SECTION [26 23 00][16430]

LOW VOLTAGE SWITCHGEAR

Square D Power-Zone™ 4 by Schneider Electric

Schneider Electric Editor’s Note:
This guide specification is written in accordance with the Construction Specifications Institute (CSI) Master Format. This section must be carefully reviewed and edited by the architect or the engineer to meet the requirements of the project. Coordinate this section with other specification sections within the Contract Documents and Drawings.

To properly use / edit this document, show formatting and hidden text by selecting ¶ on the menu or by typing (Ctrl+*) simultaneously. Except for these introductory and closing paragraphs, green hidden text will not print. Text in red is optional. Red text in [brackets] denotes multiple options where one or more should be chosen. All red text should be edited and changed to black for final project conformation. In addition, these introductory paragraphs should be deleted or changed to hidden text. Additional guidance and specifications can be found at

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, configuration and installation for Low Voltage Draw-out Switchgear assembly constructed to ANSI C37.20.1 standards (also identified as Switchgear, SWGR, LV SWGR, LVDO) as required for the complete performance of the Work, as shown on the Drawings, as specified herein.

B. Section Includes: The work specified in this Section includes, but shall not be limited to, the following:
   1. Low voltage metal-enclosed, draw-out switchgear constructed to ANSI C37.20.1 standards
   2. Low voltage metal-enclosed, draw-out switchgear constructed to ANSI C37.20.1 standards and designed to contain the effects of arc flash events inside the gear per ANSI/IEEE standard C37.20.7
   3. Front accessible Low voltage metal-enclosed, draw-out switchgear constructed to ANSI C37.20.1 standards in 42-inch deep sections

C. Related Sections: Related sections include, but shall not be limited to, the following:
   1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
   2. Applicable general requirements for electrical Work specified within Division 26 Specification Sections apply to this Section.
   3. The following SWGR information is typically depicted on the Drawings: bus configuration, bus ratings, interrupting ratings, component size and type, power line and feeder connections, application specific control wiring, elevation and footprint, etc. Where not shown on or able to be derived from the Drawings, the minimum requirements specified herein shall be provided.
   4. Refer to specification Section 26 27 13.13 Power and Energy Meters for additional requirements.
   5. Refer to specification Section 26 27 13.16 Power Quality Meters for additional requirements.
   6. Refer to specification Section 13 34 23.11 Fabricated Electrical Houses for additional requirements.
   7. Refer to specification Section 26 28 11.13 Power Circuit Breakers for additional requirements.
   8. Refer to specification Section 26 43 13 Surge Protective Devices for Power Circuits for additional requirements.
9. Refer to specification Section 26 09 13 Electrical Power Management Systems for additional requirements

1.2 REFERENCES

A. General. Publications: The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

1. Canadian Standards Association (CSA)
   a. C22.1, “Canadian Electrical Code, Part I” (CEC)
   b. CSA C22.2, No 31 - “Switchgear Assemblies”

2. Institute of Electrical and Electronics Engineers (IEEE) and American National Standards Institute (ANSI)
   b. ANSI/IEEE C37.20.1 - “Metal Enclosed Low Voltage Power Circuit Breaker Switchgear”
   c. ANSI/IEEE C37.20.7 – “Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults”
   d. ANSI/IEEE C37.51 - “Testing of Metal-Enclosed Low Voltage AC Power Circuit Breaker Switchgear”
   e. ANSI/IEEE C37.13 - “Low Voltage AC Power Circuit Breakers Used in Equipment”
   f. ANSI/IEEE C37.16 - “Preferred Rating, Related Requirement and Application Recommendations for Low Voltage Power Circuit Breakers and AC Power Circuit Protectors”
   g. ANSI/IEEE C37.50 – “Testing of Low Voltage AC Power Circuit Breakers”


4. International Organization for Standardization (ISO)

5. National Electrical Manufacturers Association (NEMA)
   a. NEMA SG-5, “Power Switchgear Assemblies”
   b. NEMA 250, “Enclosures for Electrical Equipment”
   c. NEMA SG-3, “Low Voltage Power Circuit Breakers”

6. National Fire Protection Agency (NFPA)
   a. NFPA 70, “National Electrical Code (NEC)”
   b. NFPA 79, “Electrical Standard for Industrial Machinery”

7. Underwriters Laboratories, Inc. (UL)
   a. UL 1558, “Switchgear Assemblies”
   b. UL 50, “Enclosures for Electrical Equipment”
   c. UL1066, “Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures”

1.3 DEFINITIONS

A. Unless specifically defined within the Contract Documents, the words or acronyms contained within this specification shall be as defined within, or by the references listed within this specification, the Contract Documents, or, if not listed by either, by common industry practice.

1. LVDO: Low Voltage Draw Out
1.4 SUBMITTALS

A. General: Submittals shall be in accordance with the requirements of Section [01 33 00] [01300] Submittals and Section [26 00 10][16010] Electrical Requirements, in addition to those specified herein.

1. Submit sufficient information to determine compliance with the Contract Documents. Identify submittal data with the specific equipment tags and/or service descriptions to which they pertain. Submittal data shall be clearly marked to identify the specific model numbers, options, and features of equipment and work proposed.

2. Deviations from the Contract Documents shall be indicated within the submittal. Each deviation shall reference the corresponding drawing or specification number, show the Contract Document requirement text and/or illustration, and shall be accompanied by a detailed written justification for the deviation.

3. Submit required product data and shop drawings specific to each product and accessory proposed. In addition, include the following information:
   a. Manufacturer, supplier, and proposal specific contact information.
   b. Manufacturer's catalog data indicating equipment specifications and construction features including all furnished options, and accessories.
   c. Rated operating and electrical characteristics of the equipment assembly.
   d. Enclosure type, NEMA rating, material and finishes.
   e. Certification of UL conformity
   f. Electronic 2D dimensional drawing and 3D model CAD files for standard units shall be provided upon request if not available from the manufacturer's website.
   g. Equipment assembly. Indicate dimensions, shipping section dimensions, weights, foundation requirements, required clearances, location and size of each field connection, and mounting and installation instructions.
   h. Include elementary and interconnection diagrams for power, signal, control, and communications wiring. Diagrams shall provide the minimum detail as shown for drawings in the appendix of NFPA 79. All field terminals shall be identified and updated later within the O&M data to include actual field connection information. Drawings shall not be typical, but be provided for each Switchgear and Breaker furnished.

4. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   a. Required working clearances and required area above and around Switchgear.
   b. Show Switchgear layout and relationships between electrical components and adjacent structural and mechanical elements.
   c. Show support locations, type of support, and weight on each support.
   d. Indicate field measurements.

5. Seismic Qualification Certificates: For each Switchgear assembly provide the following from manufacturer.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

B. Operation & Maintenance (O&M) manuals shall be provided in accordance with the minimum requirements specified in Section [01 78 23][1780] Operation and Maintenance Data, Section [26 00 10][16010] Electrical Requirements and additional requirements specified herein.
1. Submit required Operations & Maintenance data specific to each product and accessory proposed. In addition, include the following information:
   a. Manufacturer, supplier, support, and repair center specific contact information.
   b. Manufacturer’s standard operation and maintenance data assembled for each size and type of equipment furnished.
   c. [All construction, installation, schematic, and wiring diagrams updated to an as-installed and commissioned state.][All submittal information updated to an as-installed and commissioned state.]
   d. All configured settings/parameters for adjustable components updated to an as-installed and commissioned stated if different from the factory default. Electronic copies of configuration files shall be provided, on media acceptable to the Owner (e.g. CD, USB stick, etc.), where these configurations can be saved as an electronic file for future upload into replaced or repaired components.
   e. List of furnished and recommended spare parts.
   f. Statement of standard Warranty. [Statement of extended warranty options and costs.]

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of Switchgear of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 15 years.
   1. The manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system that is regularly reviewed and audited by a third-party registrar. Manufacturing, inspection, and testing procedures shall be developed and controlled under the guidelines of the quality assurance system.
   2. The manufacturer or their representative shall have service, repair, and technical support services available 24 hours 7 days a week basis.
   3. The Switchgear manufacturer shall have the Environment Certification ISO 14001.

B. Installer Qualifications: Installer shall be a firm that shall have a minimum of [10] years of successful installation experience with projects utilizing equipment similar in type and scope to that required for this Project [and shall be approved by the manufacturer’s representative].

C. All work performed and all materials used shall be in accordance with the [National Electrical Code], [Canadian Electrical Code] and with applicable local regulations and ordinances. Equipment assemblies, materials, and equipment shall be listed and labeled by Underwriter’s Laboratories or by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 DELIVERY, STORAGE AND HANDLING

A. Prior to delivery to the Project site, ensure that suitable storage space is available to store materials in a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Materials shall be protected during delivery and storage and shall not exceed the manufacturer stated storage requirements. As a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic energy that could reasonably cause damage.

B. Deliver materials to the Project site in supplier’s or manufacturer’s original wrappings and containers, labeled with supplier’s or manufacturer’s name, material or product brand name, and equipment tag number or service name as identified within the Contract Documents.

C. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.
1.7 WARRANTY

A. General: Refer to [Section 01 77 00 - Closeout Procedures] [Section 01770 - Closeout Procedures].

B. The manufacturer shall warrant products against defects in material and workmanship for [12 months from the date of commissioning or 18 months from the date of shipment – whichever comes first.] [24 months from the date of commissioning or 36 months from the date of shipment, whichever comes first, provided that the manufacturer performs functional testing, commissioning and first parameter adjusting of equipment.] During the warranty period the manufacturer shall repair or replace defective products. This warranty shall be in addition to any provided by the Contractor. The warranty shall exclude normal wear and tear under normal usage and any damage caused by abuse, modification, or improper maintenance by entities other than the manufacturer or its approved representative.

C. Additional Owner Rights: The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

1.8 SPECIAL TOOLS AND SPARE PARTS [- NOT USED]

A. The Contractor shall provide a recommended spare parts list with the following information provided as a minimum:

1. Contact information for the closest parts stocking location to the Owner.
2. Critical spare parts shall be identified as those parts being associated with long lead times and/or those being critical to the unit's operation.
3. Maintenance spares shall be identified as being those parts required to regularly perform scheduled maintenance on the furnished equipment. These spares shall include, but shall not be limited to, consumable spares that are required to be exchanged during scheduled maintenance periods.

B. Spare parts shall be provided for each type and size of unit installed. At a minimum, the following shall be provided:

1. Provide the minimum spare parts recommended by the manufacturer.
2. Provide [1] set of each type of power and control fuse installed within equipment
3. Provide [1] set of each type of non-LED type indicating lights installed within equipment

C. Any manufacturer specific special tool, not normally found in an electrician's toolbox, required to remove and install recommended or furnished spare parts shall be furnished. At a minimum the following shall be provided:

1. If available from manufacture[ and required to configure equipment], provide PC-based configuration software tool and a minimum of [one] communication interface cable for each type of cable required to connect a PC-based computer to the devices specified herein for configuration and programming.
2. Electronic configuration files, in a media format acceptable by the Owner (e.g. CD, USB stick, etc.), updated to an as-installed and commissioned state.

D. Spare parts shall be properly marked and packaged for long term storage. Printed circuit boards shall be provided in separate anti-static containers.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D PowerZone 4, by Schneider Electric.

B. Acceptable Products: Switchgear specified herein shall be the product of a single manufacturer. Products and manufacturers specified are to establish a standard of quality for design, function, materials, and appearance. Products shall be modified as necessary by the manufacturer for compliance with requirements. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date:
   1. Square D Power Zone 4 Switchgear by Schneider Electric
   2. (2nd manufacturer)
   3. (3rd manufacturer)

2.2 GENERAL REQUIREMENTS

A. The following SWGR information is typically depicted on the Drawings: bus configuration, bus ratings, [interrupting ratings, component size and type, power line and feeder connections, application specific control wiring, elevation and footprint, etc. Where not shown on or able to be derived from the Drawings, the minimum requirements specified herein shall be provided.

B. Switchgear Rated Voltage shall be [508Vac with Operating Voltage of 480Vac][635Vac with Operating Voltage of 600Vac] operating at a frequency of [50Hz][60 Hz].

C. The system ampacity is determined by the total combined load distribution of the feeder breakers. System ampacity shall be [1600A][2000A][3200A][4000A][5000A]. All horizontal bus shall be rated to the full ampacity of the system.

D. [The vertical bus shall be rated to the total ampacity of the feeder breakers and prepared spaces within the given vertical structure per ANSI C37.20.1.][The vertical bus shall be fully rated to the total system ampacity, equivalent to the horizontal bus]

E. The short circuit current rating of the system shall be determined by the available fault current at the switchgear as indicated on the Drawings. All circuit interruption shall be accomplished by the circuit breaker and without the aid of limiter fuses. The short time rating shall also be a function of the desired selectivity of the electrical system. Short time ratings shall be equal to interrupting ratings for systems delivering up to 85k amperes available fault current.

F. The equipment bus system shall be braced according to ANSI/IEEE C37.20.1 with a short-circuit withstand rating of [85,000][100,000][200,000] amperes (RMS symmetrical).

G. Environmental Condition Requirements
   1. Storage Temperature shall be within the following range: 0°C to 40°C,
   2. Operating Temperature shall be within the following range: 0°C to 40°C
   3. Relative Humidity shall be ≤95% relative humidity without condensation for indoor enclosures.
   4. Operating Altitude shall be 3,300 feet/1,000 meters without derating.

H. Equipment shall be suitable for use as service entrance equipment and labeled according to UL requirements.

I. Equipment shall be Seismic Qualified and Certified by 3rd party testing to meet ASCE7/IBC. Equipment capacity shall be determined from tri-axial seismic shake table test results as defined in the International
J. Equipment shall have Preapproval (OSP) under California Office of Statewide Health Planning & Development (OSHPD) Special Seismic Certification program for California Healthcare facilities.

2.3 STRUCTURE

A. General: Each steel section shall contain one or more individual circuit breakers, or instrumentation compartments, and a [rear accessible compartment for the buses, splices and incoming/outgoing power cable connections][front accessible compartment for the buses, splices and incoming/outgoing power cable connections].

B. [The equipment shall not require rear access for any cable terminations, control wiring or bus inspection. The equipment shall be certified to be installed against a wall without compromise to system integrity or performance].

C. Rigid removable steel base channel shall be provided at the front and rear of each section.

D. The finish shall be medium gray ANSI #49

E. Each vertical structure shall be provided with bus compartment side barriers, cable compartment side barriers, and rear barriers between bus/cable compartments to provide increased protection against propagating faults.

F. A lifting device shall be provided for ease of installation, removal and/or transfer of circuit breakers as follows:
   1. [Overhead traveling lifter][Floor crane] for rear accessible switchgear.
   2. [Foldaway, portable floor crane for front accessible switchgear].

G. Dimensions
   1. Depth of switchgear lineups shall be [available from 60" to 80" based on conduit entry for Rear Accessible switchgear][42" for Front Accessible switchgear].
   2. Structures shall have the capability to be a stand-alone structure and maintain ratings.
   3. Adequate cable-bending space shall be provided for main and feeder breakers with terminated conductors of up to 750 MCM.
   4. Adequate conduit space shall be provided to allow all conductors to exit the structure in the same vertical direction.

H. Moving and Handling
   1. The lineup shall be divided into shipping splits as indicated on the Drawings and shall be capable of being lifted overhead or by a forklift.
   2. Each shipping split shall be provided with removable lifting angles for crane installations purposes.
   3. Removable base channels shall be provided with prying slots for ease of final positioning at the job site.

2.4 CIRCUIT BREAKER COMPARTMENT

A. Secondary Connections
   1. All customer secondary control and communications connections shall be made from the front of the switchgear lineup.
2. A dedicated wiring area accessible from the front shall allow easy access to all control or communications terminations.

3. Control connections shall be cage clamp terminals. All control wire shall be 14 gauge, type SIS.

4. Customer control wiring shall be provided at the top and bottom of each structure conduit area, capable of landing up to a quantity of (3) 1½" conduits and accessible from the front.

5. All interconnections between structures at shipping splits shall use locking-pull apart terminal blocks.

6. All secondary and communication wiring shall be securely fastened to the switchgear without the use of adhesive backed wire anchors.

B. Instrumentation

1. Where additional space is required for instrumentation, CPTs, metering, etc., a barriered instrumentation compartment shall be used.

2. The instrumentation compartment shall not inhibit the routing of control or communication wires.

3. Individual component mounting surfaces shall be painted white as standard.

2.5 BUSING AND CABLE COMPARTMENT

A. Busing

1. All bus joints shall consist of SAE Grade 5 hardware and conical spring (e.g. Belleville) washers to withstand mechanical forces exerted during short circuits. All primary bus joints shall consist of a minimum of 2 bolts.

2. Busing shall be silver plated copper along its entire length.

3. Busing shall be braced to withstand the instantaneous interrupting rating of the main breaker(s) or 85kA minimum (RMS symmetrical).

4. All bus shall be insulated with UL listed insulating material. Bus joints shall be covered by an insulating box or boots which can be opened and resealed for joint maintenance.

5. Front Accessible switchgear shall have captive rotating splice bars accessible from the front of the switchgear via removable covers for ease of installation. Splice installation requiring access from the rear of the switchgear shall not be acceptable.

B. Cable Compartment

1. Feeder Breakers shall have adequate wire bending space regardless of the interrupting rating.

2. Conduit area for each structure shall be a minimum of 17" wide and 22" deep to provide adequate depth for all conduits.

2.6 POWER CIRCUIT BREAKERS

A. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date: Square D MTZ Power Circuit Breaker with MicroLogic™ trip units by Schneider Electric, [2nd manufacturer] or [3rd manufacturer].

B. Circuit Breakers Construction and Operation

1. Circuit breakers shall be drawout type and listed to UL 1066.

2. The circuit breaker shall be a sealed low voltage power circuit breaker operated as indicated on the Drawings with integrally mounted electronic trip units.

3. Circuit Breakers shall be 100% rated.
4. All circuit breaker operating mechanisms are to be two-step, fully-stored energy devices for quick-
make, quick-break operation with a maximum of a five-cycle closing time. The closing time shall 
be less than or equal to 50 milliseconds for ratings <800A; 70 milliseconds for ratings <4000A; 80 
milliseconds for ratings >4000A.

5. Open-close-open (O-C-O) cycle shall be possible without recharging. Motor operator shall 
automatically charge when circuit breaker is closed. Actuation of the operating handle or an 
operation cycle of the circuit breaker motor shall charge the closing springs (step one) and 
operation of a local "close" button shall close the circuit breaker contact (step two). Closing the 
circuit breaker contacts shall automatically charge the opening springs.

6. Circuit breaker shall be equipped with anti-pumping function: If opening and closing commands 
occur simultaneously, the circuit breaker shall remain in the open position. After fault tripping or 
intentional opening using the manual or electrical controls, the closing order must first be 
discontinued, then reactivated to close the circuit breaker.

7. Circuit breakers shall be suitable for the required instantaneous rating without the use of current 
limiting fuses.

8. All circuit breakers shall have provisions for field interchangeable electrical accessories including 
shunt trip, spring release, electrical operator and auxiliary contacts.

9. All secondary connections shall be made directly to the front of the circuit breaker cradle.

10. Each Circuit breaker shall have built in visible contact wear indicators.

11. Current-carrying components shall be completely isolated from the accessory mounting area and 
double insulated from the operator with accessory cover in place.

12. Each phase inside the circuit breaker shall be completely isolated from other phases and ground 
by polyester thermoset material.

13. Circuit breaker buttons shall not be isolated or covered, thereby requiring a tool to operate the 
breaker.

14. Circuit breakers shall have interrupting, close and latch, and 30-cycle withstand ratings which 
meet the application requirements.

15. All circuit breakers shall have a minimum symmetrical interrupting capacity of 65,000 amperes. 
To ensure a fully selective system, all circuit breakers shall have 30 cycle short-time withstand 
ratings equal to their symmetrical interrupting ratings, regardless of whether equipped with 
instantaneous trip protection or not.

16. Close and latch ratings up to 90 kA shall be available on all frame sizes.

17. Thirty-cycle withstand rating shall be available up to 100 kA to provide maximum coordination 
with downstream circuit breakers.

18. Circuit breakers shall be available in 800, 1600, 2000, 3200, and 4000 and 5000A frame sizes.

19. Each circuit breaker shall be mounted in its own barriered compartment.

20. Feeder circuit breakers rated 2000A or less shall be capable of being mounted in the uppermost 
compartment without derating.

21. Operational buttons on the circuit breaker as well as the trip unit and the display shall be 
accessible without opening the breaker compartment door.

22. Prepared spaces shall be completely assembled with provisions for Circuit Breakers.

23. Circuit Breaker and prepared space compartments shall be “keyed” such that a breaker cannot 
be incorrectly installed with respect to Interrupting Rating, Frame Size, or secondary connections

24. Padlocking provisions shall be furnished on the cradle to receive up to three padlocks when the 
circuit breaker is in the connected, test or disconnected position.

25. Provisions for up to two key locks shall be furnished allowing locking the cradle in the connected, 
test or disconnected position.
26. The front face of the circuit breaker shall have OPEN and CLOSE buttons with breaker contact and close spring status indicators. The indicator shall show “charged-not OK to close” if closing springs are charged but the circuit breaker is not ready to close. [A lockable clear cover shall be provided over the OPEN and CLOSE buttons.]

27. Circuit breaker racking system shall have positive stops at the connected, test, disconnected and withdrawn positions. Mounting hardware shall be installed on cradle for remote racking device.

28. Circuit breaker shall be equipped with an interlock to discharge the stored energy spring before the circuit breaker can be withdrawn from its cell.

29. Circuit breaker shall provide a positive ground contact check between the circuit breaker and cell when the accessory cover is removed while the circuit breaker is in the connected, test or disconnected positions.

30. Circuit Breakers shall provide long service life. The 3200 A circuit breaker frame and those of lower ratings shall be certified to perform a minimum of 10,000 operations without maintenance. The circuit breaker frames greater than 3200 A shall be certified to 5,000 operations without maintenance. Circuit breaker shall be equipped with a visual contact wear indicator.

C. Trip Units

1. Advanced trip units shall be imbedded within the hardware of the circuit breaker. Trip unit functionality shall be upgradable through the uploading of digital modules without the need to replace or modify trip unit hardware. Trip unit protection functions shall be electronically managed independently of measurement functions by a dedicated ASIC (application specific integrated circuit). Digital modules shall be added to the trip unit without removing power from the circuit breaker, unless hardware is required to be added in conjunction with the digital module.

2. Trip units shall provide local and remote trip indication and reason for trip (e.g. overload, short circuit or ground fault).

3. Trip units shall visually indicate the operating status of the circuit breaker: normal, warnings, alarms, ERMS, through the color changing backlit display.

4. All trip units shall be capable of setting the breaker locally, if enabled, via a smart mobile device, or remotely through communications.

5. To deter unwanted changes to the protection settings, a sealable door feature shall block the use of the local display to make adjustments of the protection settings.

6. It shall be possible to get trip cause data out of trip unit or adjust protection settings without a 24Vdc power supply or when the main circuit breaker is OFF using a portable power supply connected through the USB port, including an optional battery pack, smart mobile device (USB OTG), or laptop pc.

7. Trip units shall incorporate “True RMS Sensing” through the 40th harmonic, and have LED long-time pickup indications.

8. Coils shall provide status, self-diagnosis (functionality and number of coil operations) and wiring diagnostics. Standard coils shall be acceptable provided that alternate coil monitoring and alarming is communicated to the remote monitoring system.

9. Trip unit protection functions shall consist of
   a. adjustable long-time pickup and delay (ANSI 49RMS/51),
   b. short-time pickup and delay (ANSI 50TD/51),
   c. instantaneous pickup (ANSI 50), the Instantaneous setting shall also have an OFF setting when short-time pick-up is provided
   d. ground-fault pickup and delay (ANSI 50N-TD/51N)

10. Long-time pickup (Ir) and delay shall be adjustable. Long-time pickup (Ir) shall be adjustable from 0.4 to 1 times In, adjustable in 1 ampere increments. Long-time delay settings shall be adjustable from 0.5 to 24 seconds at six times Ir in 0.5 second increments. If it cannot adjust to 1 ampere
increments, manufacturer shall supply one complete set of rating plugs per breaker to maximize future flexibility.

11. Short-time pickup shall be adjustable from 1.5 to 10 times Ir in increments of 1%. Short-time delay shall be adjustable from 0.1–0.4 I²t ON and 0–0.4 I²t OFF in increments of 0.1 seconds.

12. Instantaneous settings on the trip units with LSI protection shall be adjustable from 1.5 to 15 times In. The Instantaneous setting shall also have an OFF setting when short-time pick-up is provided. Instantaneous settings shall have 2 selectable breaking times: “standard” when selective coordination is required and “Fast” when limiting let-thru energy is required. “Fast” is defined as 25 to 30 ms breaking time.

13. Ground-fault protection shall be available for solidly grounded three-phase, three-wire or three-phase, four-wire systems. Trip unit shall be capable of the following types of ground-fault protection: residual, source ground return, and modified differential.
   a. Ground-fault settings for circuit breaker sensor sizes 1200 A or below shall be adjustable from 0.2 to 1.0 times In in 0.1 In increments. The ground-fault settings for circuit breakers above 1200 A shall be adjustable from 500 to 1200 A.

14. An independent ground fault alarm shall provide ground fault and earth-leakage protections, having their own settings.

15. Neutral current transformers shall be available for four-wire systems.

16. Trip units shall provide additional protection selections, when determined through system study that more flexibility is required for coordination, by offering adjustable inverse definite minimum time lag (IDMTL). IDMTL provides optimized coordination by the adjustment of the slope of the long-time delay protection.

17. The circuit breaker shall trip when the active power is negative and exceeds the settings.

18. Trip unit shall provide dual trip curve settings for respective protection functions (LSIG), providing separate settings for various sources; utility, generator set or grid. User may switch from one set of settings to the other to comply with conditions of operation. Trip curve selection shall be selected by one of the following means: digital input through the IO module, Ethernet, or from the local display.

19. Trip units shall have a communication/test port for checks on electronic and trip mechanism operation in compliance with market standards (USB and PC) avoiding requiring a specific Manufacturer’s hardware tool.

20. Trip units shall have wireless communication interface for protection settings and health checks using Near Field Communications (NFC) and BLE protocols.

21. Measurement and Analysis Functions
   a. Trip units shall have embedded measurement to provide real time metering. Metering accuracy by function shall be within 0.5% for current and voltage, and 1% for power and energy measurements. Metering accuracies shall be total measurement system, including CT and meter and shall be full scale over the range 10% to 120% of Ir. If not available at the circuit breaker, an external meter shall be provided for specified measurement and analysis functions.
   b. Metering functions, at the point of measurement, shall calculate and display the imported and exported energy on each phase of the power system network. It shall calculate and display active, reactive and apparent energy per phase, as well as the total active, reactive and apparent energy.
   c. Trip units shall be capable of harmonic analysis and waveform capture. Individual harmonics of voltages and currents, up to the 40th, shall be calculated every 200 ms in accordance with IEC 61000-4-30.
   d. Measurements shall be capable of being shown on the breaker display, a smart mobile device via Bluetooth, a connected remote Operator Interface Terminal or a remote monitoring system via Modbus TCP/IP.
e. Event management shall provide user notification of alarms and traceability. Event history to include: trips, protection setting changes, diagnostics, metering, configuration, and operation.
   1) The date and time the entry was made and the user ID associated with the change.
   2) User shall be able to activate alarms based on measurement (I, V, F, P, Q, S, THD, CosPhi, FP, I_demand, P_demand,) or counters
   3) All events shall be available by communication, Bluetooth and Modbus TCP/IP, or software Engineering tool.
   4) Provide circuit breaker internal monitored functions for maintenance purposes: Coils electrical continuity checks, Circuit breaker closing time, Gear motor charging time, Circuit breaker closing & opening counter, Circuit breaker time stamp closing & opening history log.

f. Trip unit internal monitored functions shall be provided for maintenance purposes: Internal Sensors (CTs) continuity, External Sensors disconnection (ENCT, ground fault sensor and I/O modules), Internal failure discrimination (ASIC, sensor plugs, internal battery, trip solenoid), Wireless communication failure (Bluetooth Low Energy [BLE] and Ethernet).

g. Trip unit shall communicate trip cause information to a smart mobile device without requiring power to the trip unit. A smart mobile device app shall be available to provide virtual assistance in reclosing a breaker after trip event, utilizing information extracted from breaker, including wave form capture on trip event. This function shall assist the user to restore power by displaying circuit breaker event information, potential causes, a list of additional investigations needed to determine if power can be restored and recommendations for power restoration.

h. Provide Auto-test function for monitoring and communicating the following functions: trip unit state, battery state, contact state, circuit breaker remaining life estimate (algorithm based), spring charging function, and opening/closing function, indicated by Health State LED, embedded HMI display and smart mobile device app.

i. Trip unit shall allow for remote open / close operation of the circuit breaker through [wired communications][a smart mobile device that provides assistance for the reclosing or opening the circuit breaker by delivering instructions such as reset (if applicable) or charge spring (if applicable). The smart mobile device shall be capable of displaying circuit breaker status: ready-to-close, coil status or spring charging status].

D. Circuit Breaker Accessories
   1. Circuit breakers shall be equipped with accessories shown on the drawings.
   2. All accessories shall be UL Listed as field-installable and be interchangeable between frame sizes.
   3. Circuit breakers shall provide isolation from primary power when accessory cover is removed.

2.7 ARC MITIGATION AND SAFETY [- NOT USED]

A. Arc Flash Limiting Feeder Breakers [- Not Used]
   1. Provide feeder circuit breakers with Flash Limiting Feeder (L1F) option for arc flash limiting.
   2. Circuit breakers shall be suitable for 200kA short circuit rating without the use of current limiting fuses.
   3. Circuit breaker shall have published testing data and IEEE 1584 equations to support the reduction of arc flash incident energy and flash protection boundary (mm).

B. Zone Selective Interlocking [- Not Used]
   1. Shall preserve desired selective coordination between main(s), tie(s) and feeder(s) protective devices.
2. Shall be a wired connection between relays or protective devices.

3. If a feeder detects an overcurrent condition it sends a restraining signal to upstream breaker(s). The main (and tie) then follows its normal time-current characteristics and serves as a backup. However, if the main breaker detects an overcurrent condition above its short-time (or ground fault) pickup setting, but the feeders do not (e.g., main bus fault), then the main breaker shall not receive a restraint signal and it shall trip with no intentional time delay.

C. Energy Reduction Maintenance Setting Switch (ERMS) [- Not Used]

1. For each [Main][Tie][or Feeder] circuit breaker, provide a [Maintenance OFF ON selector switch on the breaker compartment door][mobile device app] to temporarily switch the circuit breaker to ERMS mode tripping characteristics during maintenance activities.

2. Trip unit shall provide a separate trip curve for arc energy-reducing maintenance setting (ERMS).

3. Trip unit shall operate in Fast Instantaneous trip mode (25 to 30 ms), when ERMS trip curve is active.

4. A lock feature shall be provided so that the ERMS may be locked in the ON position.

5. A blue indicating light shall be provided to indicate trip unit is in the ERMS ON mode.

6. ERMS mode shall be indicated via remote communication network, if provided, to plant control system.

D. Remote Racking Device [- Not Used]

1. Remote racking device shall be specifically designed by circuit breaker manufacturer.

2. Remote racking mounts can be ordered pre-installed on all specified NW breaker for PZ-4 at time of quotation or ordered to be field installed by the customer.

3. The device shall not obstruct view of the front of the breaker during operation, allowing for the breaker trip indication window to be viewed at all times.

4. The device shall have an ergonomically designed control handle with a selector switch to change between racking the breaker to the connected-to-disconnected and disconnected-to-connected states.

5. The device shall rack the circuit breaker between connected, test, and disconnected positions, stopping at each position before continuing.

6. The control handle shall come with a minimum of 25 feet control cable allowing for the user to rack the breaker from a distance. Extra control cables should be an additional option that can be connected in series to allow the user to stand as far as 90 feet away from the gear.

7. A 120V external power source shall be required to power this device.

E. Arc Resistant Enclosure [- Not Used]

1. Arc resistant switchgear structures shall be designed with a fully coordinated internal arc gas management system which is specifically designed to increase ventilation and cooling during normal operating conditions, and contain, channel, and exhaust all arc fault energy through of the top of the equipment and away from personnel in the event of an internal arc fault.

2. Circuit breaker doors shall be hinged and specifically tested to withstand an internal arcing event per ANSI/IEEE C37.20.7. Circuit breaker doors shall not utilize door mounted rubber bellow system to seal breaker compartment, which would require additional maintenance and special alignment when opening and closing the door.

3. Switchgear structures shall meet Type 2B accessibility requirements as stated in ANSI/IEEE C37.20.7.

4. Each structure shall contain a floor damper assembly which is specifically designed to increase ventilation and cooling during normal operation, and close in the event of an arc fault, sealing the
base of the equipment from exhausting any arc fault energy. Venting of front door areas is not allowed.

5. The arc resistant switchgear shall be provided with a roof baffle exhaust which maintains an ANSI/IEEE Type 2B rating and have been third-party UL witness tested. The roof baffles shall be fitted to the top of each structure and allow for ventilation and cooling under normal conditions. Each roof baffle shall be fitted with pressure-relief flaps which open, and remain open in the event of an internal arc fault, and shall open in such a manner which directs the arc fault exhaust towards the rear of the equipment. The arc resistant switchgear shall be provided with an arc plenum exhaust system which has been tested according to ANSI/IEEE C37.20.7. The arc plenums shall be UL witness tested to ANSI/IEEE C37.20.7, and shall not include any ventilated openings or baffles which may allow the escape of arc fault debris.

6. Prepared spaces will contain a prepared space cassette to maintain the ANSI Type 2B rating.

2.8 DIFFERENTIAL GROUND FAULT PROTECTION [- NOT USED]

A. 480Y/277V or 600Y/347V, 4-wire, connected equipment having multiple sources shall have a modified differential ground fault system (MDGF). The manufacturer shall complete the MDGF design prior to building equipment to ensure that the proper main or tie breaker(s) operate properly during the following occurrences on the main bus.

1. Insure the system shall trip with the occurrence of a ground fault at any location in the switchgear.
2. Insure system shall not trip without ground fault and with normal current flow.
3. Insure system shall not trip due to large single-phase currents.
4. Insure system shall trip with combination of normal current flow and ground fault current flowing together.
5. Insure system shall not trip with circulating currents through the neutral due to multiple grounds and sources external to the immediate low voltage power sources.

B. The manufacturer shall be required to include additional CT’s, ground fault relays, interlocks, wiring, components etc. to insure the ground fault systems operates without nuisance tripping on the main bus of the switchgear.

C. The manufacturer shall include a wiring diagram of the MDGF system along with a test procedure using high current injection equipment.

2.9 HIGH RESISTANT GROUNDING (HRG) [- NOT USED]

A. Manufacture shall supply complete HRG system integral to the low voltage switchgear with the following criteria:

1. This system shall be used in [four wire wye][three wire delta] system.
2. Multi tap resister that allows for adjustment of the resistor to minimize the ground current to 5A.
3. [Digital][Analog] ammeter shall be provided to measure the charging current and actual ground fault current when a ground current should occur.
4. [Digital][Analog] voltmeter shall be provided to measure the voltage drop across the resistor. The two set point contacts on the relay allow the customer to set the percentage of voltage drop across the resistor on the upper limit and lower limit to alarm in the case of a system issue.
5. Three different colored pilot lights shall be utilized to convey the status of the system. Green shall be used to indicate control power is available and system is operating normally. Red shall be used to indicate the voltage drop across the resistor is higher than the customer’s set point. Amber lights shall be installed to indicate the pulse circuit is being utilized.
6. A three position selector switch shall be provided to allow the system to operate in auto or manual mode. The third position shall be reserved for reset; to allow the system to be reset manually after the ground fault is cleared.

7. A second two position selector switch shall be provided to allow the operation to be changed from normal to pulse, in the instance a ground fault has occurred. The pulse operation shall allow for momentary pulses of higher current to be let through the resistor, such that the portable ground fault detector can be utilized.

2.10 OUTDOOR NEMA 3R ENCLOSURE [- NOT USED]

A. Outdoor NEMA Type 3R Walk-in Switchgear shall be enclosed in an outdoor walk-in NEMA type 3R enclosure conforming to all applicable requirements of [UL1558], [UL891], [CSA and labeled cUL].

B. The enclosure shall have a roof sloping toward the front and rear. Outer sections shall be the same widths as indoor structures. Appropriate spacing using standard equipment and dimensions shall be made on the left end of the lineup to adapt for the “door swing” of interior equipment.

C. The interior front aisle depth for walk-in structures shall be 42”, minimum. Access doors shall be available on both ends of the aisle.

D. The enclosure shall be provided with rear hinged pad lockable doors with wind stops for each section. Aisle doors shall be supplied with provisions for locking. A steel floor shall be provided in the walk-in aisle space. Full rear section bottom barriers shall be provided to prevent the entrance of rodents and vermin. Ventilating openings shall be provided complete with replaceable air filters. Provide necessary space heaters thermostatically controlled for breaker, bus and cable compartments of adequate wattage to prevent the accumulation of moisture within the compartments.

E. Provide panic door hardware on aisle doors at each end of the line-up. External locking of the aisle doors shall not prevent operation of the panic hardware from the interior of the enclosure. The construction of the enclosure shall be modular so future sections can be added without affecting NEMA 3R integrity. Provide interior aisle fluorescent lights, 3-way switches and GFI protected receptacles.

F. Power for the space heaters, lights and receptacles shall be obtained from a [control power transformer within the switchgear][source as indicated on the drawings]. Supply voltage shall be 120 volts AC.

G. An overhead circuit breaker lifter shall be provided in the aisle of the enclosure. Each shipping section shall be shipped completely assembled.

H. Top [busway][conduit] provisions shall be provided.

I. Transformer connection(s) shall be provided.

J. Interior exit/emergency lights shall be provided inside over each aisle door.

K. Exterior lights shall be provided over the outside of each aisle door.

L. Increased interior lighting shall be provided to allow approximate illumination to 150 FC.

M. Thermostatically controlled aisle exhaust fan shall be provided.

N. Seismic mounting brackets to meet provisions of the 1997 UBC, 2001 CBC, NFPA5000, IBC, and ASCE7.

O. The enclosure shall be provided with an undercoating applied to the underside of the enclosure.
2.11 POWER METERING [- NOT USED]

A. Provide a power meter for each application [shown on drawings] as follows:

1. LV Mains: The metering device used to monitor the low voltage mains for network management, energy cost allocation, power quality analysis, asset management, operational efficiency, and compliance reporting, shall be [as follows:] [a Power Quality Meter as specified in Section 26 27 13.16 Power Quality Meters.]
   a. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date: PowerLogic [ION9000 Meter][Circuit Monitor 4000T][PM8244 Meter][PM5563 Meter] by Schneider Electric, [2nd manufacturer and model], [3rd manufacturer and model].
   b. Power monitoring capabilities of the circuit breaker trip unit may be used instead of a mains power Meters.

2. LV Feeders: The metering device used to monitor the low voltage mains for network management, energy cost allocation, [power quality analysis] asset management, operational efficiency, and compliance reporting, shall be [as follows:] [a Power Meter as specified in Section 26 27 13.13 Power and Energy Meters][Power Quality Meter as specified in Section 26 27 13.16 Power Quality Meters.]
   a. The power monitoring capabilities of the circuit breaker trip unit shall be used for feeder power monitoring.

3. CT’s shall be appropriately sized for use on the main

4. A separate HMI and display shall be mounted on the same door as the Main Circuit Breaker. No line voltage shall be present on the breaker door for the PowerLogic metering components. S
   a. The HMI shall be a touchscreen color display.

2.12 COMMUNICATIONS [- NOT USED]

A. Switchgear lineup shall include an internal interwired communications network for connection to user’s network for power monitoring, equipment status and alarm information. The following communications capabilities to the switchgear communications network shall be provided:

1. A connection shall be available for Building Management System, Energy & Power Management System (EPMS) or software via protocol specified below.

2. Access through a standard web browser shall be available for maintenance review, troubleshooting and monitoring of each breaker’s embedded web pages.

B. The network communication system shall be pre-configured and tested at the factory with drawings of the network and device addresses. Final device addressing shall be configurable by the end user.

C. The network interwiring shall consist of shielded cables with pluggable connectors to facilitate ease of connection across shipping splits.

D. Documented communications test results including network connections shall be provided upon request.

E. The switchgear communication system shall consist of the following

F. [Ethernet Modbus TCP IP connection via daisy-chain architecture to each Stored Energy, Power Circuit Breaker and Meters. Each Stored Energy, Power Circuit Breaker shall contain embedded web pages to provide breaker/cradle status, energy monitoring, historical trending, maintenance indicators/logging, email alerts and communications diagnostics through a standard web browser. Downloadable software shall be available to adjust trip/alarm points, display tripping curves and update firmware]
G. Circuit breakers shall be provided with a communication interface with two Modbus TCP/IP 10/100 Mbps ports (dual-port, single network) for connection to an Ethernet network for real-time access to the circuit breaker device data and settings. Ethernet network accessible circuit breakers shall provide embedded web page interface using a standard PC and web browser without the need for additional hardware and software. Ethernet communication interfaces shall be compliant to Device Profile Web Service (DPWS) for auto-discovery on the local area network (LAN).

H. Ethernet interface device used on drawout circuit breakers shall be capable of reporting cradle position, viewable in the embedded Web page and over a data connection to external monitoring software.

I. [Modbus RS485 serial connection to each breaker with Ethernet Modbus TCP IP user interface provided via Ethernet Server. Meters, if any, shall be connected to the network via Ethernet. The Ethernet Server shall provide webpages for each Stored Energy, Power Circuit Breaker for breaker/cradle status, energy monitoring, historical trending, maintenance indicators/logging and communications diagnostics.]

2.13 ELECTRICAL POWER MANAGEMENT SYSTEM [- NOT USED]

A. The equipment specified herein shall provide the necessary communications connectivity and functionality of an Electrical Power Management System (EPMS). This shall include, but not be limited, to the following:

1. Communications connectivity using the specified Ethernet network and protocols of the EPMS and related EPMS connected devices and equipment necessary to provide functionality. Devices may be connected through a communications gateway as shown or specified; otherwise Ethernet and protocol connectivity shall be provided within the equipment. Equipment sections with multiple connected devices and assemblies of bolted adjacent bays shall include an internal inter-wired communications network for a singular connection to the EPMS network for power monitoring, equipment status and alarms.

2. Compliance with Cyber security requirements.

3. Remote EPMS application functionality for equipment configuration [and operational control]; electrical power monitoring; power quality monitoring, compliance and correction; and alarm monitoring with event log.

4. Circuit breakers shall support breaker aging modeling by the EPMS software.

5. Refer to the Electrical Power Management System specification section for additional requirements.

B. Native software compatibility shall be fully factory-tested, and shall include the following characteristics.

1. Capability for pre-engineered, interactive graphical display screens to view and analyze real-time device data. Data displayed shall include the following:

2. Pre-mapping of registers to standard measurement names without the need for additional configuration or internal device registers.

3. Automatic collection and logging of device data by EPMS software without additional configuration. Historical data logged shall include the following.

PART 3 - EXECUTION

3.1 GENERAL

A. In addition to the requirements specified herein, execution shall be in accordance with the requirements of specifications Section [26 00 10][16010], Section [26 08 00][16080] and Drawings.
B. Examine equipment exterior and interior prior to installation. Report any damage and do not install any equipment that is structurally, moisture, or mildew damaged.

C. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

1. Check that concrete pads are level and free of irregularities.

D. Pre-Installation Conference: Prior to commencing the installation, an onsite pre-installation conference shall review the material selections, installation procedures, and coordination with other trades. Attendees shall include, but shall not be limited to, the Contractor, the Installer, manufacturer's representatives, and any trade that requires coordination with the work. Date and time of the pre-installation conference shall be acceptable to the Owner and the Engineer.

A. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.

B. Install equipment in accordance with reviewed product data, final shop drawings, manufacturer’s written instructions and recommendations, and as indicated on the Drawings.

C. Provide final protection and maintain conditions in a manner acceptable to the manufacturer that shall help ensure that the equipment is without damage at time of Substantial Completion.

3.2 FACTORY ACCEPTANCE TESTING [- NOT USED]

3.3 FIELD QUALITY CONTROL [- NOT USED]

A. Functional testing, commissioning, and first parameter adjusting shall be carried out by a factory-trained manufacturer’s field service representative. This manufacturer’s field service technician shall provide all material, equipment, labor and technical supervision to perform inspection, testing and adjustments to ensure equipment is installed, adjusted, and tested in accordance with the manufacturer’s recommendations and is ready for operation. The manufacturer’s field service technician shall replace damaged or malfunctioning equipment and report to the Engineer any discrepancies or issues with the installation.

B. The manufacturer’s representative shall, upon satisfactory completion of inspection and testing, attach a label to all serviced devices indicating the date serviced and testing company responsible.

3.4 FIELD TESTING AND COMMISSIONING [- NOT USED]

A. Operational Readiness Testing

1. The Contractor shall inspect and test furnished equipment and associated systems for conformance to the contract documents, including equipment manufacture’s recommendations, and readiness for operation. The test shall include the following as a minimum:
   a. Visually inspect for physical damage and proper installation
   b. Perform tests in accordance with manufacturer's instructions
   c. Perform tests to ensure compliance with Contract Documents
   d. Perform tests that equipment is ready for operation
   e. Touch-up paint all chips and scratches with manufacturer-supplied paint and transfer remaining paint to Owner

2. Contractor shall submit an operational readiness test report documenting all test results, including all assumptions, conditions, allowances and corrections made during the test. The report shall
provide a listing of all modifications and adjustments made onsite to include any settings / parameters not identified as factory defaults within the equipment’s O&M documentation. The test report shall include a signed statement from the Contractor, installer(s) and the factory-trained manufacturer’s representative(s) certifying that the furnished equipment and associated system have been installed, configured, and tested in accordance with the manufacturer’s recommendations, completely conforms to the requirements of the Contract Documents and is ready for operation.

B. Functional Demonstration Testing

1. Prior to scheduling functional demonstration testing the Contractor shall submit a signed statement from the Contractor, installer(s) and the factory-trained manufacturer’s representative(s) certifying that the furnished equipment and associated system have been installed, configured, and tested in accordance with the manufacturer’s recommendations, completely conforms to the requirements of the Contract Documents and is ready for operation.

2. The Contractor shall completely demonstrate the functionality and performance of the equipment and associated systems in the presence of Owner and Engineer, observing and documenting complete compliance with the Contract Documents.

3. The Contractor shall submit a written report documenting successful completion of functional demonstrating testing including all assumptions, conditions, allowances and corrections made during the test.

3.5 TRAINING [- NOT USED]

A. O&M Training: Onsite training specific to the equipment furnished shall be provided to the Owner’s staff by a factory trained manufacturer’s representative. Training duration shall be sufficiently adequate to cover the operation and maintenance of the equipment and shall consist of not less than [1][2 repeated] session(s) with [4] hours of onsite classroom and hands-on instruction for a minimum of [4] attendees per session.

1. The instructor shall provide sufficient time and detail in each session to cover the following as a minimum:
   a. Theory of operation
   b. Major components of equipment
   c. Operation of equipment
   d. Configurations of equipment
   e. Maintenance, troubleshooting and repair
   f. Replacement of component level parts

2. [The submitted O&M manuals shall be used for training.][Manuals and documentation shall be provided to each participant for training.]

END OF SECTION [26 23 00][16430]
the specific project. This guide specification is subject to change without written notice by the manufacturer and the manufacturer expressly disclaims any warranty, expressed or implied.