**SECTION 26 13 13**

**MEDIUM-VOLTAGE METAL ENCLOSED CIRCUIT BREAKER SWITCHGEAR**

1. **GENERAL**
   1. **DESCRIPTION**
      1. This section specifies the furnishing and testing of medium-voltage (2.4 kV through 15 kV) metal enclosed vacuum circuit breaker switchgear, indicated as “switchgear” in this section.
   2. **QUALITY ASSURANCE**
      1. The equipment furnished under this Section shall be the product of a manufacturer who has produced paralleling switchgear up to 15kV for a period of at least 15 consecutive years.
      2. The switchgear equipment manufacturer shall have all aspects of design, assembly, and testing of the equipment within the same location.
      3. The switchgear manufacturer shall have field service personnel and facility with spare parts. The spare parts stocked at the facility shall include vacuum circuit breakers, automation controllers, control switches and lights, fuses, medium voltage insulators, etc.
   3. **FACTORY TESTS**
      1. Medium-Voltage Switchgear Assembly Tests:
         1. Visual and Mechanical Inspection:
            1. Verify that fuse and circuit breaker sizes and types correspond to Drawings and coordination study.
            2. Verify that current and voltage transformer ratios correspond to Drawings.
            3. Inspect bolted electrical connections using calibrated torque-wrench method.
            4. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

Attempt closure on locked-open devices. Attempt to open locked-closed devices.

* + - * 1. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
        2. Inspect insulators for evidence of physical damage or contaminated surfaces.
        3. Verify correct barrier and shutter installation and operation.
        4. Exercise active components.
        5. Inspect mechanical indicating devices for correct operation.
        6. Verify that filters are in place and vents are clear (if applicable).
        7. Perform visual and mechanical inspection of instrument and control power transformers.
        8. Inspect control power transformers.

Inspect for physical damage, cracked insulation, broken leads, and tightness of connections, defective wiring, and overall general condition.

Verify that primary and secondary fuse or circuit breaker ratings match drawings.

Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

* + - 1. Electrical Tests:
         1. Perform a power frequency dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, according to ANSI C37.20.2 Table 1.

If no evidence of uncontrolled discharge or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

* + - * 1. Control Power Transformers:

Perform insulation-resistance tests. Perform measurements from winding to winding and each winding to ground.

Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at all devices.

Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.

Verify correct function of control transfer relays located in the switchgear with multiple control power sources.

* + - * 1. Voltage Transformers:

Perform secondary wiring integrity test. Verify correct potential at all devices.

Verify secondary voltages by energizing the primary winding with system voltage.

* + - * 1. Perform current-injection tests on the entire current circuit in each section of switchgear.

Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

Vary the magnitude of the injected current and verify overcurrent trip of all the overcurrent protective relays.

* + - * 1. Perform system function tests according to "System Function Tests" Article.
        2. Verify operation of space heaters (if applicable).
        3. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.
    1. Medium-Voltage Vacuum Circuit Breaker and Isolation Devices Tests:
       1. Visual and Mechanical Inspection:
          1. Inspect physical and mechanical condition.
          2. Inspect anchorage, alignment, grounding, and required clearances.
          3. Verify the unit is clean.
          4. Perform mechanical operation tests on operating mechanism
          5. Verify cell fit and element alignment.
          6. Verify racking mechanism operation.
          7. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
       2. Electrical Tests:
          1. Verify correct operation of electrical close and trip operation, trip-free operation, and anti-pump function.
          2. Trip circuit breaker by operation of each protective device. Reset trip logs and indicators on components that are able to be reset.
          3. Perform a dielectric-withstand-voltage test. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.
          4. Verify that current transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.
          5. Verify that voltage transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3. Test results shall indicate that the circuits are grounded at only one point.
    2. Metering Devices Tests:
       1. Inspect physical and mechanical condition.
       2. Inspect bolted electrical connections.
       3. Verify all instrument node numbers, multipliers (CT and PT ratios). Instrument multipliers shall be according to system design specifications.
       4. Verify that current transformer and voltage transformer secondary circuits are intact. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.
       5. Test meter readings via secondary injection.
    3. Medium-Voltage Surge Arrester Field Tests:
       1. Visual and Mechanical Inspection:
          1. Verify that equipment nameplate data complies with Design Documents.
          2. Inspect physical and mechanical condition.
          3. Inspect anchorage, alignment, grounding, and clearances.
          4. Verify the arresters are clean.
          5. Verify that the ground lead on each device is attached to a ground bus or ground electrode.
       2. Electrical Test:
          1. Microprocessor-Based Protective Relay Field Tests:

Visual and Mechanical Inspection:

Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.

Verify operation of light-emitting diodes, display, and targets.

Record passwords for each access level.

Clean the front panel and remove foreign material from the case.

Check tightness of connections.

Verify that the frame is grounded according to manufacturer's instructions.

Set the relay according to results of the coordination study (if available).

Download and save settings from the relay.

Electrical Tests:

Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.

Functional Operation: Check functional operation of protective function used in the protection scheme as follows via secondary injection of the currents and voltages.

* + 1. System Function Tests:
       1. Conduct testing of the sequence of operation according to the Specification.
       2. Simulate the Power System conditions as required.
       3. Verify operation of every automated sequence.
  1. **SUBMITTALS**
     1. Product Data: Submit manufacturer's printed product data.
     2. Drawings: Submit shop drawings for approval. Include components, materials, finishes, detailed plan and elevation views, openings, and accessories.
  2. **APPLICABLE PUBLICATIONS**
     1. 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 basic designation only.
     2. American National Standards Institute (ANSI):

C37.54..................Indoor Alternating Current High-Voltage Circuit

Breakers Applied as Removable Elements in Metal-Enclosed Switchgear - Conformance Test Procedures

C37.55..................Medium-Voltage Metal-Clad Assemblies –

Conformance Test Procedures

* + 1. Institute of Electrical and Electronics Engineers (IEEE):

C37.04..................Standard for Rating Structure for AC High Voltage Circuit Breakers

C37.09..................Standard Test Procedure for AC High-Voltage Circuit

Breakers Rated on a Symmetrical Current Basis

C37.20.3................Standard for Metal-Enclosed Interrupter Switchgear

C37.90..................Standard for Relays and Relay Systems Associated with Electric Power Apparatus

C57.13..................Standard Requirements for Instrument Transformers

* + 1. National Electrical Manufacturer's Association (NEMA):

C37.06.1................Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis

C37.57..................Switchgear-Metal-Enclosed Interrupter Switchgear Assemblies - Conformance Testing

LA 1....................Surge Arrestors

SG-4....................Alternating-Current High Voltage Circuit Breakers

SG-5....................Standards for Power Switchgear Assemblies

SG-6....................Standards for Power Switchgear Equipment

* + 1. National Fire Protection Association (NFPA):

70-11...................National Electrical Code (NEC)

* + 1. International Electrotechnical Commission (IEC):

60694...................Common specifications for high-voltage switchgear and controlgear standards

1. **PRODUCTS**
   1. **SYSTEM RATING**
      1. System Voltage: (2.4/4.16/12.47/13.2/13.8) kV nominal, three-phase, 60 Hz.
      2. Maximum Design Voltage: (4.76/15) kV.
      3. Impulse Withstand (Basic Impulse Level): (60/95) kV.
      4. Power Frequency Withstand: (19/36) kV, 1 minute test.
      5. Fault interrupting and Short Time withstand (2 seconds): (25/40/50) kA RMS Symmetrical
      6. Main Bus Ampacity: (1200/2000/3000) amps, continuous.
      7. System X/R ratio: up to 17 without derating
   2. **GENERAL REQUIREMENTS**
      1. Manufacturers: Subject to compliance with requirements, provide switchgear of the following:
         1. Advanced Power Technologies (APT) – Contact Brandon Lopez for quotation.
         2. In order to be an approved manufacturer, the manufacturer seeking to be approved shall send pertinent product information, qualifications, references, and evidence of support capabilities as per section 1.2 of this specification thirty days prior to the bid date to both customer and engineer.
      2. Switchgear shall be in accordance with ANSI, IEEE, NEMA, NFPA, IEC as shown on the drawings, and have the following features:
         1. Switchgear shall be a complete, grounded, continuous-duty, integral assembly, metal enclosed, dead-front, self-supporting, indoor type switchgear assembly. Incorporate devices shown on the drawings and all related components required to fulfill operational and functional requirements.
         2. The “100% front access only” design shall allow access to every part of switchgear required for installation and maintenance, including front access to every bolted connection, every current carrying and insulating part. All bolted bus joints shall be “100% front access only”.
         3. Switchgear shall be supplied as a complete system and shall include all the necessary components and equipment to accommodate described system operation unless otherwise noted.
         4. Switchgear shall conform to the arrangements and details shown on the drawings.
         5. Switchgear shall be fully assembled, connected, and wired at the factory so that only external circuit connections are required at the construction site.
         6. All non-current-carrying conductive parts shall be grounded.
         7. Packaging shall include the switchgear to be stretch wrapped and mounted to a skid and to provide adequate protection against rough handling during shipment.
   3. **HOUSING**
      1. Frames and enclosures:
         1. Enclosure shall be designed according to NEMA (1/3R) standard for (indoor/outdoor) operation.
         2. The switchgear enclosure frame shall be produced from at least 11 gauge mild steel and the switchgear enclosure doors shall be produced from at least 12 gauge mild steel.
         3. Switchgear width shall not exceed the space as allocated on the floor plan with maximum width dimension of 26 inches per section and maximum depth dimension of 38.5 inches.
         4. Enclosure shall be of rigid frame construction.
         5. The switchgear construction shall allow front access only installation and maintenance so that the switchgear could be installed with its back against the wall.
         6. The assembly shall be braced with integral reinforcing gussets using bolted connections to assure rectangular rigidity.
         7. The enclosure shall be steel, leveled, and not less than the gauge required by applicable publications.
         8. Switchgear shall have mounting holes for connecting adjacent structures to insure proper alignment, and to allow for future additions.
         9. All bolts, nuts, and washers shall be zinc-plated steel.
         10. For ease of on-site cable connections and maintenance an open bottom and removable full depth side sheets shall be provided.
         11. For ease of the switchgear service, maintenance and future upgrades, all the support structures, braces and cover sheets shall be removable and attached to the frame via bolts.
      2. Equipment fronts:
         1. Each switchgear section shall have two fully removable panels, manufactured from at least, 14 gauge steel. Removal of the upper panel shall completely expose the main bus for maintenance. Removal of the lower panel shall expose the vacuum interrupters, current transformers and cable connection for inspection and connection of cables.
         2. The upper panel of each section shall cover access to the switchgear main bus and main bus isolation switch blades, and operator. visible disconnect viewing window shall be immediately below. This is to provide operators with visual assurance that the switch blades are physically disconnected from the main bus.
         3. The lower panel of each section shall cover the circuit breaker cell.
         4. The following equipment shall be mounted on the front of each circuit breaker section:
            1. Circuit breaker position indicator lamps.
            2. Removable carbon steel plate to cover Lexan viewing window for observing visual air disconnect switch position.
      3. Circuit Breaker Cubicles:
         1. An individual cubicle shall be supplied for each circuit breaker and each future circuit breaker, if applicable, as shown on the drawings.
         2. Each cubicle furnished with a circuit breaker (active or spare) shall be fully equipped as noted on drawings and specified below.
      4. Markings and Nameplates:
         1. Each switchgear section shall have a label permanently affixed to it, listing the following information: Name of manufacturer, system voltage, ampacity, interrupting rating, enclosure type, and manufacturer's shop order number.
         2. Each control switch, indicating light or other component mounted on the inner panel shall be identified by a nameplate.
         3. The nameplates shall be produced from clear textured polycarbonate, laminated on high performance pressure sensitive adhesive. The printing shall be done on the interior surface of the laminate to avoid scratching or other deterioration of text. The lettering shall be white on black background.
      5. Finish:
         1. All metal surfaces shall be thoroughly cleaned with the following cleaning process:
            1. Alkaline cleaned (phosphate free)
            2. Double rinsed
            3. Conversion coating process (phosphorous-free)
            4. Final rinse with reverse osmosis processed water
         2. Powder coat of ANSI 61 Light Gray shall be applied to all interior and exterior surfaces for superior corrosion protection.
   4. **BUS**
      1. Provide sliver plated copper bus, fully rated for the amperage shown on the drawings for entire length of the switchgear.
      2. Mount the bus on appropriately spaced insulators and brace to withstand the available short circuit currents.
      3. All bus (main, neutral, ground, extension, etc.) shall be produced from silver plated copper.
      4. Silver-plated copper, appropriately sized bus bar and extensions shall have NEMA standard hole pattern to accommodate cable connections.
      5. Install a silver plated copper ground bus the full length of the switchgear assembly.
      6. All bolts, nuts, and washers shall be zinc-plated steel. Bolts shall be torqued to 55 foot-lbs for 1/2” hardware and 35 foot-lbs. for 3/8” hardware.
   5. **CIRCUIT BREAKERS**
      1. Breakers that have the same ratings shall be interchangeable with other breakers in that line-up.
      2. The interrupting ratings of the breakers shall be not less than (25/40/50) kA, with amperages being as indicated in the drawings.
      3. Circuit breakers shall have the following features:
         1. All the circuit breakers shall be of vacuum type, with stored energy mechanism, fixed mounted on rollers (for ease of removal for repair or replacement), electrically operated, with closing coil, shunt trip coil, “a” and “b” aux. contacts.
            1. Three independent sealed high-vacuum interrupters.
            2. Hermetically sealed vacuum interrupters to protect contacts from corroding elements and contamination.
            3. Breaker total interrupting time of 3 cycles.
            4. Circuit breaker assembly shall be equipped with rollers to assist in removal of circuit breaker from switchgear.
            5. The front shield of the circuit breaker shall be metal.
            6. Secondary control circuits shall be connected automatically with a self-aligning, self-engaging plug and receptacle arrangement when the circuit breaker is racked into the connected position.
            7. Provision shall be made for the secondary control plug to be manually connected in test position.
         2. Operating mechanism:
            1. The circuit breaker shall be operated by means of a stored energy mechanism which is normally charged by a charging motor but can also be charged by the manual handle supplied on each circuit breaker for manual emergency closing or testing.
            2. The mechanism shall operate in a quick make, quick break manner and shall be charged by a small universal motor to provide stored energy for breaker operation.
            3. An interlocking system shall be provided to prevent racking a closed circuit breaker to or from any position. An additional interlock shall automatically discharge the stored-energy operating mechanism springs upon removal of the breaker out of the compartment.
            4. The speed of the contacts during the operation shall be independent of the control voltage and the operator's movements.
            5. Equip the mechanism for manual opening and closing of the contacts during loss of normal control power.
         3. Insulating barriers shall be provided between each phase of the circuit breaker and isolation switch and between the outer phases and the adjacent section of the switchgear line-up.
         4. Circuit Breaker Lifting Device:
            1. The switchgear design shall allow for the circuit breaker to slide out of the circuit breaker compartment on rails to be placed on a low cart or lifting device for withdrawal or insertion in the circuit breaker compartment.
         5. The following protective relaying functions shall be provided for each circuit breaker:
            1. Microprocessor based three phase time overcurrent, instantaneous and ground fault relay device 50/51 and 50/51G.
            2. The relay shall include an HMI (human machine interface) with an LCD display for viewing and changing of settings, record retrieval and monitoring.
   6. **MAIN BUS TO CIRCUIT BREAKER ISOLATION SWITCH**
      1. An air insulated, isolation switch shall be provided in-line with the circuit breaker with Lexan viewing window for observing visual air disconnect switch position. Viewing window shall permit full view of the position of all three switch blades.
      2. Inline visible air-disconnect isolation switch shall be pad-lockable in open and/or closed position, to ensure personnel safety during power system operation, service, maintenance and repairs.
      3. Inline visible air-disconnect isolation switch shall be mechanically and electrically interlocked with the circuit breaker and immediately trip the circuit breaker to prevent opening or closing of the switch while the circuit breaker is closed.
      4. An electrical interlock shall be provided to prevent closing of the circuit breaker unless the isolation switch is in closed position or in fully open position (primary disconnect contacts are separated by a safe distance).
      5. The complete Isolation Switch assembly, shall be easily removable from the front of the switchgear (slide-out design), to allow replacement of the complete assembly, with the minimum time needed to de-energize the main bus.
   7. **ANNUNCIATION**
      1. Circuit breaker control switches with maintained “Open”, “Auto” spring returned to center “Close” positions and two (2) position indicating lights (Open and Closed) shall be provided for each circuit breaker.
      2. All indicating lights shall be of high visibility, LED type with lenses of at least 1 inch outside diameter with service life of 100,000 hours at 77°F temperature.
   8. **SENSING & METERING**
      1. Current Transformers (CTs):
         1. Provide current transformer ratios as shown on the drawings.
         2. Accuracies shall be coordinated with the associated relays by the switchgear manufacturer to assure proper operation at the selected pick-up and operating current values.
         3. Set of 3 CTs for each circuit breaker with quantity and ratio as specified by the drawing or customer.
         4. The current transformer mounting assembly shall be insulated for the full voltage rating of the switchgear.
         5. All the current circuits shall be wired using ring type terminals.
      2. Potential Transformers (PTs):
         1. Potential transformers shall be appropriately fused, fixed mounted, connected in (wye/open delta) configuration to the line or load side of the circuit breaker as indicated on the drawings.
         2. Bus potential transformers shall be appropriately fused, drawout mounted, connected in (wye/open delta) configuration to the line or load side of the circuit breaker and indicated on the drawings.
      3. Control Power Transformers (CPTs):
         1. Switchgear shall self-derive the control power required for the switchgear space heaters, battery charger and other consumers.
         2. Control power transformers shall be provided if required for proper switchgear operation if indicated elsewhere in this specification or the drawings.
         3. The control power transformers shall be properly protected by primary current-limiting fuses.
      4. Power Metering:
         1. The following true RMS, 3 element power metering of each power source and bus shall be provided as a minimum:
            1. Line to line voltages:

Vab, Vbc, Vca

* + - * 1. Phase currents:

Ia, Ib, Ic

* + - * 1. Frequency, Hz
        2. Three phase power parameters:

kW (per phase and total)

Power Factor (per phase and total)

KVAR (per phase and total)

kVA (per phase and total)

* + - * 1. Three energy export and import power parameters:

kWh, kVARh, kVAh

* + - * 1. Power Quality parameters:

%THD Volts per phase

%THD Amps per phase

%TDD Amps per phase

K-factor per phase

Individual odd Voltage harmonics per phase up to order 39

Individual odd current harmonics per phase up to order 39

Fundamental component of KW and Power Factor (per phase and total)

* + - * 1. Other parameters:

Percent ampere peak capacity of the highest phase

Neutral current

Current unbalance

Voltage unbalance

Maximum kW demand

Maximum kVA demand

Minimum and maximum values for voltages, currents frequency and power parameters

* + - 1. Metering accuracy shall be in accordance with ANSI C12.20-1998 and rated as follows:
         1. Class 10 0.5% for energy.
         2. 0.2% of reading and 0.02% of full scale for voltages and currents.
         3. 0.3% of reading and 0.02% of full scale for active and apparent power.
      2. Dedicated high-brightness digital LED displays shall be provided which are visible in the bright sun light or in the dark.
  1. **STATIONARY BATTERY SYSTEM**
     1. Batteries:
        1. A fully integrated battery system shall be of the sealed lead-acid recombination type with a float voltage charge of 13.62V/bloc at 77°F.
        2. Battery capacity shall be based on the lowest ambient temperature in the room where it is to be installed. A safety margin of 50 percent for reserve capacity shall be included.
        3. Sufficient battery capacity provided to carry all continuous loads (lamps, relays, etc.) for 8 hours and then perform the greater of the following duties, with the charger de-energized:
           1. Trip all circuit breakers simultaneously or,
           2. Close the largest breaker in a lineup of four or less breakers, or close the two largest breakers simultaneously in a lineup of more than four breakers. Breaker closing current shall include both the spring release coil current and the starting current of the spring charging motor.
        4. The batteries shall be UL 1778 recognized and have up to 10 year design life at 77°F on float.
        5. The cell shall utilize the recombination principle. Oxygen evolved from the positive plates shall diffuse through the highly porous glass microfiber separator to the negative plate where it shall chemically be reduced to water. This process will reduce the total liquid evolved from the cell. Recombination efficiency shall be greater than 99%.
        6. Plates shall be plastic type with the positive plate being cast in a grid alloy consisting of lead, calcium and alloy.
        7. Plates shall be gravity casted grids from high purity lead calcium tin alloy to provide an optimal current conducting framework for high rate discharge. In order to inhibit grid corrosion, no antimony or cadmium shall be used in the plates to prolong service life.
        8. No gel or sealed top wet batteries shall be allowed for safety and charge life considerations. Battery posts shall incorporate copper inserts for ease of installation and maximum conductivity. Lead flag terminals or push-on terminals are not accepted.
        9. Post Seals shall have a high integrity post seal design to prevent electrolyte leakage over a wide temperature range.
        10. One-way Safety Valves shall open at 5 PSI and close at 3 PSI to allow excess gas to escape when overcharging.
        11. Flame Arrestors shall be provided to prevent any errant spark or flames from entering the battery.
        12. Container and cover shall be made from thick walled flame retardant ABS plastic. Thermally welded case to cover sealing eliminates leaks.
        13. Battery lids shall be of robust resin type. Flame rating shall meet the standard of UL 94V-O with a minimum oxygen index of 28% to ensure flame retardancy.
        14. Batteries shall have a shelf life of 6 months before boosting is required (< 2% self-discharge per month at 77°F).
        15. Operating pressure shall be 10-49 kPA.
        16. Battery connector covers for protection against external short circuits shall be provided.
        17. Cells shall be supplied fully charged and ready for use.
     2. Battery Charger:
        1. The appropriately sized stationary battery charger shall be supplied and integrated in the switchgear.
        2. The stationary battery charger shall be supplied with the following features:
           1. AC input voltage range at 60Hz: 120, 208, 240, 480 or 575
           2. Magnetic Amplifier Circuitry
           3. Automatic AC Voltage Compensation
           4. Float/Equalize Mode Switching
           5. +/- 0.5% DC Voltage Regulation
           6. Fused AC input and DC output protects Battery and Charger/Power Supply
           7. Analog DC Ammeter and DC Voltmeter
           8. Current Limiting Circuitry prevents overload and provides current control from 50 to 120% of rated output (factory set at 115%)
  2. **CONTROL WIRING**
     1. Switchgear control wiring shall be UL/CSA approved stranded copper, minimum size No. 18 AWG, 600 Volt, 90 degrees C, flame retardant, Type SIS.
     2. Voltage and Current transformer circuits shall utilize minimum size No. 12 AWG wire. Install wiring complete at the factory, adequately bundled and protected.
  3. **SEQUENCE OF OPERATION**
     1. (APPLICATION SPECIFIC, CONTACT APT TO DISCUSS YOUR REQUIREMENTS).
     2. Sample Configuration:
        1. Utility Automatic standby with closed transition return operation:
           1. Upon sensing of the utility failure (as determined by the utility under/over voltage and under/over frequency protective devices) the utility circuit breaker shall trip open and the Time Delay Engine Start timer shall start timing.
           2. If utility failure condition remains upon expiration of the Time Delay Engine Start timer the generator sets shall be automatically started and brought up to speed and voltage. At that time utility circuit breaker as well as the designated feeder breakers shall open and generator circuit breakers shall close (after adjustable time delay). The synchronizing circuit breaker of the first available generator shall close to a dead bus. At this time the generator is supplying power to the site load.
           3. Upon sensing of utility return (utility voltage and frequency are within set tolerances) the Time Delay Emergency to Normal timer shall start timing. If utility power remains healthy (utility voltage and frequency are within set tolerances) upon expiration of the Time Delay Emergency to Normal timer the soft close transition of the load to the utility shall begin.
           4. The generator bus shall be synchronized with the utility source and when in synchronism (as determined by the synchronizing check relay), close the utility circuit breaker. At this time soft unloading of the generator set shall begin.
           5. When the genset loads are gradually reduced to the level of the unload trip setpoint the generator synchronizing breakers shall trip open and the gensets shall be put in the cooldown mode of operation.
           6. The utility under/over voltage and under/over frequency setpoints, all the automatic standby operation timers, unloading rate and unload trip setpoints shall be adjustable from the operator interface panel mounted on the control panel door.
        2. Load Management operation:
           1. Upon receipt of an automatic start signal initiated locally by the operator or remotely by customer SCADA or DCS system (via closure of a dry contact or via MODBUS TCP/IP ETHERNET interface), the switchgear shall verify that utility phase voltages and frequency are within acceptable tolerances and issue a start signal to the generator set. At that time, generator set’s speed and voltage shall be controlled by the switchgear.
           2. The generator set’s voltage shall be automatically matched with the utility bus and the genset shall be automatically synchronized with the utility under the supervision of the synchronizing check relay. When all the synchronizing conditions are met the synchronizing circuit breaker shall close. At that time, the generator set shall be gradually (soft) loaded to the desired active and reactive loading levels and remain at those levels until signaled to unload.
           3. If the unit is signaled locally by the operator or remotely by customer SCADA or DCS system to operate in Import/Export control mode of operation, the desired utility kW contribution to the site load (import) or generator kW contribution to the utility grid (export) shall be automatically maintained.
           4. Generator set loading (kW) setpoint, Import/Export setpoint, reactive power (kVAR) setpoint, loading and unloading times and loading dynamics setpoints shall be viewable and adjustable from the operator interface panel mounted on the control panels front door.
           5. The switchgear shall constantly monitor utility bus to ensure constant presence of the utility at the utility side of the generator synchronizing circuit breaker. The utility intertie protection (included in the switchgear) shall sense if there is a severe fault on the utility side of the generator synchronizing circuit breaker as well as operation of the upstream distribution recloser, or any other disconnection of the generator set from the utility upstream from the generator synchronizing circuit breaker. Upon sensing of any of the above conditions, the utility incoming circuit breaker shall immediately trip open and generator set shall continue supplying power to the site load.
           6. Upon receipt of an automatic stop signal initiated locally by the operator or remotely by customer SCADA or DCS system (via closure of a dry contact or via MODBUS TCP/IP ETHERNET interface) the switchgear shall gradually (soft) unload the generator set. When the genset load is reduced to the level of the unload trip setpoint (adjustable from the operator interface panel mounted on the switchgear door), the generator synchronizing breaker shall trip open and the genset shall be put in the cooldown mode of operation.
        3. Bumpless load transfer operation:
           1. Upon receipt of an Isolate signal initiated locally by the operator or remotely by customer SCADA or DCS system (via closure of a dry contact or MODBUS TCP/IP), the switchgear shall verify that utility phase voltages and frequency are within acceptable tolerances and issue a start signal to the generator set. At that time, generator set’s speed and voltage shall be controlled by the switchgear.
           2. The generator set’s voltage shall be automatically matched with the utility bus and the genset shall be automatically synchronized with the utility under the supervision of the synchronizing check relay. When all the synchronizing conditions are met the synchronizing circuit breaker shall close. At that time, the generator set shall be gradually (soft) loaded to assume the entire site load (entire site load minus adjustable “zero power level” setpoint) and utility circuit breaker shall be tripped open. At this time the site load has been transferred to the generator power.
           3. Upon receipt of an automatic stop signal initiated locally by the operator or remotely by customer SCADA or DCS system the generator shall be synchronized with the utility source and when in synchronism (as determined by the synchronizing check relay), close the utility circuit breaker. At this time soft unloading of the generator set shall begin. When the genset load is gradually reduced to the level of the unload trip setpoint the generator synchronizing breaker shall trip open and the genset shall be put in the cooldown mode of operation. At this time the site load has been transferred to the utility power.
           4. Loading and unloading rates and “zero power level” setpoints shall be viewable and adjustable from the operator interface panel mounted on the control panels front door.
  4. **CONTROL PANEL**
     1. The control panel shall be integrated with the switchgear.
     2. Microprocessor based controller:
        1. The microprocessor based controller shall be provided with self-diagnostic features for maximum reliability and minimum maintenance.
           1. The following multifunction protection of each source shall be included in the control system:

Undervoltage (3 phase)

Overvoltage (3 phase)

Underfrequency

Overfrequency

* + - * 1. The microprocessor based controller shall have the ability to communicate via MODBUS TCP/IP ETHERNET interface.
    1. All the internal components shall be mounted on removable sub-panels.
    2. Each control switch, indicating light or other component mounted on the door shall be identified by a nameplate.
    3. The nameplates shall be produced from clear textured polycarbonate, laminated on high performance pressure sensitive adhesive. The printing shall be done on the interior surface of the laminate to avoid scratching or other deterioration of text. The lettering shall be white on black background.
    4. All indicating lights shall be of high visibility, LED type with lenses of at least 1 inch outside diameter with service life of 100,000 hours at 77 degrees F temperature.
    5. The following major components and capabilities shall be included in the control panel as a minimum:
       1. Control power circuit breaker.
       2. Control switches – the following switches shall be provided for each generator as hard-wired, door-mounted switches for the purpose of local, manual control and operational redundancy in the event of higher level automated control failure.
          1. Engine control switches – includes maintained ‘off’ position so that generator set may be taken off-line locally and override any master or SCADA control.
          2. Generator circuit breaker control switches with breaker open and closed position indicating lights – switch to include maintained ‘open’ position so that breaker may be tripped open locally and override any automatic or SCADA control.
          3. Lamp test control switch.
          4. Generator and utility synchronizing switches and lights for both generator and utility as required.
          5. Other control components, indicating lights and switches as required for system operation.
          6. Fault reset switch and fault light – generator or engine related fault shutdowns shall cause engine to be shut down and locked out and generator breaker to be tripped open and locked out until fault reset switch is activated.
       3. Voltage and speed adjust potentiometers shall be provided for each generator as hard-wired, door-mounted devices for the purpose of local, manual control and operational redundancy in the event of higher level automated control failure.
       4. Generator and utility synchronizing check relay(s).
       5. All the monitored fault conditions including engine fault shall be annunciated on the operator interface unit on the door and cause flashing of the red indicating light.
       6. Self diagnostic annunciation shall be provided to indicate health of the integrated power monitoring, protection and control system in the control panel.
    6. Metering as described in section 2.7.D above shall be supplied for each power source.
    7. The following multifunction protection of each power source shall be included in the control system:
       1. Undervoltage (3 phase)
       2. Overvoltage (3 phase)
       3. Underfrequency
       4. Overfrequency
       5. Generator reverse power (dual setpoint)
       6. Generator reverse reactive power (dual setpoint)
       7. Generator current balance (dual setpoint)
    8. Each protective setpoint and the corresponding time delay shall be adjustable from the operator interface panel mounted on the door.
    9. Failed to automatically parallel circuit shall reset an automatic start signal and put engine in cooldown if generator synchronizing breaker fails to close after an adjustable time delay.
    10. Set of sealed lead acid batteries and charging circuit to maintain clean control power to the microprocessor based components during engine cranking.
    11. Redundant circuit breaker trip circuit shall constantly monitor the health of the genset starting batteries as well as the health of the integrated multifunction protective and control unit. Should either one of the above become faulty the synchronizing circuit breaker shall be tripped immediately using the best available source of control power (switchgear sealed lead acid batteries or genset starting batteries). This will protect from motoring of the generator set due to the loss of the control power source to the circuit breaker shunt trip coil as well as from running with faulty control and protection unit.
    12. Dry contact indicating genset running condition for use in customer interlocking circuits.
    13. Dry contacts indicating generator and utility breaker positions for customer use.
    14. All the current circuits shall be wired using ring type terminals.
    15. Integrated Human Machine Interface (HMI) panel
        1. HMI shall be NEMA 4X (IP 65) touch-sensitive graphical color display screen.
        2. HMI screen shall be back-lit with automatic screen saver mode and resolution of at least 320 x 240 pixels.
        3. HMI panel shall be a color display with all the generator set operating parameters, as well as allow for viewing and changing of all the switchgear protective, process control and configuration setpoints.
        4. HMI panel shall display real time system status overview including any active alarms, faults and certain switchgear system diagnostic conditions to assist in field troubleshooting.
        5. HMI panel shall display a historical list of all the alarms, faults and events (circuit breaker operation, control switch operation, etc.) monitored by the switchgear. Each of the above occurrences shall be displayed with the date and time stamp.
        6. HMI unit shall contain no moving parts.
  1. **MASTER CONTROLS**
     1. The master controls shall be isolated from the switchgear and provided with the equipment described above.
     2. The master control panel shall isolate switchgear operator personnel from the live components of the switchgear and allow for the control of operation from a remote location.
     3. The following major components and capabilities shall be included in the master control panel as a minimum:
        1. 20” Color touchscreen industrial PC with Microsoft Windows 7.
        2. Ethernet switch for customer Ethernet connection.
        3. Genset loading controls.
        4. Alarm annunciation.
        5. Storage of monitored data (as defined by the Engineer) with date and time stamp.
        6. Logging of the events to files with date and time stamp.
        7. Emails can be sent upon any alarm condition.
        8. Complete remote monitoring and remote control capability via Ethernet connection by Windows based PC with Internet Explorer. Software shall be provided to allow any Windows based PC with Internet Explorer connected via Ethernet to the control panel to emulate the HMI screens including the ability to control the panel operation and change all the setpoints.
        9. Software shall be provided for stored data manipulation.
        10. Capability of remote system troubleshooting via Ethernet connection.
  2. **SCADA INTERFACE**
     1. The switchgear shall be appropriately instrumented to present all the information as described below. The information extracted from the switchgear shall be converted to Modbus TCP/IP Ethernet format and presented through a single Ethernet port for ease of integration in to the Owner’s remote monitoring and control system.
     2. Set-up will require hard coded network parameters. Customer network administrator to assign network parameters to APT switchgear (IP, Network mask, Default Gateway) or use a static gateway or router with port forwarding ahead of the switchgear. If a static gateway is used, the switchgear default network parameters (IP, Network mask, Default Gateway) shall be provided to the customer. It shall be the network administrator’s responsibility to integrate the gateway into the facility’s network.
     3. The following information shall be available in Modbus TCP/IP format through a single Ethernet Port for integration in to customers SCADA PC:
        1. Each generator electrical data:
           1. Line to line voltages: Vab, Vbc, Vca
           2. Generator frequency, Hz
           3. Phase currents: Ia, Ib, Ic
           4. Three phase power parameters: kW, Power Factor, KVAR, kVA
           5. Three phase energy parameters: kWh import, kWh export, kVARh import, kVARh export
        2. Each utility electrical data:
           1. Line to line voltages: Vab, Vbc, Vca
           2. Utility frequency, Hz
           3. Phase currents: Ia, Ib, Ic
           4. Three phase power parameters: kW, Power Factor, KVAR, kVA
           5. Three phase energy parameters: kWh import, kWh export, kVARh import, kVARh export
        3. System Status Information:
           1. Each utility circuit breaker position
           2. Each generator circuit breaker position
           3. Each feeder circuit breaker position
           4. System in auto (ready for remote start)
           5. Protective relaying trip
           6. Genset battery charger alarm
           7. Fuel tank alarm
           8. Low fuel level alarm
        4. Adjustable setpoints:
           1. Genset kW loading level
           2. Genset Import kW loading level
           3. Genset Export kW loading level
           4. Import or Export control select setpoint
           5. Genset kVAR loading level
           6. Time delay engine start
           7. Time delay neutral
           8. Time delay emergency to normal
        5. SCADA DCS control:
           1. Start/load
           2. Import/Export start
           3. Bumpless load transfer start
           4. Stop/unload

1. EXECUTION
   1. COMMISSIONING
      1. Install switchgear in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.
      2. Commissioning shall be performed by the switchgear manufacturer.
      3. Commissioning shall commence once system components are in place and the contractor has indicated the system is ready for activation.
      4. Training shall be performed by the switchgear manufacturer. The manufacturer shall include training for the owner’s staff. This training shall consist of hands on demonstrations of varying states of the switchgear and the proper sequence of events that should occur with instructions on how to deal with varying scenarios. Include detailed written instructions for the successful operation of the switchgear.
      5. Events that shall be included in the hands on training:
         1. Utility Failure (if applicable)
         2. Generator Failure (if applicable)

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