**SECTION 26 23 00**

**LOW VOLTAGE SWITCHBOARD**

1. **GENERAL**
   1. **DESCRIPTION**
      1. This section specifies the furnishing and testing of a UL891 listed low-voltage paralleling or distribution switchboard and switchgear, indicated as “switchboard” in this section.
      2. Switchboard shall be designed for facilities 600V and under.
   2. **QUALITY ASSURANCE**
      1. The equipment furnished under this Section shall be the product of a manufacturer who has produced paralleling switchboards up to 600V for a period of at least 15 consecutive years.
      2. The switchboard equipment manufacturer shall have all aspects of design, assembly, and testing of the equipment within the same location.
      3. The switchboard manufacturer shall have field service personnel and facility with spare parts. The spare parts stocked at the facility shall include circuit breakers, automation controllers, control switches and lights, fuses, insulators, etc.
   3. **FACTORY TESTS**
      1. Switchboard shall conform to the dielectric (HI POT) test from UL891.
      2. Low-Voltage Switchboard Assembly Tests:
         1. Visual and Mechanical Inspection:
            1. Inspect bolted electrical connections using calibrated torque-wrench method.
            2. Confirm correct operation and sequencing of mechanical interlock systems.

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

* + - * 1. Inspect insulators for evidence of physical damage or contaminated surfaces.
        2. Verify correct barrier installation and operation.
        3. Exercise active components.
        4. Inspect mechanical indicating devices for correct operation.
        5. Verify that filters are in place and vents are clear (if applicable).

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

* + - 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 UL 891.

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. Perform current-injection tests on the entire current circuit in each section of switchboard.

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.

* + - * 1. Perform system function tests according to "System Function Tests" Article.
        2. Verify operation of space heaters (if applicable).
    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 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)/IEEE:

C37.50..................Test Procedures for Low-Voltage AC Power Circuit Breakers Used In Enclosures

C37.13..................Low-Voltage AC Power Circuit Breakers

C37.90.1................Surge Withstand Capability (SWC) Tests for Relays

and Relay Systems Associated with Electric Power Apparatus

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

PB-2....................Deadfront Distribution Switchboards

PB-2.1..................Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less

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

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

* + 1. Underwriters Laboratories, Inc. (UL):

489-09..................Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

891-05..................Switchboards

1. **PRODUCTS**
   1. **GENERAL REQUIREMENTS**
      1. Manufacturers: Subject to compliance with requirements, provide switchboard 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. Switchboard shall be in accordance with ANSI, IEEE, NEMA, NFPA, UL as shown on the drawings, and have the following features:
         1. Switchboard shall be a complete, grounded, continuous-duty, integral assembly, metal enclosed, dead-front, self-supporting switchboard assembly. Incorporate devices shown on the drawings and all related components required to fulfill operational and functional requirements.
         2. Switchboard shall be supplied as a complete system and shall include all the necessary components and equipment to accommodate described system operation unless otherwise noted.
         3. Switchboard shall conform to the arrangements and details shown on the drawings.
         4. Switchboard shall be fully assembled, connected, and wired at the factory so that only external circuit connections are required at the construction site.
         5. All non-current-carrying conductive parts shall be grounded.
         6. Packaging shall include the switchboard to be stretch wrapped and mounted to a skid and to provide adequate protection against rough handling during shipment.
         7. Switchboard shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Adequate ventilation within the enclosure shall be provided.
         8. All sections and devices shall be UL listed and labeled. Service equipment shall be UL labeled as suitable for use as service entrance equipment.
      3. Performance Requirements:
         1. Minimum short circuit interrupting rating:
            1. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current of (18/35/65/100) kA symmetrical at rated voltage unless otherwise shown on the Drawings.
         2. Voltage and current ratings: as indicated on the Drawings.
         3. Surge Withstand Capability: per ANSI/IEEE C62.41 without damage.
         4. The equipment and components shall operate continuously at its rated current under the following environmental conditions without damage or degradation of operating characteristics or life:
            1. Operating Ambient Temperature: 0 degrees C to 40 degrees C maximum ambient temperature.
            2. Storage Temperature: -40 degrees C to 65 degrees C.
            3. Relative Humidity: 0 to 95%, non-condensing.
            4. Altitude: Operating to 6500 ft, de-rate for higher elevations.
   2. **HOUSING**
      1. Frames and enclosures:
         1. Enclosure shall be designed according to NEMA (1/3R) standard for (indoor/outdoor) operation.
         2. The switchboard enclosure frame shall be produced from at least 11 gauge mild steel and the switchboard enclosure doors shall be produced from at least 12 gauge mild steel.
         3. Switchboard width shall not exceed the space as allocated on the floor plan with depth dimension of approximately (22.5/30.5/36/45/61/72) inches.
         4. Enclosure shall be of rigid frame construction.
         5. Each switchboard section shall have a full length door, manufactured from at least, 12 Gauge steel.
         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. Switchboard shall have mounting holes for connecting adjacent structures to insure proper alignment, and to allow for future additions.
         9. Each vertical section containing a switch shall have a single, full-length, flanged front door and shall be equipped with two rotary latch-type padlockable handles.
         10. All bolts, nuts, and washers shall be zinc-plated steel.
         11. For ease of on-site cable connections and maintenance an open bottom and removable full depth side sheets shall be provided.
         12. For ease of switchboard service, maintenance and future upgrades, all support structures, braces and cover sheets shall be removable and attached to the frame via bolts.
         13. Stainless Steel exterior hardware shall be utilized on NEMA 3R units.
         14. For NEMA 3R installations, internal climate control to include two (2) space heaters which shall be controlled by a thermostat.
      2. Markings and Nameplates:
         1. Each switchboard section shall have a label permanently affixed to it, listing the following information: Name of manufacturer, system voltage, ampacity, type, and manufacturer's shop order number.
         2. Switchboard shall bear a UL891 listing mark as Type (1/3R) equipment for (indoor/outdoor) use.
         3. Each control switch, indicating light or other component mounted on the inner panel shall be identified by a nameplate.
         4. 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.
      3. 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.
   3. **BUS**
      1. Provide sliver plated copper bus, fully rated for the amperage shown on the drawings for entire length of the switchboard.
      2. Bus connections to switches shall be rated to carry the full continuous current of the device.
      3. Mount the bus on appropriately spaced insulators and brace to withstand the available short circuit currents.
      4. All bus (main, neutral, ground, extension, etc.) shall be produced from silver plated copper.
      5. Silver-plated copper, appropriately sized bus bar and extensions shall have NEMA standard hole pattern to accommodate cable connections.
      6. Install a silver plated copper ground bus the full length of the switchboard assembly.
      7. 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.
   4. **CIRCUIT BREAKERS** 
      1. (Insulated case/Low voltage power) circuit breakers shall be UL (489/1066) listed and utilized for the main circuit breakers with the following features:
         1. Switchboard shall be equipped with (manually/electrically) operated circuit breakers.
         2. Circuit Breakers shall be (fixed mount/drawout), 100% rated, with a stored energy mechanism, and “a” and “b” aux. contacts.
         3. Circuit breaker control interface shall have color-coded visual indicators to indicate contact open or closed positions as well as mechanism charged and discharged positions. Manual control pushbuttons on the breaker face for opening and closing the circuit breaker shall be provided.
         4. Interrupting Rating:
            1. For a circuit breaker rated under 2500A, interrupting rating shall be (65kA)@480VAC.
            2. For a circuit breaker rated at 2500A and up, interrupting rating shall be (100kA)@480VAC.
         5. Trip unit shall be solid-state, electronic microprocessor-based with true three phase RMS sensing of sinusoidal and non-sinusoidal currents.
         6. Provide the following minimum independent time-current curve shaping adjustments for each power circuit breaker:
            1. Adjustable long time pick-up and delay.
            2. (Adjustable short time pick-up, delay, and I2t settings.)
            3. Adjustable instantaneous pickup.
            4. (Adjustable ground fault pick-up, delay, and I2t settings.)
         7. The following adjustable protective features shall be provided as a complete and functional package additionally at each main circuit breaker location:
            1. Voltage phase loss.
            2. Line voltage phase unbalance, selectable from 5 to 40 percent of nominal in 5 percent increments.
            3. Voltage phase reversal.
            4. Overvoltage, selectable from 105 to 140 percent in 5 percent increments.
            5. Undervoltage, selectable from 95 to 60 percent in 5 percent increments.
            6. Time delay (adjustable from 0 to 8 seconds in 1 second intervals) for overvoltage, undervoltage, and phase unbalance trip and alarm settings.
      2. Molded case circuit breakers shall be UL 489 listed and utilized for the distribution circuit breakers with the following features:
         1. Switchboard shall be equipped with (fixed mount/drawout) circuit breakers.
         2. Circuit breakers shall be fixed mount, (80/100)% rated
         3. Circuit breaker Trip mechanism shall be quick-make, quick-break, mechanically trip-free over-center switching mechanism operated by a toggle-type handle. Handle shall indicate breaker position. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.
         4. Interrupting Rating shall not be less than the overall switchboard interrupting rating indicated on the drawings.
         5. Trip Unit shall be solid-state, electronic microprocessor-based with true three phase RMS sensing of sinusoidal and non-sinusoidal currents. Provide the following minimum independent time-current curve shaping adjustments for each power circuit breaker:
            1. Adjustable long time setting.
            2. (Adjustable short time setting and delay with selective curve shaping.)
            3. Adjustable instantaneous setting.
            4. (Adjustable ground fault setting and delay.)
         6. All circuit breaker ratings shall be as indicated per the drawings.
         7. Circuit breaker 120VAC shunt trips and 1a/1b auxiliary contacts to be provided as required.
   5. **SENSING & METERING**
      1. Current Transformers (CTs):
         1. Provide current transformer ratios as shown on the drawings. Accuracies shall be coordinated with the associated relays by the switchboard manufacturer to assure proper operation at the selected pick-up and operating current values.
         2. Set of 3 CTs for each circuit breaker with quantity and ratio as specified by the drawing or customer.
         3. The current transformer mounting assembly shall be insulated for the full voltage rating of the switchgear.
         4. All the current circuits shall be wired using ring type terminals.
      2. Potential Transformers (PTs):
         1. Switchgear shall utilize direct voltage sensing for systems 600V and below.
      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. **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. Current transformer circuits shall utilize minimum size No. 12 AWG wire. Install wiring complete at the factory, adequately bundled and protected.
  2. **ANNUNCIATION (if applicable)**
     1. 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.
  3. **GROUND FAULT PROTECTION (if applicable)**
     1. Include in the switchboard, ground fault protection and indication equipment. All parts of the systems specified shall be UL Listed.
     2. All ground fault protection and indication equipment shall be factory installed, wired and tested by the switchboard manufacturer.
  4. **INTERLOCKING (if applicable)**
     1. Customer shall provide site specific Kirk Key scheme information.
  5. **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.
  6. **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 (fully integrated/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. 15” 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 switchboard in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.

---END---