**SECTION 26 13 12**

**GENERATOR PARALLELING CONTROL SYSTEM**

1. **GENERAL**
   1. **DESCRIPTION**
      1. Furnish all labor, materials, equipment, and incidentals necessary to provide a complete Generator Paralleling Control System (GPCS) as indicated on the drawings, as specified herein, or otherwise required.
      2. Due to the critical nature of the facility and to provide for maximum reliability and responsibility, a single supplier shall have responsibility to provide a complete, coordinated standby power system and shall supply all of the following:
         1. The equipment supplied under this Section of the Specifications
         2. The equipment supplied under Section 26 13 13, Medium Voltage Metal-Clad Switchgear.
         3. The equipment supplied under Section 26 54 13, Generator Paralleling Switchgear Enclosure.
   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. 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.
      2. 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.
   4. **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.
   5. **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) / Institute of Electrical and Electronics Engineers (IEEE):

C12.....................Code for Electrical Metering

C39.1...................Requirements for Analog Indicating

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

* + 1. National Electrical Manufacturer's Association (NEMA)
    2. 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. **DEFINITIONS**
      1. GPCS - Generator Paralleling Control System
   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. System Overview
         1. Provide the generator control and distribution switch­gear, arranged to control the operation and distribution of power for the generating units specified in Section 26 32 13, Engine Generators.
         2. The GPCS shall be arranged for fully automatic or manual operation at the discretion of the operator. Manual operation shall be completely independent of the automatic control system. Each section shall be complete and include the necessary AC instrumentation, relaying, voltage regulator equipment, generator control equipment, engine governor controls, pilot lights, selector switches, etc., and accessories as specified hereinafter.
         3. All control voltage for auxiliary relays, circuit breakers, synchronizing and other automatic equipment shall be obtained from the standby generator system, station battery systems and the engine starting batteries, as required.
         4. All non-current-carrying conductive parts shall be grounded.
         5. 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. Furnish, install, test and place in satisfactory operation:
         1. Prefabricated, modular, self-contained, factory-manufactured and fully assembled GPCS.
         2. Single Source Responsibility - All equipment provided under this Section, Generator Paralleling Control System, and all components therein to be standard products of one manufacturer, except where specifically required or approved otherwise. All equipment shall be furnished to the Contractor only by a recognized, experienced supplier, who shall take full system responsibility for component purchase as an O.E.M., system engineering, system assembly, wiring and tests, supervision of installation and commissioning, and instruction of operating personnel.
   3. **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.
      3. Form C dry contacts rated for customer use shall be provided as required.
   4. **SENSING & METERING**
      1. 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. Voltage and Current transformer circuits shall utilize minimum size No. 12 AWG wire. Install wiring complete at the factory, adequately bundled and protected.
  2. **SEQUENCE OF OPERATION**
     1. (APPLICATION SPECIFIC, CONTACT APT TO DISCUSS YOUR REQUIREMENTS).
     2. Utility Generator Transfer with Breaker Load Control
        1. General:
           1. The generator system shall not be permitted to close into a faulted bus.
           2. If a breaker used in the generator control scheme is manually opened (using the control switch on the switchgear), it shall not be automatically be re-closed by the GPCS. The system must be manually re-set in order to automatically operate the breaker.
           3. If a utility main breaker is taken out of service for maintenance, it shall be placed in the manual mode, and the generator system shall ignore the status of that utility service for purposes of automatic control. The system shall start the generators based on the loss of the service(s) being used to supply power to the facility.
           4. If a generator fails to start or synchronize, an alarm shall be generated to tell the operator that the generator system has reduced capacity.
           5. Failure of the HMI shall not inhibit operation of the generator system.
     3. Sample System: Sequence of Operation:
        1. Table 1 lists the breakers involved in the proposed control sequencing in the existing switchgear located at E-1 and the new switchgear at the E-2.

Table 1: Breakers Involved in Generator Switching

| **Building** | **Bus** | **Abbreviation** | **Status** | **Function** |
| --- | --- | --- | --- | --- |
| E-1 | BUS A | 52-1 | Existing | Utility Main 1 (DOP CKT 14067) |
| E-1 | BUS B | 52-2 | Existing | Utility Main 2 (DOP CKT 14014) |
| E-1 | -- | 52-TIE | Existing | Tie breaker between BUS A and BUS B. |
| E-1 | BUS A | 52-GTA (CB-21) | Existing spare | Breaker for feeder from Generator Distribution Bus A to E-1 switchgear |
| E-1 | BUS B | 52-GTB (CB-22) | Existing spare | Breaker for feeder from Generator Distribution Bus B to E-1 switchgear. |
| E-2 | GEN BUS | 52-GA | New | Breaker for feeder from Generator Distribution Bus A to Generator Bus. |
| E-2 | GEN BUS | 52-GB | New | Breaker for feeder from Generator Distribution Bus B to Generator Bus. |
| E-2 | GEN BUS | 52-G1 | New | Connects generator 1 to Generator Bus. |
| E-2 | GEN BUS | 52-G2 | New | Connects generator 2 to Generator Bus |
| E-2 | GEN BUS | 52-G3 | New | Connects generator 3 (future) to Generator Bus |
| E-2 | GEN BUS | 52-LB | New | Allows for connection of a load bank or rental generator to Generator Bus. |

* + 1. Normal Operation: Position of breakers when all conditions are normal.
       1. E-1 breaker status
          1. 52-1 Main 1 Closed
          2. 52-2 Main 2 Closed
          3. 52-Tie Tie Open
          4. 52-GTA CB-21 Closed
          5. 52-GTB CB-22 Closed
       2. E-2 breaker status
          1. 52-GA Open
          2. 52-GB Open
          3. 52-G1 Open
          4. 52-G2 Open
          5. 52-G3 Open
          6. 52-LB Open
    2. Loss of One Utility Circuit
       1. When a utility outage occurs, assuming Utility 1 has an outage:
          1. 52-1 will open to isolate E-1 Bus A from utility.
          2. All feeder breakers on E-1 Bus A will open.
          3. 52-TIE will close to power E-1 Bus A from Utility 2 via E-1 Bus B.
          4. E-1 Bus A feeder breakers shall close sequentially at 5 second intervals.
       2. Upon restoration of Utility 1 and expiration of the “source returned” timer, the system will signal to plant SCADA that the system is ready to transfer plant load from Utility 2 to Utility 1. The system will remain in this configuration until the transfer is manually initiated.
          1. When initiated, the system will transfer E-1 Bus A from Utility 2 to Utility 1 via closed transition (100 msec) transfer of closing 52-1 and opening 52-TIE.
       3. A similar sequence will be programmed for Utility 2 outage.
       4. This sequence will mimic the existing programming of the existing E-1 switchgear.
    3. Loss of Both Utility Circuits
       1. 52-1, 52-2, and 52-TIE will open to isolate E-1 Bus A and E-1 Bus B. All feeder breakers on E-1 Bus A and Bus B will open.
       2. The generators will then be signaled to start. The first generator to be “ready” (90% nominal voltage and 59 hertz) will then signal its breaker to close to Generator Bus. The second generator to be “ready” will synchronize (match voltage and frequency) to Generator Bus and then close its breaker to connect to Generator Bus.
       3. When all the generators are operating in parallel, 52-GA will close to deliver power from Generator Bus to E-1 Bus A via Generator Distribution Bus A. Then 52-GB will close to deliver power from Generator Bus to E-1 Bus B via Generator Distribution Bus B. The E-1 feeder breakers will then close sequentially, alternating buses, at 5 second intervals to restore power to the plant.
       4. The plant will then operate in this configuration until a utility is restored.
    4. Retransfer to Utility
       1. Upon restoration of one or both utility sources and expiration of the “source returned” timer, the system will signal to plant SCADA that the plant is ready to transfer plant load from generator back to utility. The system will remain in operation until the transfer is manually initiated. When retransfer is initiated, the system will transfer the plant from generator back to the utility.
          1. If both utility circuits become available at the same time, the source for E-1 Bus A shall be the preferred source.
       2. The system will control the generators to synchronize with the active utility (same voltage and frequency).
          1. The system will then transfer E-1 Bus A (E-1 Bus B) from generator to Utility 1 (Utility 2) via closed transition (100 msec) transfer of closing 52-1 (52-2) and opening 52-GA (52-GB).
          2. The system will then transfer E-1 Bus B (E-1 Bus A) from generator to Utility 1 (Utility 2) via closed transition (100 msec) transfer of closing 52-TIE and opening 52-GB (52-GA).
       3. The generators will then disconnect from Generator Bus and begin their cool down cycle. After the cool down period, the generators will shut down.
       4. Upon restoration of second utility and expiration of the “source returned” timer, the system will signal to plant SCADA that the system is ready to transfer plant load from Utility 1 to Utility 2 (Utility 2 to Utility 1). The system will remain in this configuration until the transfer is manually initiated.
          1. When initiated, the system will transfer E-1 Bus B (E-1 Bus A) from Utility 1 to Utility 2 (Utility 2 to Utility 1) via closed transition (100 msec) transfer of closing 52-2 (52-1) and opening 52-TIE.
    5. Generator Exercising
       1. The system shall perform generator testing in three different modes, no load, loaded via plant load and load bank. The number of generators to be tested may also be selected.
          1. In no load testing, the generator system will be isolated from the plant system and the generator will run unloaded.
          2. For load testing, plant load, either both buses or E-1 Bus A or E-1 Bus B individually, will be transferred to the generators.
          3. The sequence for testing will be similar to that followed above for a utility outage, except the transfers will all be closed transition, so the plant equipment will not experience any interruptions in electrical service.

If, during a no load test, an actual utility outage occurs and the system is in automatic, the system will respond to the outage.

If a single utility is lost then the switching at E-1 will take place to transfer the plant to the second utility. The load bank test will continue.

If both utilities are lost the system will disconnect from the load bank via breaker 52-LB and pickup plant load with the generators, assuming the generators are operating within acceptable limits.

If, during a plant load test, an actual utility outage occurs and the system is in automatic, the system will respond to the outage.

If the outage is with the E-1 bus(es) connected to the generators, then test mode will be terminated and the system will continue to power the load. Steps outlined above will be followed upon restoration of the utility(s).

If the outage is with a bus that is not connected to the generators, then test mode will be terminated and the system will transfer the remaining buses to generator, assuming the generators are operating within acceptable limits. Steps outlined above will be followed upon restoration of the utility(s).

* + - * 1. For load bank testing, the generator system will be isolated from the plant system, and tested under load when a portable load bank is connected to the generator bus. The load bank will be connected into the generator switchgear through an external connection point. This will allow connection to the generator switchgear without the need to open the gear. A circuit breaker, 52-LB, on the generator bus will isolate the connection point when not in use.

If during a load bank test, an actual utility outage occurs and the system is in automatic, the system will respond to the outage.

If a single utility is lost then the switching at E-1 will take place to transfer the plant to the second utility. The load bank test will continue.

If both utilities are lost the system will disconnect from the load bank via breaker 52-LB and pickup plant load with the generators, assuming the generators are operating within acceptable limits.

* + - 1. Testing with plant load
         1. The operator selects testing with plant load.
         2. The operator selects buses to use for testing: E-1 Bus A, E-1 Bus B, or E-1 Bus A and B.
         3. Testing with plant load on E-1 Bus A

The operator starts the test.

The generators will start, sync to the Generator Bus and parallel with each other.

The system synchronizes the generators with Utility 1.

The system transfers E-1 Bus A from Utility 1 to Generator Bus via Generator Distribution Bus A by closed transition transfer of closing 52-GA and opening 52-1.

The test will continue to run until terminated by the operator.

The system synchronizes the generator with Utility 1.

The system transfers E-1 Bus A from Generator Bus to Utility 1 by closed transition transfer of closing 52-1 and opening 52-GA.

The generators will then disconnect from Generator Bus and begin their cool down cycle. After the cool down period, the generators will shut down.

* + - * 1. Testing with plant load on E-1 Bus B

The sequence will be similar to testing with E-1 Bus A.

* + - * 1. Testing with plant load on both buses

The operator starts the test.

The generators will start, sync to the Generator Bus and parallel with each other.

The system synchronizes the generators with Utility 1.

The system transfers E-1 Bus A from Utility 1 to Generator Bus via Generator Distribution Bus A by closed transition transfer of closing 52-GA and opening 52-1.

The system synchronizes the generators with Utility 2.

The system transfers E-1 Bus B from Utility 2 to Generator Bus via Generator Distribution Bus B by closed transition transfer of closing 52-GB and opening 52-2.

The test will continue to run until terminated by the operator.

The system synchronizes the generators with Utility 1.

The system transfers E-1 Bus A from Generator Bus to Utility 1 by closed transition transfer of closing 52-1 and opening 52-GA.

The system synchronizes the generators with Utility 2.

The system transfers E-1 Bus B from Generator Bus to Utility 2 by closed transition transfer of closing 52-2 and opening 52-GB.

The generators will then disconnect from Generator Bus and begin their cool down cycle. After the cool down period, the generators will shut down.

* 1. **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. Synchronizing Mode Switch with “Auto” and “Semi-Auto” positions shall be provided for each generator. In “Auto” position the corresponding generators shall automatically synchronize as described above. In “Semi-Auto” position, the system shall operate as described above, except the synchronizing control of the generator set’s frequency and voltage shall be disabled to allow for the manual synchronizing control as well as for system adjustment and troubleshooting.
          6. Other control components, indicating lights and switches as required for system operation.
          7. 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. Dedicated generator and utility synchronizing check relay.
       5. Dedicated Synchronizing switch and Synchronizing lights for each generator and utility source.
       6. Microprocessor based loading control shall be of the adjustable dual dynamics type to allow for generator set loading stability regardless of the utility voltage regulation strategies. Each control setpoint and the corresponding time delay shall be adjustable from the operator interface panel mounted on the door.
       7. 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.
       8. 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 2.4.A 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.
    16. Sequential utility disturbance and events recorder shall be provided and installed in the control panel. The information on the last 512 events with the date and time stamp shall be available. The detail information on the last eight events shall be available including utility voltages and frequency (sampled at least four times per cycle), before and after the disturbance and phasor diagrams for all three phases.
    17. Control circuit to prevent closing of multiple units to a dead bus simultaneously.
    18. Control circuit to ensure that first available generator (which builds up voltage and frequency) will close to a dead bus.
  1. **MASTER CONTROLS**
     1. The master controls shall be (fully integrated into /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 10.
        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.
     4. Processor & Human Machine Interface (HMI)
        1. Two independent and redundant programmable logic controllers (PLC) each with separate power supply, chassis, and distributed I/O cards, if required. In the event that both of the controllers fail, the system operation will allow full manual control with all required hardwired interlocks installed to prevent improper operation. PLCs shall be a manufacturer’s standard model which is readily available and stocked by the manufacturer.
        2. Operator Interface Panel (OIP): 20 inch (minimum) color touch screen Industrial Computer to display system parameters and provide necessary control functions. The OIP shall communicate with the redundant PLCs and provide operator access to set points, engine sequence, and various switchgear functions. Any of the set points and sequences can be viewed at any time, but changes shall be password protected. . Alarms shall be displayed on the OIP.
        3. Annunciation-and-shutdown-interface module for system monitoring and fault shutdown. The annunciator display shall contain individual annunciation lights. All annunciation points shall be simultaneously displayed. Alphanumeric scrolling or sequential displays are not acceptable. Display screens on the OIP shall not be acceptable. Annunciation shall comply with NFPA 110 requirements. Annunciation shall conform to ISA F3A standards. The annunciator display shall be equipped with a fast pulse horn (rated 80-95 dbA at two feet), a Horn Silence Pushbutton and an Acknowledge Pushbutton. Any pre-alarm or shutdown alarm shall cause the alarm horn to sound until the Horn Silence button is depressed. Any subsequent alarms shall re-sound the horn. The display shall operate such that any alarm point shall “flash” until acknowledged. One press of the Acknowledge button shall return alarm points to “steady on” except the “first in” alarm, which shall remain flashing. A second press of the acknowledge button shall return the “first in” alarm point to “steady on”. Status and Pre-Alarm points shall reset automatically as the alarm condition is cleared. The annunciator display shall be equipped with a lamp test pushbutton.
        4. Ethernet Switch in conformance with Section 40 95 40, Network Devices
  2. **COMPONENTS**
     + 1. The Operator Interface panel shall be supplied with a number of Screens that shall allow the operator to perform control functions in real time.
          1. Security Screen: (password is required to change any settings) this screen shall allow the operator to enter a user ID and password to change control set points. The system shall allow up to eight levels of password protection. A password is not required to view existing settings or status screens. The password is installed or changed via the Touch Screen using a virtual standard keyboard pop-up. Once an operator enters the system using his password, a password timer will run. The password lock will be reactivated after an adjustable time delay if there is no operator interaction with the OIP screen
          2. Date and Time Screen: The Date and Time screen shall allow an operator to change the system’s date and time. The operator will enter a password and then access Date/Time screen by pressing the key.
          3. System Single Line screen: This screen shall be the main access screen to other screens. There shall be a tab soft-key button off to the right side of the screen labeled “Menu” to allow the operator access to additional screens. A user block at the top of the screen shall display who is logged into the system.

This screen shall display paralleling switchgear represented by an interactive single line screen. A block at the top of the screen shall display the overview system status with indications that the system is in auto or manual mode, and test status of the system whether it is in a load test or No-load test mode of operation. The single line shall display generator status and actual generator power in kW, rated kW, % load on each generator, and circuit breaker open/closed status for each generator in the system. Feeder breaker open/closed status shall be displayed. The device symbols and bussing depicted on the single line shall change color and will be red in color when energized and green if de-energized. Should an operator wish to view information on the engines, he would touch the engine depicted on this screen which will bring up a pop up screen displaying the engine generator metered values.

* + - * 1. PLC Communication Status Screen: This screen shall indicate that the OIP is communicating properly with the two system PLCs and whether each PLC is in a run or disabled state with the PLC scan time displayed for each PLC
        2. Engine Data Screens: Each engine generator shall be represented by a pop up metering screen with twelve, individual, dial type analog meters which shall display engine oil pressure, oil temperature, coolant temperature, left and right exhaust temperature, engine RPM and engine battery voltage, generator voltage, frequency , power factor, current and KW. Soft keys shall be provided under the voltmeter to allow reading each phase to phase voltage, A-B, B-C and C-A. The Ammeter shall have soft key to allow reading individual phase current. The KW meter shall have soft keys under the meter to switch between KW, KVAR and KVA. Each value shall also be shown as a % load on each generator. These metered values shall also be displayed again on another screen in digital readout form together with all engine and generator data available through the communications link to the engine generator.

Engine operating hours and the total number of engine starts shall be displayed. In addition, a separate bar graph indication of generator loading percentage shall be displayed on this screen.

Timer set points and actual real time status of the timers for fail to synchronize shall be displayed.

* + - * 1. Master Control Screen: Two virtual switches shall be displayed. The first switch allows the operator to select automatic or manual mode of operation from this screen. The second switch is provided to allow resetting bus alarms. This screen shall also display a running time counter that displays the time in days, hours, minutes and seconds for the latest system operation.
        2. Generator Test Screen: A test screen shall be provided to allow the operator to test the operation the engine generators. In this screen an operator can select which engines shall be tested and whether they will be started all at once or sequentially. A virtual selector switch shall be provided for each engine to select the unit for test mode of operation. A digital display for each unit shall record the test duration for that unit.
        3. Alarm and Event History Log Screen: This screen will display all the events and alarms for the current day. Logging of the events and alarms to files with date and time stamp shall be also provided. Separate events and alarms data file shall be created for each day. The file format shall be compatible with both MS Excel and generic text editor.
        4. Data Storage: Storage of all the monitored data every minute with date and time stamp. Trend files shall be created and saved for every day. Trend files are presented in CSV format and can be opened in MS Excel or any other spread sheet or text editor application.
        5. A series of software keys are provided on each screen. These keys shall allow the operator to toggle between screens. Areas available for view are as follows:

Engine

Generator Metering

Generator Control

System Control

Annunciator Status

Setting Menu

Report Menu

* + - * 1. System Control: The following are areas accessible to an operator through the system control screen:

Setting and changing load priority assignments for all the load shed devices in the equipment.

Each load device will be given a priority value. A priority one load device will be the first load to be supplied during a utility power failure. When the second engine/generator is paralleled to the generator bus the second priority loads will be supplied.

Setting and changing various time delay timers and system setpoints

Engine sequence selection

No-Load Test operation

* + - * 1. Fault Tolerance

Failure of Touchscreen –Automatic operations shall not be affected by the failure of the Touchscreen.

Failure Of All Automation – Upon the failure of all automation, the system shall be capable of full manual synchronization. Once Generators are in parallel, a means shall be provided for manual load and VAR control.

* + - * 1. Remote Monitoring: The appropriate password protected, remote monitoring and control software and capability shall be provided so that any Owner’s remote MS Windows, Apple or Android based computer or mobile device can connect to the switchgear Master HMI via Ethernet port via Local Area Network or Internet. At that point the Owner shall be able to see and control the same screens on the remote computer as can be seen or controlled on the Master HMI Touchscreen locally. MS Windows remote monitoring and control software shall be provided to the owner with unlimited number of installs on any PC. A free download of the password protected, remote monitoring and control software from the Apple and Android Apps store shall be also available. The network connection and network IP address will be provided by the Owner.
  1. **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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