Electrical Equipment.
2. NEMA CC 2 – Electric Power Connectors for Substations.
3. NEMA WC 71 – Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in Distribution of Electric Energy.

4. NEMA WC 74 – 5-46kV Shielded Power Cable for Use in Transmission and Distribution of Electric Energy.

E. ASTM International (ASTM)

1. ASTM B3 – Standard Specification for Soft or Annealed Copper Wire.
2. ASTM B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
3. ASTM B263 – Standard Test Method for Determination of Cross-Sectional Area of Stranded Conductors.

1.3 SUBMITTALS

A. Submittals shall be in accordance with the requirements of Section 01 33 00 – Submittals and Submittal Procedures.

B. Product Data: Provide manufacturer data sheets and catalog pages for all materials and components.

C. Shop Drawings: Cable and conduit routing plans shall be provided by CONTRACTOR per Section 26 05 33 for review by ENGINEER prior to installation.

D. Calculations: Cable pulling calculations shall be submitted to ENGINEER and reviewed before cable installation. Provide cable pulling calculations for medium-voltage cable runs which cannot be pulled by hand and single conductors #4/0 and larger.

E. Test and Evaluation Reports: Cable testing form for Owners approval. Cable testing form shall detail tests to be performed with space to include detailed results for each test.

F. Manufacturers' Instructions: Submit instructions for storage, preparation, and installation of exothermic connectors and electrodes.

1.4 PROJECT CLOSEOUT SUBMITTALS

A. Section 01 78 50 – Project Closeout.

B. Manufacturer Data: Submit original manufacturer manuals and data sheets for products purchased.

C. Record Documentation: Provide accurate as-built record drawings in paper and electronic format.

D. Certificate of Compliance: Provide approval of construction and installation by government authority having jurisdiction.

1.5 QUALITY ASSURANCE

A. All Work shall be performed and materials provided in accordance with NFPA 70 -

National Electrical Code (NEC), the National Electrical Safety Code (NESC), and other codes and standards as applicable. Where required by the Authority Having Jurisdiction (AHJ), equipment and materials shall be listed or labeled by Underwriters Laboratory (UL) or by a nationally recognized testing laboratory acceptable to the AHJ. CONTRACTOR shall be responsible for all costs associated with obtaining the required listing.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in manufacturer's packaging and inspect for damage.

B. Store and protect in accordance with manufacturer's instructions and in accordance with Section 01 60 00 - Product Requirements.

C. Protect from weather. Provide adequate ventilation to prevent condensation.

D. Wire and cables shall be delivered in full reels and shall be protected against injury. UL approved tags showing the manufacturer's name and type of insulation, size, and length of wire in each coil or reel shall be attached.

1.7 SITE CONDITIONS

A. General

1. CONTRACTOR shall make all necessary field measurements to verify that equipment will fit in allocated space in full compliance with minimum required clearances specified in National Electrical Code.

B. Construction Materials

1. Refer to contract plans for NEMA rating requirements for equipment in each area.
2. Construction shall conform to the requirements of the plans and per Section 26 05 00 - Electrical General Requirements.

PART 2 PRODUCTS

2.1 15 kV CABLES

A. EPR Insulated Cable:

1. Extrusion: Single-pass, triple-tandem, of conductor screen, insulation, and insulation screen.
2. Type: 15kV, shielded, UL 1072, Type MV-105.
3. Conductors: Copper, concentric lay Class B round stranded in accordance with ASTM B3, ASTM B8, and ASTM B263.
4. Conductor Screen: Extruded, semiconducting ethylene-propylene rubber in accordance with NEMA WC 71 and AEIC CS 6.
5. Insulation: 133 percent insulation level, ethylene-propylene rubber (EPR), containing no polyethylene in accordance with NEMA WC 71, and AEIC CS 6.

6. Insulation Thickness: 220-mil nominal.
7. Insulation Screen: Thermosetting, semiconducting ethylene-propylene rubber (EPR), extruded directly over insulation in accordance with NEMA WC 74 and AEIC CS 6.
8. Metallic Shield: Uncoated, 5-mil, copper shielding tape, helically applied with 17-1/2 percent minimum overlap.
9. Jacket: Extruded polyvinyl chloride (PVC) compound applied over the metallic shield in accordance with NEMA WC 71.
10. Operating Temperature: 105 degrees C continuous normal operations, 130 degrees C emergency operating conditions, and 250 degrees C short-circuit conditions.
11. Manufacturers:
    a. Okonite Co.
    b. Pirelli Wire and Cable.
    c. General Cable.
    d. Kerite.
    e. Southwire Co.

2.2 GROUNDING CONDUCTORS

A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE insulation.

2.3 ACCESSORIES FOR 15 kV cable

A. Heat Shrinkable Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices with a current rating equal to, or greater than the cable ampacity, conforming to IEEE 404.
3. Class 15 kV, with compression connector, splice insulating and conducting sleeves, stress-relief materials, shielding braid and mesh, and abrasion-resistant heat shrinkable adhesive-lined rejacketing sleeve to provide a waterproof seal.
4. Manufacturers:
    a. Raychem.
    b. 3M Co.

B. Termination Kits:

1. Capable of terminating 15 kV, single-conductor, polymeric-insulated shielded cables plus a shield ground clamp.
2. Capable of producing a termination with a current rating equal to, or greater than the cable ampacity, meeting Class 1 requirements of IEEE 48.
3. Capable of accommodating any form of cable shielding or construction without the need for special adapters or accessories.
4. Manufacturers:
    a. Raychem.
    b. 3M Co.

C. Bus Connection Insulation:

1. Heat shrinkable tubing, tape, and sheets of flexible cross-linked polymeric material formulated for high dielectric strength.
2. Tape and sheet products to have coating to prevent adhesion to metal surfaces.
3. Insulating materials to be removable and reusable.
4. Manufacturer: Raychem.

D. Cable Lugs:

1. Manufacturers and Products, Uninsulated Compression Connectors and Terminators:
   a. Burndy; Hydent.
   b. ILSCO.
   c. Thomas & Betts; Color-Keyed.
2. In accordance with NEMA CC1.
3. Rated 15 kV of same material as conductor metal.

2.4 PULLING COMPOUND

A. Manufacturers:

1. Ideal Co.
2. Cable Grip Co.
3. Polywater, Inc.

B. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.

C. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

D. Approved for intended use by cable manufacturer.

E. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

2.5 SOURCE QUALITY CONTROL

A. Test medium-voltage cable in accordance with Section 26 08 01 Testing.

PART 3 EXECUTION

3.1 EXAMINATION

A. Refer to Section 26 05 00 for examination requirements of cable and wiring systems.

3.2 PREPARATION

A. Refer to Section 26 05 00 for preparation requirements of cable and wiring systems.

3.3 INSTALLATION

A. Refer to Section 26 05 00 for installation requirements of cable and wiring systems.

3.4 FIELD QUALITY CONTROL

A. Refer to Section 26 05 00 for field quality control and testing requirements of cable and wiring systems.

- END OF SECTION -

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Installation of wires or cables required for power distribution, service, feeders, and branch circuits.

B. Related work includes but is not limited to,

1. Section 26 05 26 - Grounding and Bonding for Electrical Systems
2. Section 26 05 33 - Conduit and Raceway
3. Section 26 05 34 - Electrical Boxes and Fittings
4. Section 31 23 15 - Excavation and Backfill for Buried Pipelines
5. Section 32 12 16 - Hot-Mix Asphalt Concrete Paving
6. Section 32 91 13 - Finish Grading and Soil Preparation

1.2 REFERENCES

A. NFPA 70: National Electrical Code.

B. UL: Underwriters Laboratories, Inc.

1.3 SUBMITTALS

A. Field Test Data: Submit megohmmeter test data for circuits under 600 volts.

PART 2 PRODUCTS

2.1 MATERIALS

A. Building Conductors: Copper, 600 Volt insulation, THW.

B. Branch Circuit Conductors and All Conductors: Copper conductor, with THHN, or THWN insulation #10 AWG and smaller, and THW larger than #10 AWG, where ambient temperature conditions exceed 140 deg. F.

1. All conductors shall be stranded.
2. Size all conductors per NFPA 70.
3. Minimum size to be #12 AWG.
4. For outlets to fixtures, and in fixture channels (in dry areas); THHN insulated conductor.
5. In damp locations, under slabs, on exterior provide THWN.

C. Provide permanent plastic name-tag indicating load feed.

D. Use type XHHW conductors for water pumping and regulator stations.

E. Cable Supports: OZ cable supports for vertical risers, type as required by application.

2.2 INSTRUMENTATION

A. Instrumentation cable shall have the number of twisted pairs indicated on the Plans and shall be insulated for not less than 600 volts. Unless otherwise indicated, conductor size shall be as shown on the drawings.

B. The jacket shall be flame retardant Flamenal or Okoseal, 90 degrees C temperature rating. The cable shield shall be minimum of 2.3 mil aluminum or copper tape overlapped to provide 100 percent coverage and a tinned copper drain wire.

C. The conductors shall be bare soft annealed copper, Class B, 7 strand minimum concentric lay with Okoseal or Vulkene, 15 mils nominal thickness, nylon jacket, 4 mil nominal thickness, 90 degrees C temperature rating. One conductor within each pair shall be numerically identified.

2.3 ETHERNET CONDUCTORS

A. Manufacturers:

1. Belden 7940 Inside (4 pair, 24 gauge)
2. Belden 7953A Outside (for CCTV cameras)
3. Or Approved Equal

2.4 MODBUS RS485 CABLE

A. Manufacturers/Model

1. Belden 9841
2. Or approved equal

B. Provide low-capacitance computer cable for EIA RS-485 signal transmission. Cable shall be AWG #24 stranded (7x32), with polyethylene insulation, twisted-pairs with overall shield (100% coverage) and #24 AWG drain wire.

2.5 COLOR AND CODING OF CONDUCTORS

A. 120/240 volt.

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

B. 208Y/120 volt.

1. A-Phase - Black
2. B-Phase - Red

3. C- Phase - Blue
4. Neutral - White
5. Ground - Green

C. 480Y/277 volt.

1. A-Phase - Brown
2. B-Phase - Orange
3. C- Phase - Yellow
4. Neutral - White
5. Ground - Green

PART 3 EXECUTION

3.1 INSTALLATION

A. Make conductor length for parallel feeders identical.

B. Lace or clip groups of feeder conductors at distribution center, pull-boxes, and wireway. Neatly arrange wiring within cabinets, junction boxes, fixtures, etc.

C. Provide copper grounding conductors and straps.

D. Install wire and cable in code conforming raceway.

E. Use non-detrimental wire pulling lubricant for pulling No. 4 AWG and larger wire.

F. Install wire in conduit runs after concrete and masonry work is complete and after moisture is swabbed from conduits.

G. Color code conductors to designate neutral conductor and phase.

H. Furnish necessary reels, reel jacks, and other pulling aids required to prevent damage to wires and cable.

I. Splicing:

1. Install wires and cables continuous without splices from sources of supply to distribution equipment and from source of supply to motor, lighting, or power outlet.
2. Do not use pull boxes for making splices.
3. Do not install splices in conduits.

J. Install all wiring per NFPA 70.

K. Use of cable with more conductors then specified; CONTRACTOR's option. When done, tape off and label extra conductors as spares.

3.2 CONDUCTOR CONNECTIONS

A. Use approved pressure type solderless connectors and lugs for service entrance, feeder, equipment connections and terminal posts.

B. Use connectors of a type compatible to conductors, locations, and load.

C. Make neutral connection and taps individually in order to prevent the possibility of an "open-neutral".

D. Make branch circuit connections with UL approved solderless connectors. Do not depend solely upon a single insulating material to secure connection as well as to insulate it.

E. After first either silverplating the bars or applying suitable non-oxidizing agents, bolt bus bar connections with adequate nonferrous bolts, washers, and lockwashers.

F. Insulate joints and taps with patented or molded plastic insulators. Use tapes compatible .with conductor jackets, temperature, and other conditions.

3.3 AFTER INSTALLATION TEST FOR CABLE 600 VOLTS AND BELOW

A. Prior to energization, test cable and wire for continuity of circuit for short circuits. Megger all circuit of 100 amp and greater rating.

B. Correct malfunctions.

C. Submit record of megaohmmeter readings to ENGINEER.

3.4 IDENTIFICATION OF FEEDERS

A. Affix a marker stamped or embossed on each cable at each entry to and exit for each manhole, pullhole, pullbox, cable tray, switchgear and switch, identifying circuit; i.e. "MCCI", "PANEL L" "NO 1" etc.

B. Identification letters to be 1/8 inch size minimum.

C. Markers to be rigid, noncorrosive, attached to feeder cables with feeder identification.

D. Nylon straps to be used to tie the markers.

- END OF SECTION -

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES:

A. This section includes specifications for grounding of electrical systems and equipment.

B. Related work includes but is not limited to,

1. Section 26 05 13 - Medium-Voltage Cables
2. Section 26 05 19 - Low-Voltage Power Conductors and Cables
3. Section 26 09 26 - Panelboards
4. Section 26 12 16 - Dry Type Transformers
5. Section 26 12 19 - Pad-Mounted, Medium Voltage Transformers
6. Section 26 18 39 - Medium-Voltage VFD
7. Section 26 29 13.16 - Reduced Voltage Starters

1.2 SUBMITTALS

A. Submit “Letter of Conformance” in accordance with Section 01 33 00 indicating specified items selected for use in Project with the following supporting data:

1. Product Data: For the following:
   a. Ground rods.
   b. Grounding conductors

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use. Comply with UL 467.

B. Comply with NFPA 70; for overhead-line construction and medium-voltage underground construction, comply with IEEE C2.

C. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers:

1. Grounding Conductors, Cables, Connectors, and Rods:
   a. Chance/Hubbell (573-682-5521)
   b. Copperweld Corp. (931-433-7177)
   c. Thomas & Betts, Electrical (800-816-7809)

d. Approved equals.

2.2 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Section 26 05 19 - "Low-Voltage Electrical Power Conductors and Cables."

B. Material: Copper.

C. Equipment Grounding Conductors: Insulated with green-colored insulation.

D. Isolated Ground Conductors: Insulated with green-colored insulation with yellow stripe. On feeders with isolated ground, use colored tape, alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.

E. Grounding Electrode Conductors: Stranded cable.

F. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.

G. Bare Copper Conductors: Comply with the following:

1. Solid Conductors: ASTM B3.
2. Assembly of Stranded Conductors: ASTM B8.
3. Tinned Conductors: ASTM B33.

H. Copper Bonding Conductors: As follows:

1. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
2. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

I. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulators.

J. Equipment Ground Conductor (Green) shall be included with all circuit conductors. In addition, provide a neutral conductor where applicable.

2.3 CONNECTOR PRODUCTS

A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Bolted Connectors: Bolted-pressure-type connectors, or compression type.

C. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

2.4 GROUNDING ELECTRODES

A. Ground Rods: copper-clad steel. Size: 120" long by 3/4" in diameter.

B. UFER: 25-feet of bare copper conductor installed in the footing or foundation wall. Connect copper to structural support steel.

C. Metal Water Pipes: Where metal water piping is used, provide grounding electrode conductor to metal water piping. Use UL listed connection devices as required.

PART 3 EXECUTION

3.1 APPLICATION

A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. In raceways, use insulated equipment grounding conductors.

C. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells.

D. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.

3.2 EQUIPMENT GROUNDING CONDUCTORS

A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

B. Install equipment grounding conductors in all feeders and circuits.

C. Computer Outlet Circuits: Install insulated equipment grounding conductor in branch-circuit runs from computer-area power panels or power-distribution units.

D. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.

E. SCADA RTU: For signal and data, systems, provide No. 4 AWG minimum insulated grounding conductor from grounding electrode system to the SCADA RTU.

3.3 INSTALLATION

A. Ground Rods: Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.

1. Drive ground rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

C. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

D. Metal Water Service Pipe: If metal water pipe is installed, provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

E. Water Meter Piping: If metal water piping is used, use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.

F. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.

3.4 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

D. Non-contact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A .

F. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

G. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.5 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing:

1. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81.
3. Provide drawings locating each ground rod and ground rod assembly and other grounding electrodes, identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
   a. Equipment Rated 500 kVA and Less: 10 ohms.
   b. Manhole Grounds: 10 ohms.
4. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Owner representative promptly and include recommendations to reduce ground resistance.

- END OF SECTION -

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SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Hangers and supports for electrical equipment and systems.

B. Related work includes but is not limited to,

1. Section 01 33 00 - Submittal Procedures
2. Section 26 05 33 - Conduit and Raceway
3. Section 26 05 34 - Electrical Boxes and Fittings

1.2 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

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

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this project, with a minimum structural safety factor of five (5) times the applied force.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00 - Submittal Procedures.

B. Product Data: For the following:

1. Steel slotted support systems.

C. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include product data for components.
2. Steel slotted channel systems. Include product data for components.
3. Equipment supports.

D. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."

B. Comply with NFPA 70.1.

1.6 COORDINATION

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

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07.

PART 2 PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
   a. Allied Tube & Conduit.
   b. Cooper B-Line, Inc.; a division of Cooper Industries.
   c. ERICO International Corporation.
   d. GS Metals Corp.
   e. Thomas & Betts Corporation.
   f. Unistrut; Tyco International, Ltd.
   g. Wesanco, Inc.
2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
4. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting

of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A36, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
      (1) Hilti Inc.
      (2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      (3) MKT Fastening, LLC.
      (4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
      (1) Cooper B-Line, Inc.; a division of Cooper Industries.
      (2) Empire Tool and Manufacturing Co., Inc.
      (3) Hilti Inc.
      (4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      (5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 for steel shapes and plates.

PART 3 EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT and RMC as required by NFPA 70. Minimum rod size shall be 1/4-inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
3. To Existing Concrete: Expansion anchor fasteners.
4. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete four (4) inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than four (4) inches thick.
5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks

attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.4 PAINTING

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

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Division 09 painting sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

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

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SECTION 26 05 33
CONDUIT AND RACEWAY

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Flexible or rigid conduits. couplings. supports, and nonmetallic ducts.

B. Related work includes but is not limited to,

1. Section 26 05 13 - Medium Voltage Cables
2. Section 26 04 34 - Electrical Boxes and Fittings
3. Section 31 23 15 - Excavation and Backfill for Buried Pipelines
4. Section 32 12 16 - Hot-Mix Asphalt Concrete Paving
5. Section 32 91 13 - Finish Grading and Soil Preparation

1.2 REFERENCES

A. ANSI C80.1: Rigid Steel Conduit - Zinc-Coated.

B. ANSI C80.3: Electrical Metallic Tubing - Zinc-Coated.

C. FS W-F-406: Fittings for Cable, Power, Electrical and Conduit, Metal, Flexible.

D. FS WW-C-566: Conduit, Metal, Flexible.

E. NEMA TC6: PVC and ABS Plastic Utilities Duct for Underground Installation.

F. NEMA TC9: Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation.

G. NFPA 70: National Electrical Code.

H. UL: Underwriters Laboratories, Inc.

PART 2 PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. General: Provide metal conduit. tubing and fittings of types, grades, sizes and weights (wall thicknesses) as indicated; with minimum trade size of 3/4 inch.

B. Rigid Metal Conduit (RMC): ANSI C80.1.

C. Intermediate Metal Conduit (IMC): ANSI C80.1.

D. Rigid and Intermediate Steel Conduit Fittings: Provide fully threaded malleable steel couplings; raintight and concrete tight where required by application. Provide

double locknuts and metal bushings at conduit termination, use OZ type B bushings on conduits 1-1/4 inch and larger.

E. Electrical Metallic Tubing (EMT): ANSI C80. 3.

F. EMT Fittings: Provide insulated throat non-indenter type malleable steel fittings; concrete tight where required by application. Install OZ type B bushings on conduits 1-1/4 inches and larger.

G. Flexible Metal Conduit (FMC): FS WW-C-566, Zinc-coated steel.

H. Flexible Metal Conduit Fittings: FS W-F-406, Type 1, Class 1, Style A.

I. Liquid Tight Flexible Metal Conduit: Provide liquid-tight, flexible metal conduit; constructed of single strip, flexible continuous, interlocked, and double-wrapped steel; galvanized inside and outside; coated with liquid-tight jacket of flexible polyvinyl chloride (PVC).

J. Liquid-Tight Flexible Metal Conduit Fittings: FS W-F-406, Type1, Class 3, Style G.

K. Expansion Fittings: OZ Type AX, or equivalent to suit application.

2.2 NON-METALLIC CONDUIT AND DUCTS

A. General: Minimum trade size: 3/4 inch.

B. Underground PVC Plastic Utilities Duct: NEMA TC6, Type I for encased burial in concrete, Type II for direct burial.

C. Duct Fittings: NEMA TC9, match to duct type and material.

2.3 CONDUIT, TUBING, AND DUCT ACCESSORIES

A. Provide conduit, tubing and duct accessories of types and sizes, and materials, complying with manufacturer's published product information, which mate and match conduit and tubing. Provide manufactured spacers in all duct bank runs.

2.4 LOCKNUTS, BUSHINGS, CONNECTORS, COUPLINGS, AND SUPPORTS

A. General: Provide malleable bushings, except that plastic bushings may be used in lieu of phenolic-lined malleable bushings where "insulating bushings" are required.

B. Provide "double-locknut" system (2 locknuts) throughout, each being tightened wrench tight as to effectively bond outlet box or cabinet to conduit.

C. Sealing Bushing: OZ Type FSK, WSK, or CSMI as required by application. Provide OZ type CSB internal sealing bushings.

D. Provide insulated-through type ground bushing of the malleable type.

E. Provide connectors or couplings that are proper for the conduit they are used with. Make watertight when required.

F. Provide cadmium plated or galvanized fittings.

G. Provide fittings with die-cut threads unless approved otherwise.

H. EMT connectors used with #4 and larger cable shall have throat liners of suitable plastic insulation.

2.5 CONDUIT OUTLET BOXES

A. Refer to Section 26 05 34.

2.6 SCHEDULE OF LOCATIONS

A. Chemical Rooms (Fluoride & Chlorine): Solvent welded PVC Schedule 80.

B. Exposed: Galvanized steel conduit.

C. Ceiling Attic: Electrical metallic tubing shall be permitted.

D. Underground or Underslab: Use rigid, threaded, galvanized steel conduit, or PVC Schedule 40 solvent welded conduit

E. Make connections to motors and equipment with PVC jacketed flexible conduit and liquid tight connectors. Provide 1/2 inch minimum size for motor connections.

PART 3 EXECUTION

3.1 PREPARATION

A. Excavate; Section 31 23 15 - Excavation and Backfill for Buried Pipelines

3.2 INSTALLATION

A. Install conduit concealed in all areas, excluding mechanical and electrical rooms, connections to motors, and connections to surface cabinets.

B. For exposed runs attach surface-mounted conduit with clamps.

C. Coordinate installation of conduit in masonry work.

D. Unless indicated otherwise, do not install conduit larger than 2-1/2 inches in concrete slabs. Provide a minimum concrete cover around conduits of 2-inches.

E. Install conduit free from dents and bruises. Plug ends to prevent entry of dirt and moisture.

F. Clean out conduit before installation of conductor.

G. Alter conduit routing to avoid structural obstructions, minimizing crossovers.

H. Fill end of conduit with fiberglass where conduits leave heated area and enters unheated area.

I. Provide flashing and pitchpockets, making watertight joints where conduits pass through roof or waterproofing membranes.

J. Install UL approved expansion fittings complete with grounding jumpers where conduits cross building expansion joints. Provide bends or offsets in conduit adjacent to building expansion joints where conduit is installed above suspended ceilings.

K. Route all exposed conduits parallel or perpendicular to building lines.

L. Make interconnections between difference types of raceways with manufactured fittings approved by UL.

M. Size raceways per NFPA 70 tables. Do not reduce from any sized indicated.

N. Do not exceed sizes permitted in slabs or walls.

O. Do not exceed number of bends allowed in conduit by NFPA 70.

P. Make joints wrench tight or otherwise with minimum resistance to the flow of fault currents.

Q. Use furred spaces and chases to an advantage in concealing conduits.

R. Make field bends only where needed and then carefully to minimize wire pulling tensions and for best appearance in exposed runs.

S. Test conduit runs with lignum vitale ball (mandrel) of 85-percent of conduit diameter.

T. Cut conduit with hacksaw or other approved pipe cutting tool and ream ends to clean out all burrs before connecting.

U. Keep conduits at least 6-inches away from steam or hot water pipes, breaching, and boilers, but in no case permit conductors to reach higher than rated temperatures. Avoid traps in runs and slope conduit to drain.

V. Fasten raceways securely in place. Firmly fasten conduit within 3-feet of each outlet, junction box, cabinet, or fitting. Support metallic conduit, rigid (heavy wall) and EMT at least every 10-feet. Support rigid nonmetallic conduit in strict accordance with NFPA 70. Use raceway fasteners designed for the purpose.

3.3 PULL BOXES, WIREWAYS, AND GUTTERS

A. Furnish as indicated, plus any such items required to assemble conduits and other

raceways. Provide Section 26 05 34 pull boxes as dictated by wire pulling requirements.

B. Construction: Code gage galvanized sheet steel and sized strictly in conformance with NFPA 70 requirements.

C. Finish: Free of burrs, sharp edges, un-reamed holes, and sharp-pointed screw or bolts. Paint both inside and out.

D. Coating: When mounted direct to concrete or masonry walls that are below grade or where there will be sweating or other moisture present on wall surface, coat backs of boxes with a heavy coat of black asphalt paint before mounting.

E. Protection: Adequate provisions for preventing damage to conductors either during pulling-in or from weights and tensions when in place.

F. Weatherproof, rain-tight, or special type when indicated or when required by NFPA 70.

3.4 ANCHORS, FASTENERS, AND MISCELLANEOUS SUPPORTS

A. Use compatible anchors in roof or ceiling slabs of concrete from which a load is suspended and anchors used to fasten heavy equipment without lead in their construction.

B. Make exposed conduit fastenings with one-piece, malleable conduit clamps. Two hole, galvanized sheet metal pipe straps may be used on all concealed installations.

C. Use companion bases or backs with conduit clamps when conduit is exposed to weather or continuous moisture.

D. Use ring type hangers on individual runs of conduit 3-inches and larger if suspended, complete with threaded rods. Use adjustable turnbuckles when specified or otherwise as an option.

E. Support multiple runs of suspended conduits from trapeze style hangers suspended with rigid threaded steel rods and with suitable conduit clamps or straps of the same make as cross channels used.

F. Mount multiple runs of conduit on ceiling or wall surfaces.

G. Do not hang or support electrical equipment and materials from roof decks.

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SECTION 26 05 34
ELECTRICAL BOXES AND FITTINGS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Types of electrical boxes and electrical fitting work.

1.2 RELATED SECTIONS

A. Section 26 05 19 - Low-Voltage Power Conductors and Cables

B. Section 26 05 29 - Hangers and Supports for Electrical Systems

C. Section 26 05 33 - Conduit and Raceway.

1.3 REFERENCES

A. NEMA OS 1: Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.

B. NEMA OS 2: Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports.

C. NFPA 70: National Electrical Code.

D. UL: Underwriters Laboratories, Inc.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70 as applicable for installation of electrical boxes and fittings.

B. Comply with NEMA OS 1 and NEMA OS 2 as applicable for outlet boxes, device boxes, covers and box supports.

C. Provide electrical boxes and fittings which have been UL-listed and labeled.

PART 2 PRODUCTS

2.1 INTERIOR OUTLET BOXES

A. One piece, cast iron or cast aluminum outlet wiring boxes, of types shapes and sizes, including box depths, to suit each respective location and installation. If of aluminum, essentially "copper free". Do not use on conduits of dissimilar metals, except with written permission.

B. Construct with stamped knockouts in back and sides, and with threaded screw holes with corrosion-resistant screws for securing box and covers and wiring devices.

C. Minimum depth 1-1/4 inches or 2-1/8 inch depth for boxes with 3 or more conduit

entries.

D. Use in combination with factory or field bends when indicated or advised. Complete outlet boxes with mounting brackets, hangers, extension rings, fixture studs, cable clamps, metal straps, gaskets, cover, hubs, reducers, and other accessories.

2.2 WEATHERPROOF OUTLET BOX

A. Corrosion-resistant cast-metal of types, shapes and sizes (including depth) required.

B. Threaded conduit ends, cast-metal face plates with spring hinged waterproof caps suitably configured for each application, with faceplate gaskets and corrosion-resistant fasteners.

2.3 JUNCTION AND PULL BOXES

A. Building Structure Type: Code-gage sheet steel with screw-on covers; of types, shapes and sizes to suit each respective location and installation; with welded seams and equipped with galvanized steel bolts, nuts and accessories.

B. Buried Type: Plastic body and cover, or pre-cast concrete with screw-on traffic rated cast iron covers; of types, shapes and sizes to suit each respective location and installation; equipped with stainless steel bolts, nuts and accessories.

PART 3 EXECUTION

3.1 PREPARATION

A. Coordinate installation of electrical boxes and fittings with wire/cable and raceway installation work.

B. Provide knockout closures to cap unused knockout holes where blanks have been removed.

3.2 INSTALLATION

A. A. Install where indicated, complying with manufacturer's written instruction, applicable requirements of NFPA 70 and NEMA's "Standard of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

B. Install coverplates for all boxes; weatherproof outlets for interior and exterior locations exposed to weather or moisture.

C. Install boxes and fittings to ensure ready accessibility of electrical wiring. Install recessed boxes with face of box or ring flush with adjacent surface.

D. Fasten boxes rigidly to substrates or structural surfaces to which attached, or solidly embed boxes in concrete or masonry. Use bar hangers for stud construction. Use of nails for securing boxes is prohibited. Set boxes on opposite sides of common wall

with minimum l0-inches of conduit between them.

- END OF SECTION -

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SECTION 26 05 43
UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This Section includes specifications for underground electrical conduits, ductbanks, and underground utility structures.

B. Related work includes but is not limited to,

1. Section 01 33 00 - Submittal Procedures
2. Section 26 05 13 - Medium Voltage Cables
3. Section 26 04 34 - Electrical Boxes and Fittings
4. Section 31 23 15 - Excavation and Backfill for Buried Pipelines
5. Section 32 12 16 - Hot-Mix Asphalt Concrete Paving
6. Section 32 91 13 - Finish Grading and Soil Preparation

1.2 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM):

1. ASTM C33 Specification for Concrete Aggregates

1.3 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures for submittal requirements and procedures.

B. Shop Drawings:

1. Submit shop drawings for fabrication and installation of precast concrete structures, cast-in-place concrete structures, ductwork, including the following:
   a. Excavation and shoring plans with required structural calculations;
   b. Shop drawing information may be combined on a single drawing if clarity is not thereby impaired.
2. Submit shop drawings which fully demonstrate that the work to be performed and the materials to be provided comply with the provisions of these Specifications

C. Product Data. Submit the following:

1. Complete materials list of items proposed to be provided under this Section.
2. Manufacturers' specifications and other data required to demonstrate compliance with these Specifications.
3. Catalog cuts for the following products:
   a. Raceways.
   b. Trench and wireway covers including composition of FRP materials, divider partition panels, method of joining sections, expansion joint

mounting, and support details.

4. Certificates of Compliance: Provide for specified products.

1.4 QUALITY ASSURANCE

A. Qualification of Manufacturers:

1. Select manufacturers of the products specified for work under this Section who are in the business of manufacturing similar products and are able to provide a history of successful production of the specified products.
2. Inspection: Ensure completed facilities are approved by the Resident Engineer before installation of cable and equipment. Perform corrective work at no additional cost to Owner.

PART 2 PRODUCTS

2.1 RACEWAYS

A. Conduit and duct: In accordance with Section 26 05 34 - Conduit and Raceways.

2.2 PRECAST CONCRETE ELECTRICAL BOXES, PULLBOXES, AND VAULTS

A. Reinforce concrete in a manner which is regularly provided in standard products of the manufacturer.

B. Standard manufactured structures which meet project requirements will be acceptable.

C. Provide concrete inserts for mounting cable support brackets as indicated.

D. Provide pullbox covers with two lifting eyes and two holddown bolts.

2.3 SAND

A. Clean, graded, washed, passing a No. 4 U.S. sieve, and conforming generally to ASTM C33 for fine aggregate.

2.4 WARNING TAPE

A. Heavy gage, yellow, plastic for direct burial, material resistant to corrosive soil, 6-inch minimum width, minimum 4 mils thick.

B. Printed with warning that an electrical circuit is located beneath the tape.

PART 3 EXECUTION

3.1 PREPARATION

A. Before beginning construction or installation of a section of underground conduit or ductwork, verify that the site is in suitable condition for installing conduit or ductwork as indicated.

3.2 EXCAVATION, TRENCHING AND BACKFILLING

A. Perform excavation, bedding, and backfilling for underground conduits and structures in accordance with Section 31 23 15 - Excavation and Backfill for Buried Pipelines and as indicated.

3.3 DUCTBANKS

A. Group individual conduits together to form a ductbank in conformance with the requirements specified herein.

B. Inspect ducts and couplings to ensure that only clean and undamaged pieces are incorporated in the work.

C. Install ducts, joints, and space separators according to manufacturer's printed instructions and recommendations.

D. Do not use spacers or space separators which transmit any vertical load to the conduit.

E. Install ductbanks or conduits with a minimum slope of 3 inches to each 100 feet away from buildings and towards manholes, pull boxes, and handholes.

F. Terminate conduits and ducts in end-bells in vaults.

G. Where ductbank enters rigid underground structures, provide reinforcing steel to tie the ductbank to the structure.

H. Protection: when installation of conduits and ducts is temporarily suspended or terminated, close ends of ducts with caps or plugs fitted to prevent entry of water or debris. Use caps or plugs designed for that purpose by the conduit manufacturer.

I. Mandrelling: As each section of a duct line is completed between manholes, handholes, or pullboxes, use testing mandrel not more than 1/4 inch less than the size of the conduit to drawn through each conduit, after which draw a brush with stiff bristles through until the conduit is clear of particles of earth, sand, or gravel. Install conduit caps or plugs immediately thereafter. Notify the Resident Engineer prior to mandrelling any conduit and submit a written report providing a conduit identification number, size, material, location, the type and size of mandrel used, and indicate whether the conduit is tagged. Verify the report also indicate the acceptance date and initials of the accepting inspector and be verified by the Contractor's foreman.

J. Install 1/8 inch or larger diameter polypropylene pulling cord in ducts including innerducts. Fasten each cord to pull iron anchorage in pull box, manhole, or vault with 2 feet minimum slack.

3.4 PRECAST CONCRETE STRUCTURES

A. Install precast electrical boxes, pullboxes, handholes, manholes, and vaults as

indicated.

B. Place boxes on 4 inches of compacted sand bedding.

C. Place manholes on 6 inches of compacted aggregate base.

D. Seal unused openings with cement mortar.

- END OF SECTION -

SECTION 26 05 73
SHORT-CIRCUIT/COORDINATION STUDY/ARC FLASH HAZARD ANALYSIS

PART 1 GENERAL

1.1 SCOPE

A. The contractor shall furnish short-circuit and protective device coordination studies which shall be prepared by the equipment manufacturer.

B. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.5 and Informative Annex D. The arc flash hazard analysis shall be performed according to the IEEE Standard 1584 - 2002, the IEEE Guide for Performing Arc-Flash Calculations.

C. Related work includes but is not limited to:

1. Section 26 05 05 - Electrical Equipment
2. Section 26 05 13 - Medium-Voltage Cables
3. Section 26 05 19 - Low-Voltage Power Conductors and Cables
4. Section 26 12 19 - Pad-Mounted, Medium Voltage Transformers
5. Section 26 29 26 - Panelboard
6. Section 26 29 13.16 - Reduced Voltage Soft Starters
7. Section 26 18 39 - Medium Voltage VFD

1.2 REFERENCES

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

1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
6. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations

B. American National Standards Institute (ANSI):

1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers

Rated on a Symmetrical Current Basis
4. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
5. ANSI C37.5 – Methods for Determining the RMS Value of a Sinusoidal Current Wave and Normal-Frequency Recovery Voltage, and for Simplified Calculation of Fault Currents

C. The National Fire Protection Association (NFPA)

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

1.3 SUBMITTALS FOR REVIEW/APPROVAL

A. The short-circuit and protective device coordination studies shall be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.

1.4 SUBMITTALS FOR CONSTRUCTION

A. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. No more than five (5) bound copies of the complete final report shall be submitted. For large system studies, submittals requiring more than five (5) copies of the report will be provided without the section containing the computer printout of the short-circuit input and output data. Additional copies, where required, shall be provided on CD in PDF format.

B. The report shall include the following sections:

1. Executive Summary including source of information and assumptions made.
2. Descriptions, purpose, basis and scope of the study.
3. One-line diagram showing protective device ampere ratings and associated designations, cable size & lengths, transformer kVA & voltage ratings, motor & generator kVA ratings, and switchgear/switchboard/panelboard designations.
4. Tabulations of the worst-case calculated short circuit duties as a percentage of the applied device rating (automatic transfer switches, circuit breakers, fuses, etc.); the short circuit duties shall be upward-adjusted for X/R ratios that are above the device design ratings.
5. Protective device time versus current coordination curves with associated one line diagram identifying the plotted devices, tabulations of ANSI protective relay functions and adjustable circuit breaker trip unit settings.
6. Multi-function relay setting file printouts including all ANSI protective relay functions and associated logic and control. Metering, communication, and control logic settings not associated with ANSI protective functions are not required.
7. Fault study input data, case descriptions, and current calculations including a definition of terms and guide for interpretation of the computer printout
8. Incident energy and flash protection boundary calculations.

9. Comments and recommendations for system improvements, where needed.

1.5 QUALIFICATIONS

A. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies. The Registered Professional Electrical Engineer shall be a full-time employee of the Engineering Services Organization.

PART 2 PRODUCTS

2.1 STUDIES

A. Contractor to furnish short-circuit and protective device coordination studies as prepared by equipment manufacturer. By using the equipment manufacturer the study allows coordination of proper breakers, fuses, and current transformers. The coordination study shall begin with the utility company's feeder protective device and include all of the electrical protective devices down to and include the largest feeder circuit breaker and motor starter in the 480 Volt motor control centers and power distribution panelboards. The study shall also include variable frequency drives, harmonic filters, power factor correction equipment, transformers and protective devices associated with variable frequency drives, emergency and standby generators associated paralleling equipment and distribution switchgear.

B. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.5 and Informative Annex D.

2.2 DATA COLLECTION

A. Contractor shall furnish all field data as required by the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to eliminate unnecessary delays and assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

B. Source combination may include present and future utility supplies, motors, and generators.

C. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner or Contractor.

D. Include fault contribution of existing motors in the study, with motors < 50 hp grouped together. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

2.3 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standards 141, latest edition.

B. Transformer design impedances and standard X/R ratios shall be used when test values are not available.

C. Provide the following:

1. Calculation methods and assumptions
2. Selected base per unit quantities
3. One-line diagram of the system being evaluated with available fault at each bus, and interrupting rating of devices noted
4. Source impedance data, including electric utility system and motor fault contribution characteristics
5. Typical calculations
6. Tabulations of calculated quantities
7. Results, conclusions, and recommendations

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:

1. Electric utility's supply termination point
2. Incoming switchgear
3. Unit substation primary and secondary terminals
4. Low voltage switchgear
5. Motor control centers
6. Standby generators and automatic transfer switches
7. Branch circuit panelboards
8. Other significant locations throughout the system

E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.

F. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short circuit ratings
2. Adequacy of switchgear, motor control centers, and panelboard bus bracing to withstand short-circuit stresses
3. Adequacy of transformer windings to withstand short-circuit stresses
4. Cable and busway sizes for ability to withstand short-circuit heating
5. Notify Owner in writing, of existing, circuit protective devices improperly rated for the calculated available fault current

2.4 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves shall be graphically displayed on log-log scale paper.

B. Include on each curve sheet a complete title and one-line diagram with legend

identifying the specific portion of the system covered.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.

D. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Plot the following characteristics on the curve sheets, where applicable:

1. Electric utility's protective device.
2. Medium voltage equipment relays
3. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
4. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
5. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters
6. Medium voltage conductor damage curves
7. Ground fault protective devices, as applicable
8. Pertinent motor starting characteristics and motor damage points
9. Pertinent generator short-circuit decrement curve and generator damage point
10. Other system load protective devices for the largest branch circuit and the largest feeder circuit breaker in each motor control center

F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

G. Select each primary protective device required for a delta-wye connected transformer so that the characteristics or operating band is within the transformer parameters which includes a parameter equivalent to 58% of the ANSI withstand point to afford protection for secondary line-to-ground faults.

H. Separate low voltage power circuit breakers from each other and the associated primary protective device by a 16% current margin for coordination and protection in the event of secondary line-to-line faults.

I. Engineer shall provide settings file printouts for all multifunction relays supplied under this contract including all ANSI protective relay functions and associated logic and control. Metering, communication, and control logic settings not associated with ANSI protective functions are not required.

2.5 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2012, Informative Annex D.

B. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Alternative methods shall be presented in the proposal.

C. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.

D. The Arc-Flash Hazard Analysis shall include all MV, 575v, & 480v locations and significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kVA.

E. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm2.

F. The Arc Flash Hazard analysis shall include calculations for maximum and minimum contributions of fault current magnitude. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume a minimum motor load. Conversely, the maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

G. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

H. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location in a single table. Calculations must be performed to represent he maximum and minimum contributions of fault current magnitude for normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum. Conversely, the maximum calculation will assume a maximum contribution from the utility. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable as well as any stand-by generator applications.

   The Arc-Flash Hazard Analysis shall be performed utilizing mutually agreed upon facility operational conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.

I. Arc flash computation shall include both line and load side of main breaker calculations, where necessary.

J. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on busses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors should be decremented as follows:

   1. Fault contribution from induction motors should not be considered beyond 5 cycles.
   2. For each piece of ANSI rated equipment with an enclosed main device, two calculations shall be made. A calculation shall be made for the main cubicle,

sides, or rear; and shall be based on a device located upstream of the equipment to clear the arcing fault. A second calculation shall be made for the front cubicles and shall be based on the equipment's main device to clear the arching fault. For all other non-ANSI rated equipment, only one calculation shall be required and it shall be based on a device located upstream of the equipment to clear the arcing fault.

K. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

L. Arc-Flash calculations shall be based on actual overcurrent protective device clearing time. A maximum clearing time of 2 seconds will be used based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

2.6 REPORT SECTIONS

A. Input Data:

1. Utility three-phase and line-to-ground available contribution with associated X/R ratios
2. Short-circuit reactance of rotating machines with associated X/R ratios
3. Cable type, construction, size, # per phase, length, impedance and conduit type
4. Bus duct type, size, length, and impedance
5. Transformer primary & secondary voltages, winding configurations, kVA rating, impedance, and X/R ratio
6. Reactor inductance and continuous ampere rating
7. Aerial line type, construction, conductor spacing, size, # per phase, and length

B. Short-Circuit Data:

1. Source fault impedance and generator contributions
2. X to R ratios
3. Asymmetry factors
4. Motor contributions
5. Short circuit kVA
6. Symmetrical and asymmetrical fault currents

C. Recommended Protective Device Settings:

1. Phase and Ground Relays:
   a. Current transformer ratio.
   b. Current setting.
   c. Time setting.
   d. Instantaneous setting.
   e. Specialty non-overcurrent device settings.
   f. Recommendations on improved relaying systems, if applicable.

2. Circuit Breakers:
    a. Adjustable pickups and time delays (long time, short time, ground).
    b. Adjustable time-current characteristic.
    c. Adjustable instantaneous pickup.
    d. Recommendations on improved trip systems, if applicable.

D. Incident energy and arc flash boundary calculations.

1. Arcing fault magnitude
2. Device clearing time
3. Duration of arc
4. Arc flash boundary
5. Working distance
6. Incident energy
7. Recommendations for arc flash energy reduction

PART 3 EXECUTION

3.1 FIELD ADJUSTMENT

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments to be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Owner in writing of any required major equipment modifications.

D. Following completion of all studies, acceptance testing and startup by the field engineering service division of the equipment manufacturer, a 2-year warranty shall be provided on all components manufactured by the engineering service parent manufacturing company.

3.2 ARC FLASH WARNING LABELS

A. The vendor shall provide a 4 in. x 4 in. thermal transfer type label of high adhesion polyester for each work location analyzed.

B. The label shall have an orange header with the wording, “WARNING, SHOCK & ARC FLASH HAZARD”, and shall include the following information:

1. Location designation
2. Nominal voltage
3. Arc flash boundary
4. Personnel Protective Equipment category
5. Incident energy (cal/cm^2)
6. Working distance
7. Shock Boundaries

8. Engineering report number, revision number and issue date

C. Labels shall be machine printed, with no field markings

D. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.

1. For each 600, 480 and applicable 208 volt panelboards and disconnects, one arc flash label shall be provided
2. For each motor control center, one arc flash label shall be provided
3. For each low voltage switchboard, one arc flash label shall be provided
4. For each switchgear, one flash label shall be provided
5. For medium voltage switches one arc flash label shall be provided

E. Labels shall be field installed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

3.3 ARC FLASH TRAINING

A. The equipment vendor shall train personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours). Maintenance procedures in accordance with the requirements of NFPA 70E, Standard For Electrical Safety Requirements For Employee Workplaces, shall be provided in the equipment manuals. The training shall be certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET).

- END OF SECTION -

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SECTION 26 09 26
PANELBOARD

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Electrical distribution panelboards.

B. Connections between fixtures, equipment and panelboards.

C. Related work includes but is not limited to,

1. Section 01 33 00 - Submittal Procedures
2. Section 26 05 19 - Low-Voltage Power Conductors and Cables
3. Section 26 05 26 - Grounding and Bonding for Electrical Systems
4. Section 26 05 29 - Hangers and Supports for Electrical Systems
5. Section 26 05 33 - Conduit and Raceway

1.2 REFERENCES

A. NEMA 1: Instructions for Safe Installation. Operation and Maintenance of Panelboards Rated 600 Volts or Less.

B. NEMA 250: Enclosures for Electrical Equipment (1000 Volt Maximum).

C. NFPA 70: National Electrical Code.

D. UL: Underwriters' Laboratories Inc.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer data including specifications, installation instructions and general recommendations, for each type of panelboard required.

B. Shop Drawings. Submit showing accurately scaled layouts of enclosures and required individual panelboard devices. Show circuit breakers, fusible switches, fuses, ground-fault circuit interrupters, and accessories.

1.4 QUALITY ASSURANCE

A. Construct panelboards to NEMA 1 and NEMA 250 Standards and provide UL labels.

B. Comply with NFPA 70 pertaining to installation of wiring and equipment in hazardous locations.

C. Make all grounding tight and secure throughout.

PART 2 PRODUCTS

2.1 PANELBOARD - GENERAL

A. Provide panel boards of the same make and key alike with a master key arrangement.

B. Use dead front panelboards with one-piece cabinets constructed from code gage steel. Cabinets shall have knockouts and minimum gutter space of 4- inches on all sides.

C. Provide branches with automatic circuit breakers. thermal-magnetic type, unless indicated otherwise. Multi-pole breakers shall automatically open all poles when an overload occurs in any pole. Branch circuit breakers used for switching duty shall be UL listed as SWD type. Ground fault circuit interrupter protection as required by NFPA 70 shall be provided by ground fault circuit interrupting breakers. Circuit breakers shall have positive trip indication as well as clear "off" and "on" indication.

D. Use factory assembled panelboards with amp rating units indicated. Provide spare units and blank spaces as indicated. Main circuit breaker or lugs only as indicated.

E. Affix large, permanent individual numbers to each breaker on panel board face in a uniform position. Number starting at the top, with odd numbers used in sequence down left hand side and even numbers used in sequence down right hand side.

F. Use fronts manufactured with code gage steel, finished with rust inhibiting primer and baked enamel finish and manufacturer's standard color. Provide doors with flush tumbler type locks. Provide a circuit directory frame and card with a clear plastic covering inside the door.

G. Furnish locking clips for" off" position only, with" on" trip free travel and installed in all circuits so indicated.

H. Label panel with black phenolic or acceptable alternate engraved nameplate with 1/4 inch high lettering on the interior of each panelboard; including panel name and voltage.

I. For outside locations use a NEMA 3R cabinet.

2.2 PANELBOARD - 480 VOLT

A. Voltage: 480Y/277 volts, 3 phase, 4 wire, S/N, equipped with automatic circuit breaker.

B. Amp Rating: As shown on the Panelboard Schedules on the drawings.

C. Circuit Breakers: Minimum interrupting capacity of 14,000 amps at 277 volts.

Use breakers that are UL rated for use as switches.

D. Locking Clips: 5 minimum per panel.

2.3 PANELBOARD - 240 VOLT

A. Voltage: 240/120 volts, 1 phase, 3 wire, S/N, equipped with automatic circuit breakers.

B. Circuit Breakers: Minimum interrupting capacity of 10,000 amps at 120 volts.

2.4 PANELBOARD - 208 VOLT

A. Voltage: 208Y/120 volts, 3 phase, 4 wire, S/N, equipped with automatic circuit breakers.

B. Circuit Breakers: Minimum interrupting capacity of 10,000 amps at 120 volts.

PART 3 EXECUTION

3.1 INSTALLATION

A. Provide mounting brackets, bus bar drillings and filler pieces for unused spaces.

B. Prepare and affix typewritten directory to inside cover of panelboard indicating loads controlled by each circuit.

C. Install per NFPA 70, NEMA. manufacturer's instructions and authorities having jurisdiction.

- END OF SECTION -

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SECTION 26 12 16
DRY TYPE TRANSFORMERS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes two-winding transformers.

B. Related Sections:

1. Section 01 33 00 - Submittal Procedures
2. Section 01 45 00 - Quality Control and Materials Testing
3. Section 01 60 00 - Product Requirements
4. Section 01 78 50 - Project Closeout

1.2 REFERENCES

A. National Electrical Manufacturers Association

1. NEMA ST 1 (National Electrical Manufacturers Association) - Specialty Transformers (Except General-Purpose Type).
2. NEMA ST 20 (National Electrical Manufacturers Association) Dry-Type Transformers for General Applications.

B. International Electrical Testing Association

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures.

B. Product Data: Submit outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics, tap configurations, insulation system type, and rated temperature rise.

C. Test Reports: Indicate loss data, efficiency at 25, 50, 75 and 100 percent rated load, and sound level.

1.4 CLOSEOUT SUBMITTALS

A. Section 01 78 50 - Project Closeout.

B. Project Record Documents: Record actual locations of transformers.

1.5 QUALIFICATIONS

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

1.6 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements

B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

C. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.

PART 2 PRODUCTS

2.1 TWO-WINDING TRANSFORMERS

A. Manufacturers:

1. Acme Transformer
2. General Electric
3. Square D Company
4. Approved equal.

B. Product Description: NEMA ST 20, factory assembled, air-cooled, dry type transformers, ratings as indicated.

C. Primary Voltage: 480 volts, 3 phase or 480 volts, 1 phase as shown on the drawings.

D. Secondary Voltage: 208Y/120 volts, 3 phase or 240/120 volts, 1 phase as shown on the drawings.

E. Insulation system and average winding temperature rise for rated kVA as follows:

1. 1-15 kVA: Class 185 with 115 degrees C rise.
2. 16-500 kVA: Class 220 with 115 degrees C rise.

F. Case temperature: Do not exceed 35 degrees C rise above ambient at warmest point at full load.

G. Winding Taps:

1. Transformers Less than 15 kVA: Two 5 percent below rated voltage, full capacity taps on primary winding.
2. Transformers 15 kVA and Larger: NEMA ST 20.

H. Sound Levels: NEMA ST 20.

I. Basic Impulse Level: 10 kV.

J. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.

K. Mounting:

1. 1-15 kVA: As shown on drawings.

L. Coil Conductors: Continuous copper windings with terminations brazed or welded.

1. Enclosure: NEMA ST 20, Type 1 ventilated. Provide lifting eyes or brackets.
2. Isolate core and coil from enclosure using vibration absorbing mounts.
3. Nameplate: Include transformer connection data and overload capacity based on rated allowable temperature rise.

2.2 SOURCE QUALITY CONTROL

A. Productions test each unit according to NEMA ST20.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 60 00 - Product Requirements.

B. Verify mounting supports are properly sized and located including concealed bracing in walls.

3.2 INSTALLATION

A. Provide seismic restraints.

B. Provide grounding and bonding in accordance with NFPA 70.

3.3 FIELD QUALITY CONTROL

A. Section 01 45 00 - Quality Control and Materials Testing. Testing and inspection services Testing, adjusting, and balancing.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Perform inspections and tests listed in NETA ATS, Section 7.2.1.

3.4 ADJUSTING

A. Section 01 78 50 - Project Closeout: Testing, adjusting, and balancing.

B. Measure primary and secondary voltages and make appropriate tap adjustments.

- END OF SECTION -

SECTION 26 12 19
PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of the pad-mounted, liquid-filled, medium-voltage transformers, indicated as transformers in this section.

B. Related work includes but is not limited to:

1. Section 01 33 00 - Submittal Procedures
2. Section 03 30 00 - Cast-In-Place Concrete
3. Section 26 05 13 - Medium-Voltage Cables
4. Section 26 05 19 - Low-Voltage Power Conductors and Cables
5. Section 26 05 26 - Grounding and Bonding for Electrical Systems
6. Section 26 05 43 - Underground Ducts and Raceways for Electrical Systems
7. Section 26 05 73 - Short-Circuit Coordination and Arc Flash

1.2 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.3 FACTORY TESTS

A. Factory Tests shall be required.

B. Factory Tests:

1. Transformers shall be thoroughly tested at the factory to ensure that there are no electrical or mechanical defects. Tests shall be conducted per IEEE Standards. Factory tests shall be certified. The following tests shall be performed:
   a. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground.
   b. Perform turns-ratio tests at all tap positions.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section -01 33 00 Submittal Procedures and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.

b. Include electrical ratings, nameplate data, impedance, outline drawing with dimensions and front, top, and side views, weight, mounting details, decibel rating, termination information, temperature rise, no-load and full-load losses, regulation, overcurrent protection, connection diagrams, and accessories.
c. Complete nameplate data, including manufacturer's name and catalog number.
d. Certification from the manufacturer that representative transformers have been seismically tested to International Building Code requirements. Certification shall be based upon simulated seismic forces on a shake table or by analytical methods, but not by experience data or other methods.

2. Manuals:
a. When submitting the shop drawings, submit companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
(1) Identify terminals on wiring diagrams to facilitate installation, maintenance, and operation.
(2) Indicate on wiring diagrams the internal wiring for each piece of equipment and interconnections between the pieces of equipment.
(3) Approvals will be based on complete submissions of manuals, together with shop drawings.
b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
(1) Update the manual to include any information necessitated by shop drawing approval.
(2) Show all terminal identification.
(3) Include information for testing, repair, troubleshooting, assembly, disassembly, and recommended maintenance intervals.
(4) Provide a replacement parts list with current prices. Include a list of recommended spare parts, tools, and instruments for testing and maintenance purposes.

B. Certifications:

1. Two weeks prior to the final inspection, submit the following certifications.
a. Certification by the manufacturer that the transformers conform to the requirements of the drawings and specifications.
b. Certification by the Contractor that the transformers have been properly installed, connected, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Society for Testing and Materials (ASTM):

D3487-16 Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus

C. Institute of Electrical and Electronic Engineers (IEEE):

48-09 Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5kV Through 765kV or Extruded Insulation Rated 2.5kV Through 500kV
386-16 Separable Insulated Connector Systems for Power Distribution Systems Above 600 V
592-07 Exposed Semiconducting Shields on High-Voltage Cable Joints and Separable Connectors
C2-17 National Electrical Safety Code
C37.47-11 Specification for High Voltage (>1000V) Distribution Class Current-Limiting Fuses and Fuse Disconnecting Switches
C57.12.00-15 Liquid-Immersed Distribution, Power and Regulating Transformers
C57.12.10-13 Liquid-Immersed Power Transformers
C57.12.25-90 Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution-Transformers with Separable Insulated High Voltage Connectors; High Voltage, 34500 Grd Y/19920 Volts and Below; Low-Voltage 240/120 Volts; 167 kVA and Smaller Requirements
C57.12.28-14 Pad-Mounted Equipment - Enclosure Integrity
C57.12.29-14 Pad-Mounted Equipment – Enclosure Integrity for Coastal Environments
C57.12.34-15 Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 5 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15kV Nominal System Voltage and Below
C57.12.90-15 Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
C62.11-12 Metal-Oxide Surge Arresters for AC Power Circuits

D. International Code Council (ICC):

IBC-15 International Building Code

E. National Electrical Manufacturers Association (NEMA):

TR 1-13 Transformers, Regulators, and Reactors

F. National Fire Protection Association (NFPA):

70-23 National Electrical Code (NEC)

G. Underwriters Laboratories Inc. (UL):

467-13 Grounding and Bonding Equipment

H. United States Department of Energy (DOE):

10 CFR Part 431 Energy Efficiency Program for Certain Commercial and Industrial Equipment

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Transformers shall be in accordance with ASTM, IEEE, NFPA, UL, as shown on the drawings, and as specified herein. Each transformer shall be assembled as an integral unit by a single manufacturer.

B. Transformers shall be complete, outdoor type, continuous duty, integral assembly, grounded, tamper-resistant, and with liquid-immersed windings.

C. Ratings shall not be less than shown on the drawings.

D. Completely fabricate transformers at the factory so that only the external cable connections are required at the project site.

E. Thoroughly clean, phosphatize, and finish all the metal surfaces at the factory with a rust-resistant primer and dark green enamel finish coat, except where a different color is specified in Section 09 06 00, SCHEDULE FOR FINISHES. All surfaces of the transformer that will be in contact with the concrete pad shall be treated with corrosion-resistant compounds and epoxy resin or a rubberized sealing compound.

2.2 COMPARTMENTS

A. Construction:

1. Enclosures shall be weatherproof and in accordance with IEEE C57.12.28.
2. The medium- and low-voltage compartments shall be separated with a steel barrier that extends the full height and depth of the compartments.
3. The compartments shall be constructed of sheet steel (gauge to meet ANSI requirements) with bracing and with reinforcing gussets using jig welds to assure rectangular rigidity.
4. All bolts, nuts, and washers shall be zinc-plated steel.
5. Sufficient space shall be provided for equipment, cabling, and terminations within the compartments.
6. Affix transformer nameplate permanently within the low-voltage compartment. Voltage and kVA rating, connection configuration, impedance, date of manufacture, and serial number shall be shown on the nameplate.

B. Doors:

1. Provide a separate door for each compartment with provisions for a single padlock to secure all doors. Provide each compartment door with openposition doorstops and corrosion-resistant tamperproof hinges welded in place. The medium-voltage compartment door shall be mechanically prevented from opening unless the low-voltage compartment door is open.
2. The secondary compartment door shall have a one-piece steel handle and

incorporate three-point locking mechanisms.

3. Owner will provide a 50 mm (2 inches) size padlock for each assembly. Padlocks shall be keyed to the OWNERS established key set. Firmly attach the padlock to the door assembly.

2.3 BIL RATING

A. 15 kV class equipment shall have a minimum 95 kV BIL rating.

2.4 TRANSFORMER FUSE ASSEMBLY

A. The primary fuse assembly shall be a combination of externally replaceable Bay-O-Net liquid-immersed fuses in series with liquid-immersed current-limiting fuses.

2.5 PRIMARY CONNECTIONS

A. Primary connections shall be 200A dead-front loadbreak wells and inserts for cable sizes shown on the drawings.

B. Surge Arresters: Distribution class, one for each primary phase, complying with IEEE C62.11, elbow type.

2.6 MEDIUM-VOLTAGE TERMINATIONS

A. Terminate the medium-voltage cables in the primary compartment with 200 A loadbreak premolded rubber elbow connectors, suitable for submersible applications. Elbow connectors shall have a semiconductive shield material covering the housing. The separable connector system shall include the loadbreak elbow, the bushing insert, and the bushing well. Separable connectors shall comply with the requirements of IEEE 386, and shall be interchangeable between suppliers. Allow sufficient slack in medium-voltage cable, ground, and drain wires to permit elbow connectors to be moved to their respective parking stands.

B. Ground metallic cable shield with a cable shield grounding adapter, consisting of a solderless connector enclosed in watertight rubber housing covering the entire assembly, bleeder wire, and ground braid.

2.7 LOW-VOLTAGE EQUIPMENT

A. The low-voltage leads shall be brought out of the tank by epoxy pressure tight bushings, and shall be standard arrangement.

B. Tin-plate the low-voltage neutral terminal and isolate from the transformer tank. Provide a removable ground strap sized in accordance with the NEC and connect between the secondary neutral and ground pad.

2.8 TRANSFORMERS

A. Transformer rating: 112.5 kVA and 300 kVA as shown on drawings. kVA ratings shown on the drawings are for continuous duty without the use of cooling fans.

B. Temperature rises shall not exceed the NEMA TR 1 of 65-deg C (149-deg F) by resistance.

C. Transformer insulating material shall be mineral oil in accordance with ASTM D 3487.

D. Transformer impedance shall be not less than 4-1/2% for sizes 150 kVA and larger.

E. Sound levels shall conform to NEMA TR 1 standards.

F. Primary and Secondary Windings for Three-Phase Transformers:

1. Primary windings shall be wye-connected.
2. Secondary windings shall be wye-connected. Provide isolated neutral bushings for secondary wye-connected transformers.
3. Secondary leads shall be brought out through pressure-tight epoxy bushings.

G. Primary windings shall have four 2-1/2% full-capacity voltage taps; two taps above and two taps below rated voltage.

H. Core and Coil Assemblies:

1. Cores shall be grain-oriented, non-aging, silicon steel to minimize losses.
2. Core and coil assemblies shall be rigidly braced to withstand the stresses caused by rough handling during shipment, and stresses caused by any possible short-circuit currents.
3. Coils shall be continuous-winding type without splices except for taps. Material shall be copper.
4. Coil and core losses shall be optimum for efficient operation.
5. Primary, secondary, and tap connections shall be brazed or pressure type.
6. Provide end fillers or tie-downs for coil windings.

I. The transformer tank, cover, and radiator gauge thickness shall not be less than that required by ANSI.

J. Accessories:

1. Provide standard NEMA features, accessories, and the following:
   a. No-load tap changer. Provide warning sign.
   b. Lifting, pulling, and jacking facilities.
   c. Globe-type valve for oil filtering and draining, including sampling device.
   d. Pressure relief valve.
   e. Liquid level gauge and filling plug.
   f. A grounding pad in the medium- and low-voltage compartments.
   g. A diagrammatic nameplate.
   h. Dial-type liquid thermometer with a maximum reading pointer and an external reset.
2. The accessories shall be made accessible within the compartments without disassembling trims and covers.

K. Transformers shall meet the energy conservation standards for transformers per the United States Department of Energy 10 CFR Part 431.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install transformers outdoors, as shown on the drawings, in accordance with the NEC, and as recommended by the manufacturer.

B. Anchor transformers with rustproof bolts, nuts, and washers not less than 12 mm (1/2 inch) diameter, in accordance with manufacturer's instructions, and as shown on drawings.

C. In seismic areas, transformers shall be adequately anchored and braced per details on structural contract drawings to withstand the seismic forces at the location where installed.

D. Mount transformers on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm (8 inches) thick, reinforced with a 150 by 150 mm (6 by 6 inches) No. 6 mesh placed uniformly 100 mm (4 inches) from the top of the slab. Slab shall be placed on a 150 mm (6 inches) thick, well-compacted gravel base. The top of the concrete slab shall be approximately 100 mm (4 inches) above the finished grade. Edges above grade shall have 12-1/2 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 200 mm (8 inches) beyond the equipment. Provide conduit turn-ups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00 - Cast-In-Place Concrete.

E. Grounding:

1. Ground each transformer in accordance with the requirements of the NEC. Install ground rods per the requirements of Section 26 05 26- Grounding and Bonding for Electrical Systems, to maintain a maximum resistance of 5 ohms to ground.
2. Connect the ground rod to the ground pads in the medium- and low-voltage compartments.
3. Install and connect the cable shield grounding adapter per the manufacturer's instructions. Connect the bleeder wire of the cable shield grounding adapter to the loadbreak or deadbreak elbow grounding point with minimum No. 14 AWG wire, and connect the ground braid to the grounding system with minimum No. 6 AWG bare copper wire. Use soldered or mechanical grounding connectors listed for this purpose.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform manufacturer's required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:
    a. Compare equipment nameplate data with specifications and approved shop drawings.
    b. Inspect physical and mechanical condition. Check for damaged or cracked bushings and liquid leaks.
    c. Verify that control and alarm settings on temperature indicators are as specified.
    d. Inspect all field-installed bolted electrical connections, using the calibrated torque-wrench method to verify tightness of accessible bolted electrical connections, and perform thermographic survey after energization under load.
    e. Vacuum-clean transformer interior. Clean transformer enclosure exterior.
    f. Verify correct liquid level in transformer tank.
    g. Verify correct equipment grounding per the requirements of Section 26 05 26 - Grounding and Bonding for Electrical Systems.
    h. Verify the presence and connection of transformer surge arresters, if provided.
    i. Verify that the tap-changer is set at rated system voltage.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the transformers are in good operating condition and properly performing the intended function.

3.4 SPARE PARTS

A. Deliver the following spare parts for the project to the Owner two weeks prior to final inspection:

    1. Six insulated protective caps.
    2. One spare set of medium-voltage fuses for each size and type of fuse used in the project.
    3. Six elbow parking stands.

3.5 INSTRUCTION

A. The Contractor shall instruct maintenance personnel, for not less than one 2 hour period, on the maintenance and operation of the equipment on the date requested by the Resident Engineer.

- END OF SECTION -

SECTION 26 13 00
MEDIUM-VOLTAGE SWITCHGEAR

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Pad-mounted switchgear.

B. Related work includes but is not limited to,

1. Section 01 33 00 - Submittal Procedures
2. Section 01 60 00 - Product Requirements
3. Section 03 30 00 - Cast-In-Place Concrete
4. Section 01 78 50 - Project Closeout
5. Section 26 05 13 - Medium-Voltage Cables
6. Section 26 05 29 - Hangers and Supports for Electrical Systems
7. Section 26 05 43 - Underground Ducts and Raceways for Electrical Systems
8. Section 26 05 73 - Short-Circuit/Coordination Study and Arcflash Hazard Analysis
9. Section 26 12 19 - Pad-Mounted, Medium Voltage Transformers
10. Section 26 18 39 - Medium-Voltage VFD

1.2 REFERENCE STANDARD

A. IEEE

1. C37.20.1 - IEEE Standard for Metal-Enclosed Low-Voltage (1000 Vac and Below, 3200 Vdc and Below) Power Circuit Breaker Switchgear; 2015, with Amendment (2020).
2. IEEE C37.20.2 - IEEE Standards for Metal-Clad Switchgear
3. IEEE C37.20.3 - IEEE Standard for Metal-Enclosed Interrupter Switchgear.
4. IEEE C37.62 - IEEE Standard for Pad-Mount, Dry Vault, Submersible and Overhead Fault Interrupters for Alternating Current Systems up to 38 kV.
5. IEEE C37.74 - IEEE Standard Requirements for Subsurface, Vault, and Pad-mounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems up to 38 kV.

B. Metal-Enclosed Interrupter Switchgear.

C. IEEE

D. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2013.

E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authorized Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.3 SUBMITTAL

A. See 01 33 00 - Submittal Procedures for submittal procedures.

B. Shop Drawings: Indicate electrical characteristics and connection requirements, outline dimensions, connection and support points, weight, specified ratings and materials.

1. Identify mounting conditions required for equipment seismic qualification.

C. Product Data: Provide electrical characteristics and connection requirements, standard model design tests, and options.

D. Manufacturer's equipment seismic qualification certification.

E. Test Reports: Indicate procedures and results for specified factory and field testing and inspection.

F. Manufacturer's Installation Instructions

G. Manufacturer's Field Reports: Indicate activities on site, final adjustments and overcurrent protective device coordination curves, adverse findings, and recommendations.

H. Project Record Documents: Include copy of manufacturer's certified drawings.

I. Operation Data: Include operating instructions for manually and electrically opening and closing circuit breakers.

J. Maintenance Data: Include maintenance instructions for cleaning methods; cleaning material recommended; instructions for circuit breaker removal, replacement, testing and adjustment, and lubrication.

K. Maintenance Materials: Furnish the following for Owner's use in maintenance project.

1. See Section 01 60 00 - Product Requirements, for additional provisions.
2. Tools: One each of every special tool required to operate and maintain switchgear.

1.4 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Products: Listed, classified, and labeled as suitable for the purpose intended.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect products from weather and moisture by covering with heavy plastic or canvas and by maintaining heating within enclosure in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 MANUFACTURES

A. S&C Electric Company, or approved equal

2.2 DESCRIPTION

A. The switchgear shall consist of a gas-tight tank containing SF6 gas, load-interrupter switches, resettable fault interrupters with visible open gaps and integral visible grounds, and a microprocessor based overcurrent control. Load-interrupter switch terminals shall be equipped with bushings rated 600 amperes continuous, and fault-interrupter terminals shall be equipped with bushing wells rated 200 amperes continuous or bushings rated 600 amperes continuous (as specified) to provide for elbow connection. Manual operating mechanisms and viewing windows shall be located on the opposite side of the tank from the bushings and bushing wells, so operating personnel shall not be required to perform any routine operations in close proximity to high voltage elbows and cables.

B. High-Voltage Bus

1. Bus and interconnections shall withstand the stresses associated with short circuit currents up through the maximum rating of the switchgear.
2. Before installation of aluminum bus, all electrical contact surfaces shall first be prepare by machine-abrading to remove any oxide film. Immediately after this operation, the electrical contact surfaces shall be coated with a uniform coating of an oxide inhibitor and sealant.

C. Provisions for Grounding

1. One ground connection pad shall be provided on the gas-tight tank of the switchgear.
2. The ground connection pad shall be constructed of stainless steel and welded to the gas-tight tank, and it shall have a short circuit rating equal to that of the switchgear.
3. When an enclosure is provided, no less than one enclosure ground pad shall be provided.
4. One ground-connection pad per way shall be provided.

2.3 SERVICE CONDITIONS

A. Meet requirements for usual service conditions described in IEEE C37.20.1 and IEEE 37.74 for the specified unusual service conditions.

B. Meet requirements for disconnecting means.

2.4 RATINGS

A. Seismic Qualification: Provide switchgear and associated components suitable for

application under the seismic Zone III. Include certification of compliance with submittals.

B. Certification of Ratings

1. The manufacturer of the switchgear shall be completely and solely responsible for the performance of the load-interrupter switch and fault interrupter as well as the complete integrated assembly as rated.
2. The manufacturer shall furnish, upon request, certification of ratings of the load-interrupter switch, fault interrupter, and the integrated switchgear assembly consisting of switches and fault interrupters in combination with the gas-tight tank.

C. Nominal Voltage: 15 kV, three phase, 60 Hz.

D. Main Bus Ampacity: 600 amperes, continuous.

E. kV BIL Voltage, 95 kV.

F. The switchgear shall conform to or exceed the applicable requirements of the following standards and codes:

1. The applicable portions of ANSI C57.12.28, covering enclosure integrity for pad equipment.
2. The applicable portions of ANSI C37.71, ANSI C37.72, ANSI C37.73, IEC 56, and IEC 265-1 (Class A), which specify test procedures and sequences for the load-interrupter switches, fault interrupters, and the complete switchgear assembly.

G. Connections

1. For gear rated 12.5 kA short circuit, load-interrupter switches shall be equipped with 600 Ampere bushings, and fault interrupters shall be equipped with 200 Ampere bushing wells.
2. Bushings and bushing wells shall be located on one side of the gear to reduce the required operating clearance.
3. Fault interrupters shall be equipped with 600 Ampere bushings without studs.
4. Load-interrupter switches shall be equipped with 600 Ampere bushings with studs.

H. Bushings and Bushing Wells

1. Bushings and bushing wells shall conform to ANSI/IEEE Standard 386,
2. Bushings and bushing wells shall include a semiconductive coating.
3. Bushings and bushing wells shall be mounted in such a way that the semiconductive coating is solidly grounded to the gas-tight tank.

2.5 BASIC COMPONENTS

A. Load-Interrupter Switch

1. The three-phase, group-operated load-interrupter switches shall have a three-time and ten-time duty-cycle fault-closing rating as specified under "Ratings". This rating defines the ability to close the switch the designated number of times against a three-phase fault with asymmetrical (peak) current in at least one phase equal to the rated value, with the switch remaining operable and able to carry and interrupt rated current. Certified test abstracts establishing such ratings shall be furnished upon request.
2. The switch shall be provided with an integral ground position that is readily visible through the viewing window to eliminate the need for cable handling and exposure the high voltage to ground the equipment.
3. The ground position shall have a three-time and ten-time duty-cycle fault-closing rating.
4. The switch shall be provided with an open position that is readily visible through the viewing window to eliminate the need for cable handling and exposure to high voltage establish a visible gap.
5. The open gaps of the switch shall be sized to allow cable testing through a feedthru bushing or the back of the elbow.

B. Fault Interrupters

1. Fault interrupters shall have a three-time and ten-time duty-cycle fault-closing and fault interrupting rating as specified under "Ratings". This rating defines the fault interrupter's ability to close the designated number of times against a three-phase fault with asymmetrical (peak) current in at least one phase equal to the rated value and clear the resulting fault current, with the interrupter remaining operable and able to carry and interrupt rated current. Certified test abstracts establishing such ratings shall be furnished upon request.
2. The fault interrupter shall be provided with a disconnect with an integral ground position that is readily visible through the viewing window to eliminate the need for cable handling and exposure to high voltage to ground the equipment.
3. The ground position shall have a three-time and ten-time duty-cycle fault-closing rating.
4. The disconnect shall be provided with an open position that is readily visible through the viewing window, eliminating the need for cable handling and exposure to high voltage the establish a visible gap.
5. The fault interrupter, including its three-position disconnect, shall be a single integrate design so that operation between the closed and open positions or the open and grounded positions is accomplished with a single, intuitive movement.
6. The open gaps of the disconnect shall be sized to allow cable testing through a feedthru bushing or the back of the elbow.
7. An internal indicator shall be provided for each fault interrupter to show when it is in the tripped condition. The indicator shall be clearly visible through the viewing window.

C. Operating Mechanism

1. Load-interrupter switches and fault interrupter make, quick-break mechanism.
2. The manual handle shall charge the operating mechanism for closing, opening,

and grounding of the switches and fault interrupters.

3. A single, integrated operating mechanism shall fully operate each fault interrupter or load interrupter switch in a continuous movement so that additional operations are not required to establish open or grounded positions.
4. Operating mechanisms shall be equipped with an operation selector to prevent inadvertent operation from the closed position directly to the grounded position, or from the grounded position directly to the closed position. The operation selector shall require physical movement to the proper position to permit the next operation.
5. Operating shafts shall be padlockable in any position to prevent operation.
6. The operation selector shall be padlockable to prevent operation to the ground position.
7. The operating mechanism shall indicate switch position, which shall be clearly visible from the normal operating position.

D. Provisions for Grounding

1. One ground-connection pad shall be provided on the gas-tight tank of the switchgear.
2. The ground-connection pad shall be constructed of stainless steel and welded to the gas tight tank, and it shall have a short-circuit rating equal to that of the switchgear.
3. When an enclosure is provided, no less than one enclosure ground pad shall be provided.
4. One ground-connection pad per way shall be provided.

E. Overcurrent Control

1. A microprocessor-based overcurrent control shall be provided to initiate fault interruption.
2. For dry-vault-mounted style and pad-mounted style switchgear, the control shall be mounted in a watertight enclosure. For UnderCover style and wet-vault-mounted style switchgear, the control shall be mounted in a submersible enclosure. The control shall be removable in the field without taking the gear out of service.
3. Control settings shall be field-programmable using a personal computer connected via a USB port to the control. The USB port shall be accessible from the exterior of the enclosure. All programming software is resident on the control and can be accessed via personal computer using the Internet Explorer or Firefox web browser. Energization of the gear shall not be required to set or alter control settings.
4. Power and sensing for the control shall be supplied by integral current transformers.
5. The control shall feature time-current characteristic (TCC) curves including standard speed, K-speed, T-speed, coordinating-speed tap, coordinating-speed main, and related curves per IEEE C37.112-1996. Coordinating-speed tap curves shall optimize coordination with load-side weak-link/backup current-limiting fuse combinations, and coordinating-speed main curves shall optimize coordination with tap-interrupter curves and upstream feeder breakers.

6. The standard E-speed curve shall have phase-overcurrent settings ranging from 7E through 400E. The standard K-speed curve shall have phase-overcurrent settings ranging from 8K through 200K. The standard T-speed curve shall have phase-overcurrent settings ranging from 8T through 200T. The coordinating-tap curve shall have phase-overcurrent and independent ground-overcurrent settings ranging from 15 Amperes through 400 Amperes. The coordinating-main curve shall have phase-overcurrent and independent ground-overcurrent settings ranging from 25 Amperes through 800 Amperes.
7. Time-current characteristic curves shall conform to the following IEEE C37.112-199 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays:
    a. U.S. Moderately Inverse Curve U1, U.S. Inverse Curve U2, U.S. Very Inverse Curve U3, U.S. Extremely Inverse Curve U4, U.S. Short-Time Inverse Curve U5, I.E.C. Class A Curve (Standard Inverse) C1, I.E.C. Class B Curve (Very Inverse) C2, I.E.C. Class C Curve (Extremely Inverse) C3, I.E.C. Long-Time Inverse Curve C4, and
    b. I.E.C. Short-Time Inverse Curve C5.
8. The control shall have two independently settable and field-adjustable definite-time delay settings. (A definite-time delay setting can be configured to be an instantaneous- trip setting if the definite-time delay is set to 0 milliseconds.)
9. The minimum trip current shall be 14 Amperes for Vista switchgear with 660:1 ratio current transformers, and 28 Amperes for models with 1320:1 ratio current transformer.
10. Event records shall be easily viewable from the control using a personal computer connected to the USB port. The event log shall capture the last 64 events recorded by the overcurrent control.
11. The control shall store sufficient energy to operate the fault interrupters without affecting the accuracy or coordination under fault conditions.

F. Pad-Mounted Style

1. The gas-tight tank shall be made of 7-gauge mild-steel.
2. To guard against corrosion caused by extremely harsh environmental conditions, the gas-tight tank shall be made of Type 304L stainless steel.
3. For gear rated 12.5 kA short circuit, the switchgear shall conform to or exceed the requirements of applicable portions of IEC 298, Appendix AA, covering arc resistant through 12.5 kA for 15 cycles.
4. Enclosure
    a. The switchgear shall be provided with a pad-mounted enclosure suitable for installation of the gear on a concrete pad.
    b. The pad-mounted enclosure shall be separable from the switchgear to allow clear access to the bushings and bushing wells for cable termination.
    c. The basic material shall be a 14-gauge hot-rolled, pickled, and oiled steel sheet.
    d. The enclosure shall be provided with removable front and back panels and hinged lift-up roof sections for access to the operating and termination compartments. Each roof section shall have a retainer to

hold it in the open position.

e. Lift-up roof sections shall overlap the panels and shall have provisions for pad-locking that incorporate a means to protect the padlock shackle from tampering.
f. The base shall consist of continuous 90-degree flanges, turned inward and welded at the corners, for bolting to the concrete pad.
g. Panel openings shall have 90-degree flanges, facing outward, that shall provide strength and rigidity as well as deep overlapping between panels and panel openings to guard against water entry.
h. For bushings rated 600 Amperes continuous, the termination compartment shall be of an adequate depth to accommodate encapsulated surge arresters mounted on 600 Ampere elbows having 200 Ampere interfaces.
i. For bushing wells rated 200 Amperes continuous, the termination compartment shall be of an adequate depth to accommodate 200 Ampere elbows mounted on feedthru inserts.
j. An instruction manual holder shall be provided.
k. Non-removable lifting tabs shall be provided.

5. Enclosure Finish
   a. All exterior welded seams shall be filled and sanded smooth for neat appearance.
   b. To remove oils and dirt, to form a chemically and anodically neutral conversion coating to improve the finish-to-metal bond, and to retard underfilm propagation of corrosion, all surfaces shall undergo a thorough pretreatment process comprised of a fully automated system of cleaning, rinsing, phosphatizing, sealing, drying, and cooling before any protective coatings are applied. By using an automated pretreatment process, the enclosure shall receive a highly consistent thorough treatment, eliminating fluctuations in reaction time, reaction temperature, and chemical concentrations.
   c. After pretreatment, protective coatings shall be applied that shall help resist corrosion and protect the steel enclosure. To establish the capability to resist corrosion and protect the enclosure, representative test specimens coated by the manufacturer's finishing system shall satisfactorily pass the following tests:
      (1) 4000 hours of exposure to salt-spray testing per ASTM B 117 with:
         (a) Underfilm corrosion not to extend more than 1/32 inch (0.79 mm). from the scribe, as evaluated per ASTM D 1645,
         (b) Procedure A, Method 2 (scraping); and
      (2) Loss of adhesion from bare metal not to extend more than 1/8 in. (3.2 mm) from the scribe.
      (3) 1000 hours of humidity testing per ASTM D 4585 using the Cleveland Condensing Type Humidity Cabinet, with no blistering as evaluated per ASTM D 714.
      (4) 500 hours of accelerated weathering testing per ASTM G 53 using lamp UVB-313, with no chalking as evaluated per ASTM D 659, and no more than 10% reduction of gloss as evaluated per ASTM D 523.

(5) Crosshatch-adhesion testing per ASTM D 3359 Method B, with no loss of finish.
(6) 160-inch-pound impact, followed by adhesion testing per ASTM D 2794, with no chipping or cracking.
(7) 3000 cycles of abrasion testing per ASTM 4060, with no penetration to the substrate.

d. The finish shall be inspected for scuffs and scratches. Blemishes shall be touched up by hand to restore the protective integrity of the finish.

6. Labeling

a. Hazard-Alerting Signs

(1) The exterior of the pad-mounted enclosure (if furnished) shall be provided with "Warning-Keep Out-Hazardous Voltage Inside-Can Shock, Bum, or Cause Death" signs.
(2) Each unit of switchgear shall be provided with a "Danger-Hazardous Voltage--Failure to Follow These Instructions Will Likely Cause Shock, Burns, or Death" sign. The text shall further indicate that operating personnel must know and obey the employer's work rules, know the hazards involved, and use proper protective equipment and tools to work on this equipment.
(3) Each unit of switchgear shall be provided with a "Danger-Keep Away-Hazardous Voltage-Will Shock, Burn, or Cause Death" sign.

b. Nameplates, Ratings Labels, and Connection Diagrams

(1) Each unit of switchgear shall be provided with a nameplate indicating the manufacturer's name, catalog number, model number, date of manufacture, and serial number.
(2) Each unit of switchgear shall be provided with a ratings label indicating the following: voltage rating; main bus continuous-current rating; short-circuit rating; fault-interrupter ratings, including interrupting and duty-cycle fault-closing; and load-interrupter switch ratings, including duty-cycle fault-closing and short-time.

G. Voltage Indication

1. Voltage indication with provisions for low-voltage phasing

a. Voltage indication with provisions for low-voltage shall be provided for each load-interrupter switch and fault interrupter by means of capacitive taps on the bushings, eliminating the need for cable handling and exposure to high voltage to test the cables for voltage and phasing. This feature shall include a flashing liquid-crystal display to indicate the presence of voltage for each phase and a solar panel to supply power for testing of the complete voltage-indication circuit and phasing circuit.
b. The voltage-indication feature shall be mounted on the covers for the viewing windows, on the opposite side of the gear from the bushings and bushing wells, that operating personnel shall not be required to perform any routine operations in close proximity to high-voltage elbows and cables.

2.6 ACCESSORIES

A. Current Transformer/Voltage Transformer/Sensor:

1. Provide 200:5 current transformers on the incoming 600A disconnect switch for the owner to remotely monitor current. Transformer secondary shall be wired to a standard shorting terminal accessible within the low voltage compartment. CT's shall be wired in a four wire "Y" connection.
2. Provide 12.47KV:120V fused potential transformers or voltage sensors to provide 120 Volts to the owner'‘s remotely installed Power Quality Monitor (Shark 250). Low voltage shall be wired to terminals accessible within the low voltage compartment. PT's shall be wired in a four wire "Y" connection.

B. Viewing Windows

1. Each load-interrupter switch shall be provided with a large viewing window at least 6 inches by 12 inches (15 cm by 30 cm) to allow visual verification of the switch blade position (closed, open, and grounded) while shining a flashlight on the blades.
2. Each fault interrupter shall be provided with a large viewing window at least 6 inches by 2 inches (15 cm by 30 cm) to allow visual verification of the disconnect-blade position (closed, open, and grounded) while shining a flashlight on the blades.
3. Viewing windows shall be located on the opposite side of the gear from the bushings and bushing wells so that operating personnel shall not be required to perform any routine operations in close proximity to high-voltage elbows and cables.
4. A cover shall be provided for each viewing window to prevent operating personnel from viewing the flash that may occur during switching operations.

C. Retractable lifting tab.

D. Pentahead bolt locking mechanism to accommodate padlock with 0.375" diameter shackle.

E. Vista remote supervisory low voltage enclosure.

F. Potential indication with test feature and provisions for low-voltage phasing.

G. Vista junction box assembly.

H. Motor operators: provide motor operated switches for the PME12 Main Incoming way and the Vista two load ways (ie, VFD feed and transformer feed).

I. Six-way Vista electronics rack for future motor operators.

2.7 FABRICATION

A. Construction: Outdoor.

1. SF6 -Gas Insulation
   a. The SF6 gas shall conform to ASTM D2472.

b. The switchgear shall be filled with SF6 gas to a pressure of 7 psig at 68 deg. F (201 C).
c. The gas-tight tank shall be evacuated prior to filling with SF6 gas to minimize moisture in the tank.
d. The switchgear shall withstand system voltage at a gas pressure of 0 psig at 68 deg. F (20° C).
e. A gas-fill valve shall be provided.
f. A temperature-compensated pressure gauge shall be provided that is color coded to show the operating range. The gauge shall be mounted inside the gas-tight tank (visible through a large viewing window) to provide consistent pressure readings regardless of the temperature or altitude at the installation site.

2. Gas-Tight Tank
   a. The tank shall be submersible and able to withstand up to 10 feet water over the base.
   b. The tank shall be of welded construction and shall be made of 7-gauge mild steel or Type 304L stainless steel, as specified in Section 4.0.
   c. A means of lifting the tank shall be provided.
3. Gas-Tight Tank Finish (for mild steel only)
   a. To remove oils and dirt, to form a chemically and anodically neutral conversion coating to improve the finish-to-metal bond, and to retard underfilm propagation of corrosion, mild-steel surfaces shall undergo a thorough pretreatment process comprised of a fully automated system of cleaning, rinsing, phosphatizing, sealing, drying, and cooling, before any protective coatings are applied. By using an automated pretreatment process, the mild-steel surfaces of the gas-tight tank shall receive a highly consistent thorough treatment, eliminating fluctuations in reaction mild steel time, reaction temperature, and chemical concentrations.
   b. After pretreatment, protective coatings shall be applied that shall help resist corrosion and protect the mild-steel surfaces of the gas-tight tank. To establish the capability to resist corrosion and protect the mild steel, representative test specimens coated by the manufacturer's finishing system shall satisfactorily pass the following tests:
      (1) 1500 hours of exposure to salt-spray testing per ASTM B 117 with:
         (a) Underfilm corrosion not to extend more than 1/32 in. (0.79 mm) from the scribe, as evaluated per ASTM D 1645, Procedure A, Method (scraping); and
         (b) Loss of adhesion from bare metal not to extend more than 1/8 in. (3. mm) from the scribe.
      (2) 1000 hours of humidity testing per ASTM D 4585 using the Cleveland Condensing Type Humidity Cabinet, with no blistering as evaluated per ASTM D 714
      (3) Crosshatch-adhesion testing per ASTM D 3359 Method B, with no loss of finish.
      (4) Certified test abstracts substantiating the above capabilities shall be furnished upon request.
   c. The finish shall be inspected for scuffs and scratches. Blemishes shall be touched up by hand to restore the protective integrity of the finish.
   d. The finish shall be indoor light gray, satisfying the requirements of ANSI

Standard Z55.1 for No. 61.

B. Main Bus: Copper.

2.8 FACTORY FINISHES

A. Finish Color: Factory standard green.

3.1 INSTALLATION

A. Install in accordance with IEEE C37.20.1.

B. Provide required support and attachment in accordance with Section 26 05 29 - Hangers and Supports for Electrical Systems.

C. Install switchgear plumb and level and with each section aligned properly.

D. Make electrical connections between equipment sections using connectors furnished by manufacturer.

3.2 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS. Section 7.1.

3.3 ADJUSTING

A. Adjust protective devices in accordance with recommendations in the coordination study.

B. Provide printout of the final adjustment and submit to the Owner.

3.4 CLOSEOUT ACTIVITIES

A. Demonstrate operation of motor operated devices and switching mechanisms.

- END OF SECTION -

SECTION 26 13 10
MEDIUM-VOLTAGE PAD-MOUNTED SWITCHGEAR

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related work includes but is not limited to,

1. Section 01 33 00 - Submittal Procedures
2. Section 01 60 00 - Product Requirements
3. Section 26 05 13 - Medium-Voltage Cables
4. Section 26 05 26 - Grounding and Bonding for Electrical Systems
5. Section 26 05 43 - Underground Ducts and Raceways for Electrical Systems
6. Section 26 05 73 - Short-Circuit/Coordination Study and Arcflash Hazard Analysis
7. Section 26 12 19 - Pad-Mounted, Medium Voltage Transformers
8. Section 26 18 39 - Medium-Voltage VFD

1.2 SUBMITTAL

A. Product Data: For each type of switchgear and related equipment.

1. Features, accessories, characteristics, and ratings for pad-mounted gear.
2. Time-current characteristic curves for overcurrent protective devices, including fusible devices.

B. Shop Drawings: For medium voltage pad-mounted gear and related equipment.

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show method of field assembly and location and size of each field connection. Include the following:
    a. Outline and general arrangement drawing shown in each assembled section.
    b. Drawing of cable termination compartments showing preferred locations for conduits and indicating space available for cable terminations.
    c. Plan view drawing showing locations for anchor bolts.
        (1) Wiring Diagrams: For medium voltage pad-mounted gear and related equipment, differentiate between manufacturer-installed and field-installed wiring.
            (a) Power, signal, and control wiring.
            (b) Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.

(c) Schematic control diagrams.
(d) Diagrams showing connections of component devices and equipment.
(e) Schematic diagrams showing connections to remote devices.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For pad-mounted gear include in operation and maintenance manuals. In addition to items specified in Division 1 Section "Closeout Procedures," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent device.

1.3 QUALITY ASSURANCE

A. Source Limitations: Obtain medium voltage pad-mounted gear and components through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

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

D. Comply with IEEE C2

E. Installing contractor shall have at least 10 years of documented experience of installation of similar equipment and work required for this project.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver gear and components properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory-fabricated type containers or wrapping for gear and components which protect equipment from damage. Inspect equipment to ensure that no damage has occurred during shipment.

B. Whenever possible, store gear in area where protected from physical damage. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, etc.

C. If stored in areas subjected to weather, cover gear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear.

D. Handle pad-mounted gear with care to prevent physical damage to equipment and

components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which may damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new.

1.5 PROJECT CONDITION

A. Environmental Limitations: Rate equipment for continuous operation ratings for the following conditions:

1. Ambient temperature not exceeding 122 degrees F.
2. Altitude of 4800 feet above sea level.

B. Installation Pathway: Remove and replace building components and site obstructions to provide pathway for moving switchgear into place.

C. Interruption of Existing Utility Service: Do not interrupt utility service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed utility interruptions. Do not proceed with utility interruptions without Owner's written permission.

1.6 COORDINATION

A. Coordinate layout and installation of pad-mounted gear and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

C. Schedule delivery of pad-mounted gear equipment, which permits ready building ingress for large equipment components to their designated installation spaces. Coordinate delivery of equipment with the installation of other building components.

1.7 WARRANTY

A. Provide manufacturer's Warranty that all goods supplied are free from non-conformities in workmanship and materials for 12 months from date of Substantial Completion.

1.8 EXTRA MATERIAL

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Six of each type and rating used. Include spares for future transformers,

control power circuits, and fusible devices.
2. Touchup Paint: Three containers of paint matching enclosure finish, each 0.5 pint.

B. Maintenance Tools: Furnish tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include the following:

1. Fuse-handling tool.

PART 2 PRODUCTS

2.1 MANUFACTURES

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

1. S&C Electric Company, Type PME
2. Equivalent, approved by Owner.

2.2 DESCRIPTION

A. Factory assembled and tested. The pad-mounted gear shall consist of a single self-supporting enclosure, containing interrupter switches and power fuses with the necessary accessory components, and complying with IEEE C37.20.1.

B. Ratings: Suitable for application in 3-phase, 60-Hz, grounded wye system.

C. System Voltage: 12.47 kV nominal; 15 kV maximum.

D. Switch Ratings

1. Line Switches: 600 Amperes
2. Load Switches: 200 Amperes

2.3 PAD-MOUNTED GEAR

A. Description: Factory assembled and tested. The pad-mounted gear shall consist of a single self-supporting enclosure, containing interrupter switches and power fuses with the necessary accessory components, and complying with IEEE C37.20.3. The pad-mounted gear shall feature handle-operated Mini-Rupter Switches for three-pole switching of source circuits. Unit shall be S&C, configurations as shown on drawings.

B. Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.

C. Penta-Latch Mechanism: Provides vandal-resistant three-point door latching. Closing the door releases the charged latch mechanism, automatically latching the door and securing the pentahead actuator. Only after pentahead actuator is secured can a padlock be installed. Protective hood shields the padlock shackle.

D. Circuit Diagram shall provide instant view of circuit configuration. Label shall

indicate all gear and fuse ratings.

E. Interphase and end barriers for all switches and fuses of fiberglass-reinforced polyester.

F. S&C Mini-Rupter Switches furnished with operating handle. Handle folds for storage behind the switch-operating hub cover. Provide surge arrestors on Mini-Rupter Switches.

G. Ground pads on inside at bottom door stile in each compartment, accommodate connectors for attachment of cable concentric-neutral ground leads. Ground studs for fuse terminals, switch terminals, and the ground pad in each compartment.

H. CyPoxy, S&C's cycloaliphatic epoxy resin system, insulated all live parts from ground.

I. Power Fuses: S&C SML-20 power fuses.

1. Indicator: Integral with each fuse to indicate when it has blown.
2. Mounting: Positively held in position with provision for easy removal and replacement from the front without special tools.
3. Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube. Provide silencers on fuses.

2.4 FABRICATION

A. Outdoor Enclosure: Galvanized heavy (11-gauge) sheet steel, weatherproof construction; insulated roof, integral structural-steel base frame, with lifting eyes and factory-applied asphaltic undercoating. All structural joints are welded.

1. Pad-mounted gear shall have the following features:
   a. Structural design and anchorage adequate to resist loads imposed by 125-mph wind.
   b. Segregated circuits: full-length steel barriers separate side-by-side compartments fiberglass-reinforced polyester barriers separate front compartments from rear compartments and isolate the tie bus.
   c. Dual-purpose front barriers of GP03 grade fiberglass-reinforced polyester for all fuses and switches guard against inadvertent contact with live parts when in the normal vertical position. Inserted into the open gap of a fuse or switch, barriers provide isolation from bus and upper contacts.
   d. Storage racks on each fuse compartment door hold up to six SM-4 refill units or three SMU-20 fuse units per rack.
   e. Grappler, S&C fuse handling fitting shall be provided for each fuse within the gear
   f. Doors: Door-edge flanges shall overlap with door-opening flanges, and shall be formed to create a mechanical maze that guards against water entry and discourage tampering or insertion of foreign object, yet, allow for ventilation. Door shall have a minimum of two extruded-aluminum hinges with stainless steel pins. Mounting hardware shall be stainless

steel.

g. Door holders store above door openings, in full view with doors open, behind door when closed.
h. Viewing window for visible verification of switch position.
i. Compartment identification and phase identification labels.
j. Key interlocks, C3 option, shall be provided to prevent opening fuse compartment doors unless all switches are locked open.
k. Base-mounted distribution class surge arresters, metal-oxide type rated 15 kV shall be provided at all source switch terminals.

B. Finish: Manufacturer's standard factory applied enamel with factory standard green over corrosion-resistant pretreatment and compatible standard primer.

2.5 ACCESSORIES

A. Two sets of three (3) grounding jumpers, 3 feet in length, complete with storage bag for each set.

B. One set of three (3) fuse refills, for each fuse type, shall be provided.

C. Provisions shall include, but not limited to, providing additional cable lengths at time of initial installation to provide future interconnecting control-wiring-base spacer, adding future voltage transformers, adding future current transformers."

2.6 IDENTIFICATION

A. Materials: Refer to Division 16 Section "Electrical Identification". Identify units, devices, controls and wiring.

B. Provide Hazard-Alerting Signage on exterior doors, inside of each door, interrupter switch compartments, fuse compartments, and barriers.

2.7 SOURCE QUALITY CONTROL

A. Pad-mounted gear shall be assembled in manufacturer's plant. Before shipment of equipment, perform the following tests and prepare test reports:

1. Production tests on completed pad-mounted gear assembly according to IEEE C37.20.2, Section 5.3.

B. Prepare equipment for shipment.

1. Provide suitable crating, blocking, and supports so equipment will withstand domestic shipping and handling shocks and vibration.
2. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive pad-mounted gear for compliance with requirement for installation tolerances and other conditions affecting performance.

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

3.2 INSTALLATION

A. Handle gear carefully to prevent internal damage, breakage, denting, and scoring of enclosure finish. Do not install damaged equipment. Protect unit from dirt, fumes, water, construction debris and traffic.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, brackets and temporary blocking of moving parts from switchgear units and components.

C. Install on existing concrete pad. Coordinate placement with existing openings in concrete pad

D. Install ground grid and ground rods. Ground pad-mounted gear ground bus and enclosure per manufacturer's recommended practices.

E. Anchor pad-mounted gear per manufacturer’s recommended practices.

F. Tighten bus connections and mechanical fasteners. Do not tighten factory-made connections employing Belleville washers unless they are visibly loose. Refer to manufacturer's installation instructions for proper torque levels.

G. Adjust S&C gear operating mechanism per manufacturer's recommendations

H. Touch-up any areas of the exterior that are marred or damaged during construction.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide signs as specified in Division 16 Section "Electrical Identification."

3.4 CONNECTION

A. Cable terminations at switchgear are specified in Section 26 05 13 - Medium-Voltage Cables.

3.5 FIELD QUALITY CONTROL

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

B. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchgear bus, phase-to-phase and

phase-to-ground for one minute.
2. Test continuity of each circuit.
3. Test integrity of grounding.

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

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS Certify compliance with test parameters.
2. Switchgear: Perform tests and inspections stated in NETA ATS, Section 7.1.
3. Surge Arresters: Perform tests and inspections stated in NETA ATS, Section 7.1
4. Capacitors: Perform tests and inspections stated in NETA ATS, Section 7.20.
5. Schedule tests and notify Architect at least one week advance.
6. Test all electrical and mechanical interlock systems for proper operation and sequencing.
7. Inspect insulators for evidence of physical damage or contaminated surfaces.
8. Inspect for proper barrier and shutter installation and operation.
9. Exercise manually operated and power-operated switches.

3.6 CLEANING

A. On completion of installation, inspect interior and exterior of switchgear. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair damaged finishes.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to demonstrate switchgear and train Owner's maintenance personnel to adjust, operate, and maintain medium-voltage switch. Refer to Division 1 Section "Demonstration and Training."

1. Conduct a minimum of 4 hours, training in operation and maintenance as required under Division 1 Section "Closeout Procedures." Include both classroom training and hands-on equipment operation and maintenance procedures.
2. Schedule training with at least one week of advance notification.

- END OF SECTION -

SECTION 26 18 16
MEDIUM-VOLTAGE FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. The medium voltage fuses shall be general purpose type current limiting. The fuses shall be designed to operate with the fusible switch and shall be tested and rated in accordance with the current ANSI standards.

B. Related work includes but is not limited to,

1. Section 01 33 00 - Submittal Procedures
2. Section 01 60 00 - Product Requirements
3. Section 01 78 50 - Project Closeout
4. Section 26 05 73 - Short-Circuit/Coordination Study and Arcflash Hazard Analysis
5. Section 26 12 19 - Pad-Mounted, Medium Voltage Transformers
6. Section 26 18 39 - Medium-Voltage VFD

1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE)

1. ANSI/IEEE C37.40 through C37.47.

1.3 SUBMITTALS

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

B. Product Data: Provide manufacturer data sheets and catalog pages for all materials and components, including component list, assembly ratings (including short-circuit rating, voltage, continuous current), dimensions, and terminal sizes.

C. Manufacturer’s Instructions: Submit instructions for storage, preparation, and installation of fuses.

1.4 PROJECT CLOSEOUT SUBMITTALS

A. Section 01 78 50 – Project Closeout

B. Manufacturer Operation and Maintenance Data: Submit original manufacturer manuals, installation instructions, and data sheets for products purchased.

C. Record Documentation: Provide accurate as-built record drawings in paper and electronic format.

D. Certificate of Compliance: Provide approval of construction and installation by government authority having jurisdiction.

1.5 QUALIFICATIONS

A. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

B. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installation with similar equipment shall be provided demonstrating compliance with this requirement.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in manufacturer's packaging and inspect for damage.

B. Store and protect in accordance with manufacturer's instructions and in accordance with Section 01 60 00.

C. Protect from weather, dirt and debris. Store in a clean, dry environment. Provide adequate ventilation to prevent condensation.

1.7 SITE CONDITIONS

A. General

1. CONTRACTOR shall make all necessary field measurements to verify that equipment shall fit in allocated space in full compliance with minimum required clearances specified in National Electrical Code.

PART 2 PRODUCTS

2.1 GENERAL

A. Product Description: Provide Fuse Type as required for the fuse holder in the individual equipment.

B. Provide and install fuses for all services shown on the Drawings.

C. Furnish three (3) spare fuses for each switch and store in switchgear cabinet.

D. Ratings (1000 E Well):

1. Fuse Type: 50E, 20E and 10E
2. Nominal System Voltage: 12.47kV
3. Maximum Design Voltage: 15.5 kV
4. Interrupting Rating: 63kA RMS Sym

E. Construction: High purity, graded silica-sand filler with pure silver (0.999 fine)

elements encased in a glass-epoxy casing. Fuses shall fit the various holders as supplied.

F. Manufacturers:

1. Eaton (Cutler-Hammer)
2. Or approved equal.

2.2 FUSE HOLDERS

A. Product Description: Fuse holders as required for fuses specified above.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install fuse holders and fuses in accordance with manufacturer's instructions.

B. Install fuses so fuse information (manufacturer, type, rating) is readable without removing fuse.

C. All necessary hardware required to secure the fuse assemblies in place shall be provided by the CONTRACTOR.

- END OF SECTION -

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SECTION 26 18 39
ADJUSTABLE FREQUENCY DRIVES – MEDIUM VOLTAGE

PART 1 GENERAL

1.1 SCOPE

A. This Specification defines the requirements for Medium Voltage Adjustable Frequency Drive Systems (AFD's) for the variable speed operation of Medium Voltage AC Motors.

B. The Bidder shall prepare the bid to be in complete compliance with this specification. Any exception shall be included in the bid with an explanation, clearly indicating the paragraph of this specification to which the exception applies, and concisely stating the reasons.

C. Unless clearly identified as an exception, this specification shall have precedence where there is conflict between bidder's descriptive information and this specification.

D. The contractor shall furnish all tools, equipment, material, supplies and perform all labor required to install the Medium Voltage Adjustable Frequency Drive system as indicated on the drawings and specified herein in order to install, test and place the AFDs into satisfactory operation.

E. Current source inverter (CSI) drives are not an acceptable technology and will not be allowed.

F. Any conflict between this specification and related codes, standards, datasheets, drawings, requisitions, etc. shall be referred to the purchaser in writing.

G. Related work includes but in snot limited to:

1. Section 26 05 13 - Medium-Voltage Cables
2. Section 26 13 00 - Medium-Voltage Switchgear
3. Section 26 18 16 – Medium-Voltage Fuses
4. Section 26 05 73 - Short-Circuit/Coordination Study/Arc Flash Hazard Analysis

1.2 REFERENCES

A. Institute of Electrical and Electronic Engineers

1. IEEE 519-2022 - Guide for Harmonic Control and Reactive Compensation of Static Power Converters
2. IEEE 1100 – Powering and Grounding Sensitive Electronic Equipment
3. IEEE 399 – Recommended practice for industrial and commercial power systems analysis.
4. IEEE/ANSI C57 – Pad-Mounted Equipment
5. IEEE 995 – Recommended Practice for Efficiency Determination

B. National Electrical Manufacturers Association (NEMA)

1. NEMA ICS 6 – Industrial Control and Systems Enclosures
2. NEMA ICS 7 – Industrial Control Systems Adjustable Speed Drives
3. NEMA MG.1-2009 Section IV Part 31 Performance Standards for Definite Purpose Inverter Fed Polyphase Motors.

C. National Fire Protection Association (NFPA)

1. NFPA 70 – National Electrical Code® (NEC)

D. Underwriters Laboratory

1. UL 347A – Medium Voltage Control Equipment
2. UL 508C – Safety for Power Conversion Equipment

1.3 SUBMITTALS – FOR REVIEW / APPROVAL

A. The buyer shall approve final ship drawings prior to release for manufacturing. These drawings shall be provided for all the equipment included in this specification. The AFD Manufacturer shall provide digital copies of:

1. Dimensional outline and plan arrangement drawings including clearance requirements, foundation details and weights, ratings, protection, controls, diagnostics and operation.
2. Electrical schematics, wiring and interconnection drawings.
3. Heat loss data & typical air flow data for each typical unit.

B. Power Factor

1. The AFD shall maintain a minimum power factor of 100% as measured on the input side of the AFD including transformer while operating across the usable speed range.

C. The bidder shall provide computer estimated harmonic calculations to the 49th harmonic with the bid when requested. The calculations shall show total harmonic voltage and current distortion at the IEEE-designated Point of Common Coupling (PCC). PCC1 is utility transformer. To make accurate computer generated harmonic estimates, the study would require kVA and impedance of transformers, short circuit availability, and other linear and non-linear loads.

D. Warranty details.

1.4 SUBMITTALS – FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:

1. Final as-built drawings and information for items listed in Paragraph 1.3 above, and shall incorporate all changes made during the manufacturing process
2. Wiring diagrams
3. Certified production test reports

4. Installation information, including equipment anchorage provisions
5. Seismic certification as specified
6. Descriptive bulletins
7. Product sheets
8. Computer Generated Harmonic Estimation Analysis.

1.5 QUALIFICATIONS

A. All equipment furnished under this section shall be warranted by the installing contractor and the equipment manufacturer(s) for a minimum period of 36 months after shipment. Manufacturer shall offer an extended warranty of 5 years, which includes parts and labor. This extended warranty is to be offered at time of purchase during the first 12 months of warranty period to extend the 3 year warranty to 5 years. Any warranty past 3 years requires a PM on the AFD at the end of year 3.

B. The AFD manufacturer shall have ISO 9001 certification.

C. The AFD manufacturer shall be able to provide start-up service, 24-hour/day emergency call service, repair work, and maintenance and troubleshooting training of customer personnel.

D. The supplier of the AFD and assembly shall be the manufacturer of the electromechanical power components used within the assembly, such as bypass contactors when specified.

E. The supplier of this equipment shall have produced similar electrical equipment for a minimum period of ten (10) years and installed at least one hundred (100) medium-voltage AFD's. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

F. Vendor shall have also demonstrated installed systems which are similar in design, construction, voltage rating, power rating, speed range and torque range.

G. Adjustable Frequency Drives shall be on the basis of TMEIC Tmdrive-MVe2 for function and quality. Products that are in compliance with the specification and manufactured by others will be considered as "Approved Equal" only if pre-approved by the Engineer fourteen (14) days prior to bid date. Alternate suppliers shall submit documentation showing itemized compliance to the specifications and experience specific to the proposed AFD including a list showing details of the installation, application, location, contact name and telephone number of at least five (5) users.

H. Provide Seismic tested equipment as follows:

1. The medium voltage AFDs and accessories shall be designed, constructed and installed suitable for earthquake regulations in accordance with the seismic requirements of the Uniform Building Code for Zone * (* = refer to UBC Zone Map for specific job site location). The following test data must be provided for the medium voltage drive equipment being provided:
   a. SDS: Design spectral response acceleration at short period, as

determined in Section 1613.5.4 of the IBC

b. z/h: Height factor ratio. For nonstructural components located at grade or below, z/h= 0
c. Ip: Component importance factor, as set forth in Section 13.1.3 of ASCE 7
d. Aflx-h: Horizontal spectral acceleration calculated for flexible components
e. Arig-h: Horizontal spectral acceleration calculated for rigid components
f. Aflx-v: Vertical spectral acceleration calculated for flexible components at z/h = 0
g. Arig-v: Vertical spectral acceleration calculated for rigid components at z/h = 0

2. The medium voltage AFD must have “Office of Statewide Health Planning and Development” (OSHPD) seismic certification where required.

1.6 VENDOR QUALIFICATIONS

A. Vendors shall have a minimum of two fully trained and factory authorized startup and field service engineers within 100 miles of the job site (Salt Lake City Utah). Submittal information shall include the locations of the factory-authorized field service engineers.

B. In addition, the factory shall have a minimum of 20 factory-authorized field service engineers in the United States to provide backup support, if required.

C. Vendor shall have 24/7/365 factory tech support.

1.7 VENDOR RESPONSIBILITY

A. Assumptions to cover lack of information are not allowed. The vendor is obliged to obtain reliable information of the motor, driven equipment speed-torque profile and power delivery system data from the purchaser or other sources.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. TMIEC/TMdrive-MVe2

B. Or Approved Equal

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer fourteen (14) days prior to bid date.

2.2 SYSTEM DESCRIPTION

A. The Adjustable Frequency Drive shall consist of the following main components: fused isolation switch, isolation contactor, drive isolation/phase shifting transformers with

minimum 24-pulse rectification, DC bus pre-charge circuit, 9-level (zero to peak) Medium Voltage IGBT inverter. All above items are to be integrated in one AFD enclosure not to exceed 185" W x 64” D x 111” H, except for the fused isolation switch and isolation contactor, which shall be mounted outside in a NEMA 3R enclosure.

B. Filters on either the input or output of the AFD, used to meet the performance requirements of this specification, will not be allowed.

C. Regardless of technology used, all AFD proposals shall include an isolation transformer. AFD proposals not including isolation transformers will not be acceptable under this specification.

D. The supplier of the AFD shall also supply line side fuses, switches, contactors, and circuit breakers where specified and shall take full responsibility for integration of AFD power and control circuitry with this equipment.

E. The integrated dedicated fused contactor with isolation switch will be rated to protect the AFD from specified short-circuit levels. The input contactor controls shall be integrated with the AFD to operate as specified by the AFD manufacturer to close by AFD command and to open under conditions of AFD derangement. The AFD enclosure doors shall be key-interlocked to prevent opening when main power is available.

F. The AFD enclosure shall be suitable for installation in an indoor, and unclassified area.

G. DC bus capacitor charging is accomplished by use of a DC bus pre-charge circuit. The DC bus capacitors are charged before application of main power, which limits the very high damaging inrush currents to the main rectifier/converter bridge devices. When the proper DC bus voltage is attained, the pre-charge circuit is turned off.

H. The AFD shall meet the requirements of IEEE 519-2022 with the Point of Analysis (POA) at the input terminals of the AFD. The point of common coupling shall be located at the utility. The harmonic current distortion shall not exceed the limits listed in table 10.3 of IEEE 519 - 2022 at the POA. The harmonic voltage distortion shall not exceed the limits listed in table 11.1 of IEEE 519-2022 at the POA. Total Harmonic Current Distortion of the AFT shall not exceed 5% of the rated FLA of the AFD.

I. Drive shall operate with a +/-10 % input voltage variation.

J. Auxiliary power 480V, 3-phase, 50/60 Hz shall be provided external to the integrated Drive to power the cooling fans. Control power 120V, 1-phase shall be provided external to the integrated Drive to provide control power for convenience receptacles. In addition, power for the motor space heaters shall be supplied to the Drive as specified. The Drive shall provide control to turn the heaters on when the Drive is not running and off when the Drive is running.

K. The AFD shall be air cooled. The AFD blower fan motors shall be protected by an input circuit breaker located in the AFD. Metal squirrel cage ball bearing 460 VAC three-phase fan motors with 7-year design life shall be used in the Drive design. Plastic muffin fans are not acceptable.

L. The AFD shall be provided with redundant cooling fans. Redundancy shall apply to each and every cooling fan used in the AFD. Controls in the AFD shall automatically operate redundant fans as necessary to ensure that cooling fan failure does not interrupt AFD operation.

M. The drive shall receive 12.47 kV, 3-phase and control the motor rated 4,160V, 3-phase, 60 Hz, 700 HP.

N. For variable torque applications the overload capacity shall be 110% of rated current for 1 minute repeated every 10 minutes. For constant torque applications the overload capacity shall be 150% of rated current for 1 minute repeated every 10 minutes.

O. The AFD shall be suitable for use with a new or an existing standard squirrel cage motor and standard medium-voltage insulation. For new motor installations, the motor shall be designated inverter-duty (NEMA MG.1-2009 Section IV Part 31).

P. The AFD shall be rated to operate the 700 HP motor at full load in an ambient temperature of 50 deg C.

Q. All enclosure openings exceeding 0.25 inch (6 mm) width shall be provided with screens to prevent the entrance of snakes, rodents, etc. the maximum screen mesh opening width shall be 0-.25 inch (6 mm).

2.3 INVERTER DESIGN

A. The AFD inverter shall be of the pulse width modulated (PWM) type.

B. The output of the AFD inverter shall have at least 9 levels from zero to peak or 17 levels from peak to peak, at 4,160 V.

C. The AFD frequency output accuracy shall be within plus/minus 5% of any given set point between 5-100% of the control range.

D. If the external speed reference signal goes out of range or is lost, the AFD shall be capable of selectively defaulting to coast to stop, deceleration stop, or the operating speed prior to the loss of signal.

E. The AFD shall have three programmable skip speeds between 0-100% and shall be provided with critical speed avoidance circuitry.

F. The output of the inverter shall produce harmonic current of not more than 3% over a speed range of 50% to 100% regardless of load.

2.4 INTEGRATED INPUT ISOLATION TRANSFORMER AND RECTIFIER

A. The AFD shall contain an incoming dry-type isolation transformer whose primary voltage shall be as specified. The transformer shall be a rectifier grade isolation transformer designed with the appropriate K rating for the type of drive.

B. The transformer impedance shall be selected to limit available fault current to a value that is safe for the converter components and reducing the arc-flash exposure. Typically, a 7-1/2% impedance transformer is required.

C. The transformer and rectifier shall be an integral part of the AFD assembly along with a primary disconnect switch, input vacuum contactor and secondary fusing eliminating the need for separate components, field installation, or wiring.

2.5 RELIABILITY

A. Importance is given for trouble free operation, reliability and availability of the equipment.

B. The manufacturer shall list any control or power components that require recommended maintenance or replacement before 50,000 hours of operation. Information must be available in the manufacturer's maintenance manual and available for submittal.

C. All components of the AFD will be included in the overall calculation for Mean Time Between Failure using Failure In Time (FIT) Analysis.

D. The published Mean Time Between Failure (MTBF) of the current carrying devices of the AFD shall be at least 16 years.

E. Following any momentary dip of the input voltage supply, auxiliary voltage supply, or both, the drive shall be able to operate up to 300 ms and regain control once main power is established (flying restart).

2.6 INPUT POWER QUALITY

A. The AFD shall comply with the latest edition of IEEE 519-2022.

B. The AFD total harmonic voltage distortion (THD) contribution at each point of common coupling between the drives and other loads within the facility (Load PCC) shall not exceed the 5% THD limit recommended for General Systems as listed in Table 10.3 of IEEE 519-2022, throughout the speed range.

C. True power factor at the input of the drive shall be unity (1.0) over 30-100% speed range without the use of any line-side filters.

D. The AFD shall be able to inject leading VAR’s back to the utility system for the remaining capacity that is not used for motoring.

2.7 OUTPUT POWER QUALITY

A. Output waveform switching transients and harmonic content shall have a negligible contribution to motor heating, acoustical noise in the motor, torsional stress in the power train, and motor insulation.

B. Common mode voltages on the AFD output shall be isolated from the motor.

C. Motor cable voltage reflections and the resulting restrictions on motor cable length shall be taken into consideration and the AFD shall properly be applied to the motor.

D. On new installations, the AFD shall be compatible with motors manufactured in accordance with NEMA MG1.Section IV Part 31Definite Purpose Inverter Fed Polyphase Motors. For installations involving motors not in compliance with NEMA standards for Inverter Fed motors, the AFD manufacturer shall assure that the AFD protects the motor insulation from voltage excursions in excess of the insulation rating.

E. For input voltages within the range 90 percent and 110 percent of rated voltage, the AFD shall be capable of developing the following percentage of the motor base frequency rated torque:

1. 100 percent of rated motor torque continuously at any speed below base frequency
2. 120 percent of rated motor torque at any speed for at least 60 seconds.
3. The input transformers, filters, converter, and other components of the AFD shall be rated to supply the current requirements for the above operations without damage.

F. The output of the AFD inverter shall have at least 9 levels (4160V) from zero to peak or 17 levels (4160V) from peak to peak.

G. The AFD frequency output accuracy shall be within +/- 0.5 percent of any given set point between 5 - 100% of the control range.

H. If the external speed reference signal goes out of range or is lost, the AFD shall be capable of selectively defaulting to:

1. Coast to stop
2. Deceleration stop
3. The operating speed prior to the loss of signal

2.8 CONTROL FUNCTIONS

A. A door-mounted drive backlit LCD keypad shall be included as standard, mounted on the AFD enclosure and used as the standard operator interface.

B. The keypad shall include a local/remote pushbutton selection. Both start/stop source and speed reference shall be independently programmable for the keypad, remote I/O or communications interface as specified.

C. The operator keypad shall be used to read and write parameter data, to present operational information, to produce first fault and device indication, to show alarms, to allow metering of parameters, and to provide Ethernet connectivity to the drive software programming tool on the Buyer’s PC.

D. The operator keypad shall include at least four levels of security.

E. Digital communications shall be Modbus RTU and ethernet.

F. The AFD shall include a comprehensive microprocessor based digital diagnostic system that monitors its own control functions and displays faults and operating conditions. Microprocessor systems must be products of the same manufacturer as the AFD.

G. A Remote Diagnostics Module or an on-board computer shall be provided that can be accessed internally via the Owner or the AFD supplier to remote troubleshooting.

H. A copy of the AFD software shall be provided that will give the owner full access to the drive parameters, configuration, trending, fault data, etc.

I. A fault log shall record, store, display and print upon demand, the following for the 100 most recent events: time stamp with day and day of fault occurrence and type of fault.

J. The following setups and adjustments, at a minimum, are to be available:

1. Start/Stop command from keypad, remote or communications port
2. Speed command from keypad, remote or communications port
3. Motor direction selection
4. Maximum and minimum speed limits
5. Acceleration and deceleration times, two settable ranges
6. Critical (skip) frequency avoidance
7. Torque limit
8. Multiple attempt restart function
9. Multiple preset speeds adjustment
10. Catch a spinning motor start or normal start selection
11. Programmable analog output
12. DC brake current magnitude and time
13. PID process controller.

2.9 THE AFD SHALL HAVE THE FOLLOWING SYSTEM INTERFACES:

A. Inputs — The AFD shall include as a minimum:

1. Remote Start/Stop
2. Remote fault reset
3. Process control speed reference interface, 4-20mA dc
4. RS232 programming and operation interface port via Serial communications port
5. Interface with specified communication protocols, including ModBus RTU, BACnet, Ethernet IP, Profibus DP, LonWorks, CanOpen, DeviceNet, ModBus TCP, and Johnson Controls N2.

B. Outputs - A minimum of two (2) programmable relay outputs, and one (1) programmable analog output shall be provided, with the following available at minimum:

1. Programmable relay outputs with one (1) set of Form C contacts for each,

selectable with the following available at minimum:
a. Fault
b. Run
c. Ready
d. Reversed
e. Jogging
f. At speed
g. Torque Limit Supervision
h. Motor rotation direction opposite of commanded
i. Over-temperature.

2. Programmable analog output signal, selectable with the following available at minimum:
a. Motor current
b. Output frequency
c. Frequency reference
d. Motor speed
e. Motor torque
f. Motor power
g. Motor voltage
h. DC-bus voltage
i. Analog Output 1 to match Analog Input 1
j. Analog Output 2 to match Analog Input 2
k. PT100 temperature
l. Jog Speed.

2.10 ALARMS

A. Comprehensive alarm and trip indications shall be provided:

1. The alarm or fault diagnostics shall have a “first out” or “sequence of events” memory function that identifies the cause of any malfunction.
2. The alarm shall provide sufficiently detailed information to enable personnel familiar with the equipment to troubleshoot the AFD.

2.11 CONTROL POWER

A. 480 VAC, 3-phase power for the cooling fans shall be provided by the owner.

B. 120 VAC, single-phase control power for the AFD shall be provided by the owner.

2.12 INPUT ISOLATION SWITCHGEAR

A. The AFD shall work in conjunction with an external fused disconnect and contactor. The AFD shall de-energize the contactor and subsequent AFD in the event of an abnormal AFD condition.

B. The external fused disconnect and contactor shall be provided by the AFD supplier.

2.13 INTEGRATED DRIVE ISOLATION TRANSFORMER

A. A drive isolation transformer shall be integrated in the AFD enclosure to provide power conversion from the line voltage to the required AFD voltage and to isolate the line from harmonics and common mode voltages.

B. The transformer shall be designed to withstand a short circuit. It shall maintain electromagnetic symmetry when only one secondary winding is in short circuit in order to minimize the resulting short circuit forces. The transformer shall be capable of thermally withstanding a short circuit for 2 seconds.

C. Transformers shall be of a high efficiency type with full load losses of no greater than 2%.

D. Transformer design shall be open type, air-cooled, and forced ventilated.

E. Only rectifier grade K-factor transformers shall be utilized, with K-rating for the type of the drive.

F. A minimum of one (1) temperature detector shall be provided.

G. Transformers shall be capable of continuously carrying current corresponding to the rated direct current of the converter while operating at a maximum design operating temperature, without exceeding the rated thermal limit of the transformer.

H. The supplied input isolation transformer shall include distribution class surge arresters.

2.14 HARMONIC FILTERS AND POWER FACTOR CORRECTION

A. Harmonic filters shall not be used to compensate for AFD performance not in accordance with this specification.

B. Power factor correction shall not be required to maintain the specified 100% true power factor from 30% to 100% speed.

2.15 EFFICIENCY AND NOISE LEVEL

A. Overall efficiency of the AFD shall include the drive isolation transformer, AFD and all AFD auxiliaries, power factor correction and harmonic filter.

B. AFD system efficiency calculations shall be in accordance with IEEE 995.

C. The overall efficiency shall be greater than 96% at full load, full speed.

D. AFD noise level shall be no greater than 80dB(A) in front of the door panel. AFD's with higher than 80dB(A) will not be acceptable.

2.16 MOTOR PROTECTION RELAYS

A. RTD Module and Display accepting up to 12 channel inputs (3 wire 100 ohm platinum RTD's (PT100)) and 3 relay outputs, and shall provide an RS485 output.

B. The RTD Module shall be a Minco CT224 or approved equal.

C. The ASD shall be supplied with motor protection against overload, stall, locked rotor, single-phasing, phase and ground faults, and internal motor fault.

2.17 AUXILIARY DEVICES

A. For stand-alone AFD's, provide fixed mounted potential transformers.

B. Provide current transformers of the quantity and current rating as required by the application.

C. Provide an auxiliary control power transformer of the quantity and kVA rating as indicated on the contract drawings.

D. Over-voltage protection devices shall be provided for AFD power circuits, auxiliary circuits, motor and motor cable, input transformers, DC reactors and motor.

E. One pair of fail-safe contacts (one open and one closed) shall be provided that change state for conditions that could lead to damage of the AFD system or driven equipment, for use with eternal control or external trip circuits.

F. Relays which trip the AFD for fault conditions shall have a manual-reset lockout feature. The trip information shall be memorized, and this memory will not be lost if the AFD system is isolated or de-energized.

G. Over-speed protection shall immediately shut down the AFD if the frequency exceeds 105 percent of input set point or exceeds a preset maximum speed limit. Response time of the overspeed protection system shall prevent any damage to the motor or to the driven machine.

2.18 ENVIRONMENTAL CONDITIONS

A. The AFD shall operate in an ambient temperature range of 0° C to 50° C (32° F to 122° F) with a relative humidity of up to 95% (non-condensing), unless specified otherwise.

B. The equipment shall be capable of being stored in an environment with an ambient temperature range of -40° C to 70° C.

C. The equipment shall operate at altitudes from 0 to 1000m (3,300 ft.) above sea level, without de-rating. For applications above 1000m, the maximum ambient temperature and Basic Impulse Levels (BIL) of the controllers shall be de-rated as necessary, and vacuum contactors shall be compensated for operation at the specified altitude. Derating shall not prevent the AFD from operating the motor at full load, at site elevation (Orem, Utah), at 50-Deg C.

2.19 ENCLOSURES

A. Indoor enclosures shall be NEMA 1A with gasketing and filters.

B. All components of the AFD shall be front accessible only.

C. The AFD Converter enclosure doors shall include an electromechanical “kirk-key” type interlocking system including matching kirk-key on the outdoor fused switch. Access to any power section within th AFD will require opening the fused switch and removing the kirk-key.

D. All painted surfaces shall have an exterior finish of ANSI 61 Gray.

E. The AFD enclosure shall be as per UL 347A standards suitable for installation in an indoor, unclassified area.

F. All enclosure openings exceeding 0.25 inch (6 mm) in width shall be provided with screens to prevent the entrance of snakes, rodents, etc. The maximum screen mesh opening width shall be 0.25 inch (6 mm).

G. Air filters shall be of a reusable type that can be easily cleaned. All doors or front panels will be fully gasketed. Air exhaust from cooling fans will be at the top of the enclosure and direct exhaust airflow away from personnel. Provide redundant cooling fans.

1. The air filters shall be a reusable type that can be easily cleaned while the drive is in operation.

2.20 COOLING

A. A “loss of cooling” fault shutdown shall be furnished with force-cooled equipment. In the event of clogged filters or fan failure, the drive will shut down safely without electronic component failure.

B. Fan motors shall be protected by an input circuit breaker. Metal squirrel cage ball bearing low voltage three phase fan motors with 7-year design life are to be used in the drive design. Plastic muffin fans are not acceptable. Fan power shall be provided from the primary power source through a 480V, 3-phase, 60 Hz external power supply. Convection cooling in the case of fault or main contactor opening is unacceptable as a method to insure proper cooling of the drive.

C. The AFD shall have adequate fans internal to insure proper operation in the above referenced ambient. When specified, the AFD shall be capable of adding a redundant fan to insure operation in the event of primary fan failure.

2.21 SPACE HEATERS

A. AFD Enclosure Space Heaters

1. When specified, space heaters shall be supplied.
2. The space heater circuit shall turn on automatically when the drive is not operating.
3. A fused switch or circuit breaker for space heater circuit shall be provided for

overload protection and as a disconnecting means.

4. When specified, a meter and a test circuit shall be provided on the enclosure door for indication that space heater power is available.
5. Space heater elements shall be rated 240 Vac and operated at 120 Vac, single-phase.

2.22 NAMEPLATES, MARKING AND LABELING

A. Nameplates shall be 2-inch high x 2-1/2 inch wide, laminated white with black lettering core.

B. Unit nameplate and device marker lettering shall be 3/16-inch high.

C. Warning labels shall be provided to advise the proximity of live components.

D. Rating labels shall be installed to each main item of a AFD system, citing the equipment's rating and relationship to other equipment.

E. Equipment labeling shall clearly identify the following according to schematic and wiring diagrams:

1. All terminals
2. Removable links
3. Fuses, control and indication devices
4. Identifiable components
5. Internal wiring.

F. Labels shall also be provided to indicate major parts replacements (like fans, fuses, filters) and also bolting torque standards.

G. Meters, relays, switches and other devices within the AFD shall be permanently identified using the same name as those appearing on the schematic diagrams.

H. All bolts shall have torque marks before drive shipment.

2.23 WIRING AND TERMINATIONS

A. Bus bar with standard NEMA four-hole pattern shall be supplied fo input and output connection of external wiring and shall be conveniently located, clearly numbered and identified.

B. Control wire terminal blocks for external wiring terminations shall be insertion type, designed to accommodate stripped insulation bare wire ends, and shall accept only one No. 16 AWG wires.

C. Connection points for inputs and outputs of different voltage levels shall be segregated to reduce possibility of electrical noise.

D. Where wiring is run through sheet metal or any barrier, bushings, grommets, protection around the sheet or barrier opening shall be provided.

E. All internal wiring shall be terminated with no more than two (2) conductors per terminal point.

F. The AFD shall have an internal mechanical ground connection suitable for terminating a stranded copper ground conductor of the same size as the incoming phase conductors.

G. Ground bus-bar connections shall be near the incoming and outgoing power cable termination points and control wiring connections.

H. Enclosure shall be designed to accommodate power cable entry from either top or bottom.

I. Minimum wire bending space shall meet or exceed the value shown in NEC Table 430-10(b) for termination of the power cable.

2.24 FINISH

A. The finish for internal and external parts shall consist of a coat of ANSI 61 (gray) thermosetting, polyester, powder paint applied electrostatically to pre-cleaned phosphatized steel and aluminum surfaces.

2.25 ACCESSORIES

A. If specified, provide a portable lifting device for transporting contactor outside its compartment.

PART 3 EXECUTION

3.1 FACTORY TESTING

A. The AFD System shall undergo standard manufacturing testing.

B. Each AFD shall be factory load tested with an induction motor on a dynamometer or M-G test stand for a minimum of 8 hours at rated ambient temperature (40-deg C standard) and rated load with AFD system at full voltage. Resistive or Inductive load-bank testing shall not be acceptable.

1. Constant torque AFD's shall be tested at 100% rated load for 9 minutes, 150% rated load for 1 minute. This cycle will continue throughout the 8-hour test.
2. Variable torque AFD's shall be tested at 100% rated load for 9 minutes, 110% rated load for 1 minute. This cycle will continue throughout the 8-hour test.

C. The manufacturer shall provide three (3) certified copies of factory test reports.

D. If required, factory tests as outlined above shall be witnessed by the owner's representative. The manufacturer shall notify the owner two (2) weeks prior to the date the tests are to be performed.

3.2 FIELD QUALITY CONTROL

A. If required, the Supplier and User shall schedule an on-site meeting to cover the following:

1. The start-up and commissioning plan
2. The start-up and commissioning schedule
3. The AFD's installation requirements.

B. The AFD Manufacturer shall provide the services of a manufacturer's employed field service engineer for the start-up of the AFD after it is installed according to the manufacturer's recommendations. Functional testing, commissioning and first parameter adjusting is carried out by the manufacturer's employed field service engineer. (No third-party representatives will be permitted).

C. Testing, final parameter adjustment and performance tests are carried out by the manufacturer's employed field service engineer with the customer present.

D. After commissioning, the manufacturer's employed field service engineer shall review the customer's operating procedures and provide (2) two hours of basic hands-on maintenance and operation training to the customer's personnel.

E. Typical commissioning will be at (3) consecutive eight-hour man-days per AFD. Rate schedule for commissioning, travel to the jobsite and living expenses during the period of work shall be included with the bid proposal.

F. Microsoft Windows™ based software shall be provided for AFD commissioning, parameter setup, fault log viewing, diagnostic analysis, and monitoring and control. The software shall provide real time graphical displays of AFD performance.

G. The Contractor shall provide three (3) copies of the manufacturer's field startup report.

H. The AFD manufacturer shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

I. The Contractor shall provide three (3) copies of the manufacturer's representative's certification.

3.3 TRAINING

A. If requested, the manufacturer shall provide a training session for five (5) owner representative(s) for one normal workday at a job site location determined by the owner.

B. The training session shall be conducted by the manufacturer (no third-party representatives will be permitted) and include instruction on assembly, starters, and other major components.

3.4 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

3.5 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component.

3.6 INSTALLATION

A. The Contractor shall install all equipment per the manufacturer's recommendations and the contract drawings.

B. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

C. Check all bolted connections to assure that they are in accordance with the manufacturer's recommended torque requirements.

3.7 FIELD ADJUSTMENTS

A. If included with AFD, the motor protective relay will be programmed in accordance with the recommendations documented by the coordination study in Section 16011 and as directed by the owner or owner's representative. If settings are not provided by owner, the motor protection relay will be set to minimum values.

B. AFD parameters shall be programmed to owner or owner representative provided settings.

C. If RTD Module is included with the AFD, program Module settings as determined by owner or owner's representative.

3.8 FIELD TESTING

A. Vendor shall provide a detailed commissioning procedure / check-list for review and approval prior to shipping the equipment to site.

B. Field testing by a manufacturer employed and trained Engineering Services Field Service Engineer will include the following as a minimum:

1. Sight Inspection
2. Power-Off Checklist
3. Power Up (Control Assembly only) checklist
4. Full Voltage Main Power-Up No Load Testing
5. Full Load Testing.

3.9 MAINTENANCE / WARRANTY SERVICE

A. Warranty to commence 24 months from the date of commissioning by manufacturer, not to exceed 30 months from the date of shipment, and include all parts, labor, and travel time.

B. Spare Parts

1. The AFD manufacturer shall provide a complete list of spare parts for the AFD.
2. The AFD manufacturer shall provide local support for renewal parts and stock spares.
3. As a minimum, the AFD manufacturer shall include these spare parts as part of the bid:
   a. 100% spares of each type of medium voltage fuse.
   b. 100% spares of each type of low voltage fuse.
   c. Special tools for testing or maintaining equipment.

   All spare parts shall be properly marked and packaged for long-term storage. All printed circuit boards shall be provided in separate anti-static containers.

- END OF SECTION -

SECTION 26 29 23
VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.1 SUMMARY

A. Section includes enclosed variable frequency controllers.

1.2 RELATED WORK

A. Related Work specified in other Sections:

1. Section 01 33 00 Submittal Procedures
2. Section 01 75 50 Project Closeout
3. Section 26 06 05 Electrical Equipment
4. Section 26 05 13 Conductors and Cables

1.3 REFERENCES

A. IEEE C62.41 (Institute of Electrical and Electronics Engineers) - Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

B. NEMA FU 1 (National Electrical Manufacturers Association) - Fuses.

C. NEMA ICS 3.1 (National Electrical Manufacturers Association) - Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems.

D. NEMA ICS 7 (National Electrical Manufacturers Association) - Industrial Control and Systems:

1. Adjustable Speed Drives.

E. NEMA 250 (National Electrical Manufacturers Association) - Enclosures for Electrical Equipment (1000 Volts Maximum).

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

1.4 SUBMITTALS

A. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.

B. Product Data: Submit catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings dimensions, and enclosure details.

C. Test Reports: Indicate field test and inspection procedures and test results.

D. Manufacturers Field Reports: Indicate start-up inspection findings.

E. Five copies, plus the number of copies the CONTRACTOR wishes returned, shall be submitted to the ENGINEER for approval.

F. Manufacturer's warranty.

1.5 SUBMITTED AT SHIPMENT

A. Include system manuals, complete with wiring diagrams, schematics, operating, and maintenance instructions, shall be provided with the VFD and VFD systems at the time of shipment, on both hard and digital copies.

1.6 CLOSEOUT SUBMITTALS

A. Section 01 78 50 - Project Closeout.

B. Operation and Maintenance Data: Submit instructions complying with NEMA ICS 3.1. Include procedures for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions. Include routine preventive maintenance schedule.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years experience and service facilities within 100 miles of the project.

1.8 STANDARDS

A. The VFD shall be UL listed and not require external fuses except where input power is supplied from multiple transformer secondaries.

B. All VFD and VFD systems shall be designed in accordance with applicable portions of NEMA standards, and panel build ups manufactured by a UL508 listed manufacturer.

C. The VFD shall be compatible with the installation requirements of interpretive codes such as National Electrical Code (NEC) and Occupational Safety & Health Act (OSHA).

D. The VFD shall be capable of operating in compliance with IEEE 519-2022.

E. The VFD shall meet IEC 612 00-2 for vibration levels.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to components, enclosure, and finish.

1.10 ENVIRONMENTAL REQUIREMENTS

A. Section 26 05 00 - Electrical General Requirements.

B. Conform to NEMA ICS 7 service conditions during and after installation of variable frequency controllers.

1.11 WARRANTY

A. Equipment furnished under this Section shall be guaranteed against defective parts and workmanship for 1 year from date of Final Acceptance of the system and shall include labor and travel time for necessary repairs at the job site.

B. The manufacturer shall provide the service of a factory-trained service representative to verify the correctness of the CONTRACTOR’s completed installation; to check all electronic circuitry and mechanical components to assure their proper function; and to make all necessary measurements in and around the unit to ensure proper operation. A minimum of 1-day startup service shall be provided. The manufacturer shall provide through the CONTRACTOR to OWNER a written certification that the installation is complete, correct and properly calibrated.

1.12 MAINTENANCE SERVICE

A. Provide service and maintenance of variable frequency controller for one year from Date of Final Acceptance.

1.13 MAINTENANCE MATERIALS

A. Supply two of each air filter.

B. Provide three of each fuse size and type.

PART 2 PRODUCTS

2.1 VARIABLE FREQUENCY CONTROLLER

A. Manufacturers:

1. Allen-Bradley
2. Gault
3. Mitsubishi

5. Square D, Altivar Process 630 Drive
6. WEG
7. No Equals

B. Product Description: NEMA ICS 7, enclosed 6 pulse variable frequency controller suitable for operating the indicated loads. Select unspecified features and options in accordance with NEMA ICS 3.1.

2.2 RATINGS

A. Rated Input Voltage: 480 Volts, three phase, 60 Hertz. The VFD shall be able to withstand voltage variations of -15% to +10% without tripping or affecting VFD performance.

B. Motor Nameplate Voltage: 460 Volts, three phase 60 Hertz.

C. Motor Nameplate Horse power: 300 horsepower design B.

D. Displacement Power Factor: Between 1.0 and 0.95 lagging over entire range of operating speed and load.

E. Operating Ambient: 0 degrees C to 50 degrees C.

F. Relative Humidity: 5 to 95 percent non-condensing.

G. Minimum Efficiency at Full Load: 96 percent.

H. Elevation: The VFD shall be suitable for operations up to 4,700 feet.

2.3 DESIGN FEATURES

A. Employ microprocessor-based inverter logic isolated from power circuits.

B. Employ pulse-width-modulated inverter system.

C. Design for ability to operate controller with motor disconnected from output.

D. Design to attempt five automatic restarts following fault condition before locking out and requiring manual restart.

E. The VFD shall be capable of 4 different acceleration and different deceleration rates, each rate independently adjustable from 0.01 to 3600 seconds. Selectable accel/decel patterns to include linear, S-curve, and non-linear for variable torque loads.

F. The VFD shall have the capability of determining motor characteristics to optimize its operation with the use of pre-programmed motor data information or self-tuning operation. Self-tuning is to be available with or without the motor coupled to the load. Tuning shall also include an online mode that automatically and dynamically compensates the VFD regulator for changes in motor temperature.

2.4 INDICATORS AND MANUAL CONTROLS

A. Input Signal: 4 - 20 mA DC.

B. Display:

1. Provide integral LCD display to indicate output voltage, output frequency, output current, fault codes and drive status.
2. Upon a fault condition, the LCD shall display VFD output current, voltage, frequency, torque, DC link voltage, operating hours, I/O terminal status, and temperature at the time of fault. The last four (4) faults will be stored in memory and selectively be displayed on the LCD.

C. Indicator Lights:

1. Provide an indicator light to indicate VFD failure.

D. The drive shall have a built-in keypad that is installed on the outside cover and shall include Forward/Reverse/Stop/Jog keys, Drive reset key and Reference increment/decrement keys.

E. Volts Per Hertz Adjustment: Plus or minus 10 percent.

F. Current Limit Adjustment: 60 - 110 percent of rated.

G. Acceleration Rate Adjustment: 0.5 - 30 seconds.

H. Deceleration Rate Adjustment: 1 - 30 seconds.

I. HAND-OFF -AUTOMATIC selector switch and manual speed control.

J. Control Power Source: Integral control transformer.

2.5 SAFETIES AND INTERLOCKS

A. Includes undervoltage release.

B. Door Interlocks: Mechanical means to prevent opening of equipment with power connected, or to disconnect power if door is opened; include means for defeating interlock by qualified persons.

C. Safety Interlocks: Terminals for remote contact to inhibit starting under both manual and automatic mode.

D. Control Interlocks: Furnish terminals for remote contact to allow starting in automatic mode.

E. The VFD shall be able to automatically reset up to ten (10) times after over-current, over-voltage, overheating, and overload faults. Reset attempts and reset intervals

must be programmable.

F. Disconnecting Means: Integral circuit breaker on the line side of each controller.

2.6 VFD INPUT/OUTPUT PARAMETERS

A. The VFD shall accept and follow a selectable external frequency reference of either analog 0-5 VDC, 0-10 VDC, 4-20m A with signal inversion.

B. The VFD shall maintain the output frequency to within 0.2% of reference when the reference is analog, and to within .01% of reference when the reference is digital (Speed level inputs from keypad, contact closure, digital interface, or serial communication).

C. The VFD shall have a reference filter to reduce noise in the analog signals and a low noise control power supply system.

D. The VFD shall accept inputs from external dry contacts for the following functions:

1. Run forward command
2. Run reverse command
3. Multi-step frequency selection
4. Acceleration/Deceleration time selection
5. Stop command
6. Coast to stop command
7. Alarm reset
8. Trip command (external fault)
9. Jogging operation
10. Frequency reference selection (2)
11. DC brake command
12. Torque limits (2)
13. Switching operation between line and inverter (50 and 60 Hz)
14. Speed Increase command
15. Speed Decrease command
16. Write enable for keypad
17. PID control cancel
18. Inverse mode changeover
19. Interlock signal
20. Serial communications enable
21. Universal DI
22. Pick up start mode
23. Forced stop command
24. Forced stop command with Deceleration time

E. The frequency reference shall be from, selectively, an external speed potentiometer, external analog signals (0-5 VDC, 0-10 VDC, 4 to 20mA with signal inversion), from the built in keypad, or from serial communication.

1. The VFD shall provide five selectable digital outputs indicating the following:
   a. Inverter running

b. Frequency equivalence signal
c. Frequency level detection
d. Torque polarity
e. Torque limiting
f. Auto-restarting
g. Overload early warning
h. Keypad operation mode
i. Inverter stopping
j. Ready input
k. Line/Inverter changeover
l. Motor 2 / Motor 1
m. Auxiliary terminal
n. Time-up signal
o. Cycle completion time
p. Stage No Indication (1, 2, and 4)
q. Alarm Indication (1, 2, 4, and 8)
r. Fan operation signal
s. Auto resetting
t. Universal DO
u. Overheat early warning
v. Second frequency level detection
w. Second overload early warning
x. Terminal C1 off signal

2.7 PROTECTIVE AND DIAGNOSTIC FEATURES

A. When a fault occurs, the VFD shall have a controlled shut down sequence. A Form C relay fault output shall be available. The reason for the fault condition shall be enunciated on the LED display, and the LCD graphic screen shall display the current, temperature, frequency, and voltage at the time of the fault as well as potential reasons for the condition. The VFD shall monitor, sense, and display the following fault conditions:

1. Over-current during acceleration
2. Over-current during deceleration
3. Over-current during constant speed operation
4. Ground fault
5. Input phase loss
6. Fuse blown
7. Over-voltage during acceleration
8. Over-voltage during deceleration
9. Over-voltage during constant speed operation
10. Under-voltage
11. Overheating of heatsink
12. External thermal relay
13. Over-temperature of internal air
14. Overheating at Dynamic Braking circuit
15. Motor 1 overload
16. Motor 2 overload
17. Inverter unit overload

18. Over-speed
19. Memory Error
20. Keypad panel communication error
21. CPU error
22. Option error
23. Operational procedure error
24. Output wiring error / Impedance imbalance
25. Modbus-RTU error

B. The VFD shall have a selectable Torque Limiting function for both motoring and braking that will sense an overload condition and will reduce frequency and current temporarily until the load reaches acceptable levels. If the overload condition is not settled in the proper amount of time, the Drive will trip on overload. The Torque Limiting shall be programmable from 20-150% of Drive rated motor torque (30 HP and below) and from 20-150% of Drive rated motor torque (40 HP and above), with 1% resolution.

C. The VFD shall have a selectable electronic inverse time thermal overload function as required by NEC and UL Standard 991 for an AC Induction Motor (Refer to applicable codes for specific installation requirements). The overload shall be programmable from 20 - 135% of Drive rated current.

D. The VFD shall have an over-voltage protection function that operates if supply voltage rises above rated value or by motor's regeneration.

E. The VFD shall treat short circuits in either the output load or the output module as an over-current.

F. If the VFD heat sink temperature exceeds approximately 100-degrees C, the Drive will shut down on over temperature fault.

G. The VFD shall provide output ground fault protection.

H. The VFD shall provide LED indication of DC bus voltage, which, when lit, will signify to maintenance people the presence of potentially dangerous voltage.

2.8 VFD CONSTRUCTION

A. The VFD shall be a sinusoidal PWM type Drive with sensor-less vector control capability. The VFD Supplier shall provide open chassis, IP20, NEMA 1 enclosures at all ratings as required for the application. Drive shall be of modular construction for ease of access to control and power wiring, and maintenance. It shall consist of the following general components:

1. Full wave diode AC/DC rectifier, to eliminate line voltage notching of the three phase source and maintain an input displacement power factor of 0.95 or greater, regardless of speed or load. SCR front ends with gate firing electronics are unacceptable.
2. DC link capacitors standard, DC link reactor available at all ratings, standard on systems 100HP+.

3. Input surge protection performed by internal MOV'S (metal oxide varistors) or devices providing equal protection.
4. Insulated Gate Bipolar Transistor (IGB T) power section. The power section control shall use vector dispersal pulse width modulated (PWM) control and fourth generation soft switching IGBTs to reduce noise and allow longer cable length from VFD to motor without the need for output filters.
5. The VFD shall be microprocessor based and fully transistorized with a 32 bit MCU and 33 MIPS processing speed.
6. Separate control and power terminal boards, with option plug shall be provided by the VFD to allow for remote operation.
7. The VFD shall have an RS485 serial communications port as a standard with options for communicating with recognized industry standard device level networks such as Ethernet, Modbus. A universal ethernet adapter shall be provided as an interface with the serial communications port.
8. The VFD shall have a Keypad capable of copying, uploading and downloading Drive function codes.

2.9 INPUT FILTER

A. Harmonic Filter: Provide a Matrix Harmonic Filter to reduce the harmonic currents going back into the utility power grid and power system. The total harmonic voltage distortion factor (DF) at the main 480 volt bus for voltage shall be less than 5 percent.

B. The filter shall include a contactor that shall de-energize the capacitors when the drive is less than 30% output.

2.10 PROCESS ALARM SWITCH

A. Manufacturer/Model:

1. CR Magnetics/CR3595.
2. Or approved equal.

B. Description - Provide a process alarm switch to monitor the VFD output Hz. When the control loop exceeds the set point the relay becomes energized and the on-board LED illuminates.

C. Input Power: 24 VDC.

D. Output: Form C Relay, 10A at 125 VAC.

E. Process variable: 4-20 mA DC

F. DIN Rail mounting.

2.11 MOTOR RTD TEMPERATURE MONITOR

A. Manufacturer:

1. **Minco CT224**
2. Or Approved equal.

B. The VFD enclosure shall be supplied with an eight-channel temperature monitor. The monitor shall accept 10 0 ohm platinum RTD sensors. The motor will be supplied with 2 embedded RTD sensors in each winding and 2 for the motor bearings. The temperature monitor shall scan all eight sensors. The unit shall provide four programmable Form C relays, plus provide an audible alarm.

C. The unit shall be provided with a display showing the highest, lowest or any other zone temperature as programmed.

D. The alarm relays shall be programmable to react to any or all scanned input zones. The audible alarm shall sound when certain relays trip and also at its own setpoint. The unit shall be supplied with a silence pushbutton to quiet the alarm.

E. The unit shall operate on 115 V AC, single phase 10 -percent, 50 /60 hertz.

2.12 POWER MONITOR (Delete if not required)

A. See 26 05 05

2.13 SURGE PROTECTIVE DEVICE

A. TVSS Manufacturer:
1. Eaton
2. Raycap
3. Square D
4. Or Approved equal.

B. This Section describes the materials and installation requirements for an integrated Transient Voltage Surge Suppressor (TVSS), also referred to as Surge Protective Device (SPD), inside VFD enclosure. These devices are used to protect AC electrical circuits from the effect of lightning induced currents, substation switching transients and internally generated transients resulting from inductive and or capacitive load switching.

C. References

1. UL 1449 Second Edition 2005 - Transient Voltage Surge Suppressors
2. UL 1283 - Electromagnetic Interference Filters
3. ANSI/IEEE C62.41.1-2002 - IEEE Guide on the Surge Environment in Low Voltage (1000 V and Less) AC Power Circuits; C62.41.2-2002 - IEEE Recommended Practice on Characterization of Surge Voltages in Low Voltage AC Power Circuits; and C62.45-2002 - IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.
4. NEC 2017 Article 285

D. Internal TVSS

1. TVSS shall be Listed in accordance with UL 1449 Second Edition 2005 and UL 1283, Electromagnetic Interference Filters.
2. Integrated surge protective devices (SPD) shall be Component Recognized in accordance with UL 1449 Second Edition, Revision 2/9/2005 Section 37.3 and 37.4 at the standard's highest short-circuit current rating (SCCR) of 200 kA, including intermediate level of fault current testing that will be effective 2/9/2007.
3. TVSS shall be tested with the ANSI/IE EE Category C High exposure waveform (20kV -1.2/50s, 10kA-8/20s).
4. TVSS shall provide suppression for all modes of protection: L-N, L-G, and N-G in WYE systems.
5. Recommended TVSS ratings:
    a. Minimum surge current rating shall be 90 kA per phase (80 kA per mode) for service entrance and 80 k A per phase (40 kA per mod e) for distribution applications.
    b. UL 14 49 clamping voltage must not exceed the following: 480Y/277
    c. Pulse life test: Capable of protecting against and surviving 5000 ANSI/IE EE Category C High transients without failure or degradation of clamping voltage by more than 10%.
6. TVSS shall be designed to withstand a maximum continuous operating voltage (MCOV) of not less than 115% of nominal RMS voltage.
7. TVSS shall be constructed of one self-contained suppression module per phase.
8. Visible indication of proper TVSS connection and operation shall be provided. The indicator lights shall indicate which phase as well as which module is fully operable. The status of each TVSS module shall be monitored on the front cove r of the enclosure as well as on the module. A push-to-test button shall be provided to test each phase indicator. Push-to-test button shall activate a state change of dry contacts for testing purposes.
9. TVSS shall be equipped with an audible alarm which shall activate when any one of the surge current modules has reached an end-of-life condition. An alarm on/off switch shall be provided to silence the alarm. The switches and alarm shall be located on the front cover of the enclosure.
10. A connector shall be provided along with dry contacts (normally open or normally closed) to allow connection to a remote monitor or other system. The output of the dry contacts shall indicate an end-of-life condition for the complete TVSS or module.
11. Terminals shall be provided for necessary power and ground connections.
12. The TVSS shall be equipped the following optional items:
    a. A transient voltage surge counter shall be located on the diagnostic panel on the front cover of the enclosure. The counter shall be equipped with a manual reset and battery backup to retain memory upon loss of AC power.

E. TVSS shall have a warranty for a period of ten (10) years from date of Final Acceptance. Warranty shall be the responsibility of the electrical distribution equipment manufacturer and shall be supported by the irrespective field service division.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that building environment can be maintained within the service conditions required by the manufacturer.

3.2 INSTALLATION

A. Install in accordance with NEMA ICS 3.1.

B. Tighten accessible connections and mechanical fasteners after placing controller.

C. Select and install overload heater elements in motor controllers to match installed motor characteristics.

D. Provide engraved plastic nameplates under the provisions of Section 26 05 00.

E. Motor Data: Neatly type label inside controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place label in clear plastic holder.

F. Ground and bond controller under the provisions of Section 26 05 26.

3.3 QUALITY ASSURANCE

A. All VFD's shall be 100 % factory tested to ensure proper performance upon delivery.

B. VFD's installed in panels shall be 100% factory tested as a system by the VFD supplier.

3.4 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.16 and NEMA ICS 3.1.

3.5 MANUFACTURER'S FIELD SERVICES

A. Prepare and startup variable frequency controller.

B. VFD operational and maintenance training and startup service shall be provided by the VFD supplier. The VFD vendor shall have factory trained personnel at field locations convenient to the installation site, available for trouble shooting and/or startup assistance 24/7.

C. Coordinate factory startup with the VFD, motor and Motor Protector factory representatives.

D. Coordinate VFD settings and the Backup Power Generator so that the facility operates as intended on both utility power and on backup generator power.

3.6 DEMONSTRATION AND TRAINING

A. Provide 4 hours of instruction each for 6 persons, to be conducted at Project Site with manufacturer's representative.

3.7 WARRANTY

A. The VFD vendor shall provide a warranty for material and workmanship, for a period of twenty-four months after Final Completion.

B. Warranty and non-warranty service shall be available in house and in the field. There shall be authorized service centers locally available within 4 hours.

3.8 SPARE PARTS

A. Provide a list of all spare parts to the OWNER at Substantial Completion.

3.9 RTD TEMPERATURE MONITOR

A. Install the temperature monitor in the front of the VFD enclosure, at +50-inches above the floor, but not exceeding +60-inches (to the top of the unit).

B. Wiring:

1. Wire Relay #1 shall be wired to stop the motor on high temperature alarm.
2. Wire Relay #2 to provide a high temperature warning alarm to the SCADA RTU.
3. Alarm set ponts to be determined during startup.

C. Nameplate

1. Provide an engraved nameplate above the unit.

- END OF SECTION -

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SECTION 26 42 00
GALVANIC CATHODIC PROTECTION SYSTEM

PART 1 GENERAL

1.1 WORK INCLUDED:

A. This section covers the work necessary to furnish and install electrical isolation, dc blocking devices, and pump column and well casing isolation, complete.

B. CONTRACTOR to have a third party Corrosion Expert to perform CONTRACTOR required quality control testing as defined this section.

1.2 STANDARDS

A. The following standards are included by reference:
   1. NACE SP-0169
   2. NACE SP-0177

1.3 QUALIFICATIONS

A. All CONTRACTOR specified testing shall be performed by a third party Corrosion Expert whom holds a current NACE accreditation as a Cathodic Protection Specialist (CP-4) or Cathodic Protection Technologist (CP-3), and/or a registered professional engineer.

B. CONTRACTOR performed quality control testing shall include the following tests, which shall be performed as defined this section.

   1. Insulating Joint Testing
   2. DC blocking devices
   3. Pump column and well casing isolation

1.4 DEFINITIONS

A. Electrical Isolation: The condition of being electrically isolated from other metallic structures (including, but not limited to, piping, reinforcement, casings) and the environment as defined in NACE Recommended Practice SP0169.

1.5 SUBMITTALS

A. Provide Submittals in accordance with Section 001 33 00 – Submittal Procedures.

B. Shop Drawings: Catalog cuts and other information for products proposed for use.

C. Quality Assurance Submittals:
   1. Manufacturers' Certificates of Compliance.
   2. Field Test Reports.
   3. Qualifications of NACE Accredited Testing Personnel.

PART 2 MATERIALS

2.1 GENERAL

A. Like items of materials provided hereunder shall be the end product of one manufacturer to achieve standardization for appearance, maintenance, and replacement.

B. Materials and workmanship as specified in this section shall be installed concurrently with pipe installation. Coordinate all work specified herein with related sections.

2.2 SUPPLIERS

A. Alternate suppliers will be considered, subject to approval of ENGINEER. Address given is that of the general office; contact these offices for information regarding the location of their representative nearest the project site.
   1. Corrpro, Inc., Chicago, IL
   2. Farwest Corrosion Control, Gardena, CA
   3. MESA Products, Tulsa, OK

2.3 INSULATING JOINTS

A. General: Insulating joints shall be dielectric unions or flanges. The complete assembly shall have an ANSI rating equal to or higher than that of the joint and pipeline. All materials shall be resistant for the intended exposure, operating temperatures, and products in the pipeline.

B. Insulating Flanges:
   1. Gaskets:
      a. Full-face, fiberglass (G10) with O-ring seal gasket. Buried insulating flanges shall be full face gaskets only.
      b. Complete assembly shall have an ANSI rating equal to the flanged joint.
      c. Gasket materials shall be resistant to intended chemical exposure, operating temperatures, and pressures in the pipeline.
   2. Insulating Sleeves: Full-length Mylar or fiberglass reinforced epoxy (NEMA G-10 grade).
   3. Insulating Washers: Fiberglas reinforced epoxy (NEMA G-10 grade).
   4. Steel Washers: Plated, hot-rolled steel, 1/8-inch thick.
   5. Manufacturers:
      a. GPT industries, Houston, TX.
      b. Advanced Products and Systems, Scott, LA
      c. Central Plastics Co., Shawnee, OK.

C. Insulating Unions: O-ring sealed with molded and bonded insulating bushing to union body, as manufactured by Central Plastics Company, Shawnee, OK; or equal.

2.4 DC BLOCKING DEVICES

A. DC isolation devices shall be solid-state electronic devices capable of passing ac current while blocking dc current.

B. Device shall have electrical rating of 3KA fault current at 30 cycles and 40 amperes steady state ac current, minimum.

C. Device shall have symmetrical dc blocking capabilities of –2 volts to +2 volts.

D. DC isolation devices shall be as manufactured by Dairyland Electrical Industries, Inc., Stoughton, Wisconsin.

PART 3 WORKMANSHIP

3.1 GENERAL

A. The installation of the facilities herein specified and described shall conform to the latest applicable NEC rules.

B. The workmanship shall be of the highest grade and shall be in strict accordance with material manufacturer's instructions. Equipment or materials damaged in shipment or in the course of installation shall be replaced.

C. CONTRACTOR shall examine all Drawings and coordinate his work so as to avoid conflicts, errors, delays, and unnecessary interference with the construction of the facilities and to avoid duplication of the work such as excavation, filling, etc. In the event of any conflicts in the Specifications, ENGINEER shall be consulted.

3.2 INSULATED JOINTS

A. Install insulated joints to electrically isolate the pipeline from other pipes or structures where shown on the Drawings.

B. Install insulated joints as shown on the Drawings.

C. Align and install insulating joints according to the manufacturer's recommendations to avoid damaging insulating materials.

D. CONTRACTOR shall test each insulated joint for electrical insulation as specified this section. Defective insulating joints shall be repaired by CONTRACTOR at his sole expense. All damaged or defective insulation parts shall be replaced.

3.3 DC BLOCKING DEVICES

A. Install dc blocking devices at the following locations:

B. In ground wire to each well pump motor, location to be determine in field.

C. Where shown on the Contract Drawings.

D. Support of dc blocking device shall be on either a 2-inch diameter hot-dipped galvanized steel pipe support, 4-inch hot dipped galvanized channel support, or shall be mounted to a concrete wall at CONTRACTOR's option. ENGINEER shall review and approve the applicable equipment support based on the conditions present.

3.4 QUALITY CONTROL TESTING

A. General:
   1. CONTRACTOR shall correct all construction defects identified during testing.
   2. Provide ENGINEER with 7 days advance notice of completion for ENGINEER acceptance testing.
   3. CONTRACTOR required testing as defined herein shall be performed by a Corrosion Expert, with qualifications as specified this section, whom is an employee or subcontractor to CONTRACTOR.

B. Well Isolation Test:
   1. CONTRACTOR shall provide a Cathodic Protection Specialist to test electrical isolation on the well at the following locations:
      a. Between well casing and pump and pump column during installation.
      b. Between well discharge head and well casing.
      c. Between well discharge head and discharge pipe.
      d. Between well discharge head and pump house grounding.
   2. The Cathodic Protection Specialist shall conduct additional insulating joint testing as required to insure that insulating flanges are not electrically shorted by other equipment or incidental contact with concrete reinforcement or electrical grounding.
   3. Testing between well pump column and well casing shall be performed as the pump and pump column is installed within well.
   4. CONTRACTOR to replace damaged or defective insulation parts identified during testing.
   5. Electrical Isolation is defined as a condition of being electrically isolated from other metallic structures (including, but not limited to, other piping, concrete reinforcement, casings, and other structures not intended to be cathodically protected) and the environment as defined in NACE Recommended Practice RP0169-83.
   6. CONTRACTOR shall submit a report prepared by the Cathodic Protection Specialist certifying insulating joint testing isolation and any corrective action required.

C. General
   1. CONTRACTOR shall correct all construction defects identified during testing.
   2. Provide ENGINEER with one week advance notice before beginning tests.

- END OF SECTION -