# SECTION 26 23 15
# GENERATOR LOW-VOLTAGE PARALLELING SWITCHGEAR

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of low-voltage switchgear, PLC type Engine Generator Control, PLC based paralleling system, automatic transfer switches, remote/manual control for the Automatic Transfer Switches, automatic load bank, and integration into the Building 100 Emergency Power Supply System (EPSS) Supervisory Control and Data Acquisition (SCADA) system.

B. This section specifies the work required for modification and re-integration of the existing paralleling switchgear in Building 103 for existing PLC type paralleling controls and programming, automatic transfer switch control cabinet, automatic transfer switches, and the Building 100 EPSS SCADA system.

### 1.2 WORK

A. Section 01 91 00, General Commissioning Requirements

B. Section 26 05 41, Underground Electrical Construction

C. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirement for seismic restraint for nonstructural components.

D. Section 25 10 10, ADVANCED UTILITY METERING: Electric meters installed in switchgear.

E. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

F. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

G. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible fault currents.

H. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.

I. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

J. Section 26 43 13, SURGE PROTECTIVE DEVICES: For surge protective devices integral to the switchgear.

K. Section 26 36 23 AUTOMATIC TRANSFER SWITCHES. Requirements

for automatic transfer switches.

L. Section 26 32 13: ENGINE GENERATORS: Requirements for Engine generators.

M. Section 27 05 11, Requirements for Communications Installations

N. Section 27 15 00, Communications Horizontal Cabling

## 1.3 QUALITY ASSURANCE

A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

B. The Emergency Power Systems Supplier must be capable of servicing the Generator sets, the Generator Paralleling Switchgear, Automatic Transfer Switches and the Building 100 EPSS SCADA System, and be able to supply replacement parts for each factory supplied equipment. Proof for factory qualified dual ticketed service technicians within the EPSS organization is required.

## 1.4 FACTORY TESTS

A. Switchgear shall be thoroughly tested at the factory, with the circuit breakers in the connected position in their compartments. Tests shall be in accordance with IEEE C37.20.1 and NEMA C37.51. Factory tests shall be certified, and shall include the following tests:

1. Design tests.
2. Production tests.
3. Conformance tests.

B. The following additional tests shall be performed:

1. Verify that circuit breaker sizes and types correspond to drawings, and the Overcurrent Protective Device Coordination Study.
2. Verify tightness of bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
3. Confirm correct operation and sequencing of key-type mechanical interlock systems for multiple circuit breakers by attempting closure on locked-open devices, and attempting to open locked-closed devices, and making key exchange with devices operated in off-normal positions.
4. Verify correct barrier and shutter installation and operation.
5. Exercise all active components.
6. Inspect indicating devices for correct operation.
7. Perform an insulation-resistance test, phase to ground, on each bus section, with phases not under test grounded, in accordance

with manufacturer's published data.

8. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 V DC for 300-volt rated cable and 1000 V DC for 600-volt rated cable, or as required if solid-state components or control devices cannot tolerate the applied voltage.

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

10. Generator paralleling controls shall be thoroughly tested at the factory to assure that there are no electrical or mechanical defects. Refer also to related specification sections for tests Test shall be conducted as per UL and ANSI standards. Factory tests shall be certified.

11. Check operation of all metering devices using secondary current and/or voltage injection.

C. Furnish two (4) hard copies and an electronic copy of certified manufacturer's factory test reports prior to shipment of the switchgear to ensure that the switchgear has been successfully tested as specified.

D. The Government shall have an option to witness the factory tests. All expenses of the Government Representative's trips to witness the testing will be paid by the Government. Notify the COR not less than 30 days prior to making tests at the factory.

E. The paralleling control PLC system components shall be assembled at a manufacturer's facility in order to demonstrate system component and software functions. Demonstration shall be witnessed and successfully completed prior to installation in the VA facilities.

F. The Government shall have the option to witness the factory demonstrations and testing. The Government shall pay for all expenses of the first Government Representatives' trips to witness the demonstrations and testing. The contractor is required to pay for all expenses of the Government Representatives' for all additional compliance testing and demonstrations. Notify the COR not fewer than 30 days prior to making tests at the factory.

## 1.5 SUBMITTALS

A. Submit two hard copies and an electronic copy of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1. Shop Drawings:

a. Switchgear shop drawings shall be submitted simultaneously with or after the Overcurrent Protective Device Coordination Study.

b. Submit sufficient information to demonstrate compliance with drawings and specifications.

c. Prior to fabrication of switchgear, submit the following data for approval:

1.) Complete electrical ratings.

2.) Circuit breaker sizes.

3.) Interrupting ratings.

4.) Safety features.

5.) Accessories and nameplate data.

6.) Switchgear one - line diagram, showing ampere rating, number of bars per phase and neutral in each bus run (horizontal and vertical), bus spacing, equipment ground bus, and bus material.

7.) Elementary and interconnection wiring diagrams.

8.) Technical data for each component.

9.) Dimensioned exterior views of the switchgear.

10.) Dimensioned section views of the switchgear.

11.) Floor plan of the switchgear.

12.) Foundation plan for the switchgear.

13.) Provisions and required locations for external conduit and wiring entrances.

14.) Approximate design weights.

d. Certification from the manufacturer that representative switchgear has been seismically tested to International Building Code requirements. Certification shall be based upon simulated seismic forces on a shake table or by analytical methods, but not by experience data or other methods.

2. Manuals:

a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.

b. The terminals of wiring diagrams shall be identified to facilitate installation, maintenance, and operation.

c. Wiring diagrams shall indicate internal wiring for each piece of equipment and the interconnection between the pieces of equipment, including related equipment specified in other sections.

d. Provide a clear and concise description of operation,

including detailed information required to properly operate the equipment.

e. Approvals shall be based on complete submissions of manuals together with shop drawings.

f. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

g. Schematic signal and control diagrams, with all terminals identified, matching terminal identification in the switchgear.

h. Include information for testing, repair, trouble shooting, assembly, disassembly, and factory recommended/required periodic maintenance procedures and frequency.

i. Provide a replacement and spare parts list. Include a list of tools and instruments for testing and maintenance purposes.

1.) If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Test Reports:

a. Two weeks prior to the final inspection, submit certified field test reports and data sheets.

4. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the manufacturer that switchgear conforms to the requirements of the drawings and specifications.

b. Certification by the Contractor that switchgear has been properly installed, adjusted, and tested.

## 1.6 APPLICABLE PUBLICATIONS

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

B. Institute of Engineering and Electronic Engineers (IEEE):

C37.13-08 .....Low-voltage AC Power Circuit Breakers Used in Enclosures

C37.20.1-07 .....Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

C57.13-08 .....Instrument Transformers

C62.41.1-03 .....Surge Environment in Low-voltage (1000V and less)

AC Power Circuits

C62.45-92.....Surge Testing for Equipment connected to Low-Voltage AC Power Circuits

C. International Code Council (ICC):

IBC-15.....International Building Code

D. National Electrical Manufacturers Association (NEMA):

C37.51-10.....Metal-Enclosed Low Voltage AC Power Circuit Breaker Switchgear Assemblies — Conformance Test Procedures

E. National Fire Protection Association (NFPA):

70-17.....National Electrical Code (NEC).

99-15.....Health Care Facilities

110-16.....Emergency and Standby Power Systems

F. Underwriters Laboratories, Inc. (UL):

977-07.....Safety Fused Power-Circuit Devices

1053-99.....Ground Fault Sensing and Relaying Equipment

1558-99.....Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

508A-07 .....Industrial Control Panels

## PART 2 - PRODUCTS

### 2.1 GENERAL

A. The Generator Switchgear shall be in accordance with ANSI, IEEE, NEMA, NFPA, UL, as shown on the drawings, and have the following features:

1. The Switchgear shall be a complete, grounded, continuous-duty, integral low voltage (277/480 VAC), metal clad, dead-front, dead-rear, self-supporting, indoor type switchgear assembly. Incorporate devices shown on the drawings and all related components required to fulfill operational and functional requirements.
2. Switchgear shall be Type 2 front, and rear accessible.
3. Ratings shall not be less than shown on the drawings. Short circuit ratings shall not be less than 85 kA.
4. Switchgear shall conform to the arrangements and details shown on the drawings.
5. Key-type mechanical interlocks for multiple circuit breakers shall be provided as shown on the drawings.
6. Switchgear shall be assembled, connected, and wired at the factory so that only external circuit connections are required at the

construction site. Split the structure only as required for shipping and installation. Packaging shall provide adequate protection against rough handling during shipment.

7. All non-current-carrying parts shall be grounded per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS for additional requirements.

## 2.2 HOUSING

A. Shall have the following features:

1. Frames and enclosures:

a. The assembly shall be braced with reinforcing gussets using bolted connections/ to assure rectangular rigidity.

b. The enclosure shall be steel, leveled, and not less than the gauge required by applicable publications.

c. Die-pierce the holes for connecting adjacent structures to insure proper alignment, and to allow for future additions.

d. All bolts, nuts, and washers shall be cadmium-plated steel.

2. Circuit breaker compartments:

a. An individual compartment shall be supplied for each circuit breaker and each future circuit breaker as shown on the drawings. Compartments shall be provided with isolated wireways for control wiring between devices.

B. Separate each compartment so that the circuit breaker, buses, and cable terminations are in separate compartments with steel partitions or barriers of approved and properly installed insulation.

C. Each compartment furnished with a circuit breaker (active or spare) shall be fully equipped as noted on drawings and specified below.

D. Each compartment noted as space for future circuit breaker, as shown on drawings, shall be fully equipped for positioning and connecting the breaker. Provide all equipment required to implement the future breaker installation.

1. Auxiliary compartments:

a. Compartments shall be provided for auxiliaries, metering, and transition or termination sections as required by the manufacturer, and as shown on drawings. Compartments shall be provided with isolated wireways for control wiring between devices.

2. Compartment doors:

a. The doors shall permit convenient removal and interchanging of circuit breakers between compartments.

The doors shall be capable of a swing approaching 180 degrees.

b. Concealed or semi-concealed hinges shall be provided to attach the doors. Weld the hinges to the equipment structure and to the compartment doors.

E. ATS Manual Operation Control Compartment:

1. Separate lineup compartment adjacent to the Master Control compartment.

2. The ATS Manual Operation Control Compartment shall consist of individual ATS control switches for ten (10) existing ME-2 ATSs, two (2) new ATSs in Building 103A, and eight (8) future ATSs, totaling twenty (20) ATS switches. Switch operation shall consist of TEST EMERGENCY – AUTO – LOAD SHED, providing manual operational control, independent of the PLC based paralleling system for the Building 100 EPSS SCADA system.

1) For each transfer switch, incorporate a three-position contact switch.

2) Label switch positions, TEST EMERGENCY – AUTO – LOAD SHED. The TEST position shall simulate an outage of normal power at the transfer switch. The AUTOMATIC position shall place the transfer switch in normal operation. The LOAD SHED position shall transfer the switch to the alternate position regardless of whether power is available.

3. For each transfer switch, incorporate red (emergency), orange (bypass), and green (normal) LED lamps, indicating the position of the transfer switch.

4. For each transfer switch, incorporate red (emergency) and green (normal) LED lamps, indicating the sources available.

F. Finish:

1. All metal surfaces shall be thoroughly cleaned, phosphatized and factory primed prior to applying baked enamel or lacquer finish.

2. Provide a light gray finish for indoor switchgear.

## 2.3 BUSES

A. Bus Bars and Interconnections:

1. Provide copper phase and neutral buses, fully rated for the amperage as shown on the drawings for the entire length of the switchgear. Bus laminations shall have a minimum of 6 mm (1/4 inch) spacing.

2. Mount the buses on appropriately spaced insulators and brace to withstand the available short circuit currents.

3. The bus and bus compartment shall be designed so that the acceptable NEMA standard temperature rises are not exceeded.
4. Install a copper ground bus the full length of the switchgear assembly.
5. Main Bonding Jumper: An un-insulated copper bus, size as shown on drawings, shall interconnect the neutral and ground buses, when the switchgear is used to establish the system common ground point.
6. All bolts, nuts, and washers shall be cadmium-plated steel. Bolts shall be torqued to the values recommended by the manufacturer.
7. Make provisions for future bus extensions by means of bolt holes or other approved method.
8. Analog/Digital meters for voltage, amperage, power factor, and kilowatts, independent of the PLC based control system, shall be provided on the Master Control Compartment door to display values related to the primary buss.

## 2.4 LOW-VOLTAGE POWER CIRCUIT BREAKERS

A. General: Circuit breakers shall be dead front, draw-out, stored energy type with solid state trip devices and ground fault protection. Arcing contacts shall be renewable.

B. Rating: Circuit breakers shall be 3 pole, 600 volts AC and below, 60 cycle with frame size, trip rating and functions, and system voltage as shown on drawings. Breakers shall have 30 cycle short time current ratings. AIC rating shall be 65KAIC.

C. Draw-out Mounting: Provide a racking mechanism to position and hold the breaker in the connected, test, or disconnected position. Provide an interlock to prevent movement of the breaker into or out of the connected position unless the breaker is tripped open.

D. Each Generator circuit breaker shall be provided with a microprocessor, high reliability, utility grade multifunction protective relay, to provide protection, control, and communications.

E. Each Feeder Circuit Breaker shall be electrically and mechanically trip free and shall have trip devices in each pole. Trip devices shall be of the solid state type with adjustable pick-up settings, with both long time and short time, instantaneous elements, and integral trip unit testing provisions. Devices shall have time-delay band adjustment. Long-time delay element shall have inverse time characteristics.

F. Position Indicator: Provide a mechanical indicator visible from the front of the unit to indicate whether the breaker is open or closed.

G. Trip Button: Equip each breaker with a mechanical trip button accessible from the front of the door.

H. Padlocking: Provisions shall be included for padlocking the breaker in the open position.

I. Operation: All circuit breakers shall be electrically operated.

## 2.5 MASTER CONTROL CUBICLE

A. Shall contain all PLC based system-totalizing controls for the integrated system operation as specified below:

1. Bus Metering:
   a. AC ammeter.
   b. AC voltmeter.
   c. Frequency meter 55-65 Hz Scale.
   d. Watt/Var meter.
   e. Ammeter/Voltmeter phase selector switches with current and potential transformers and proper fuses.
2. Reverse Power Monitors: Solid-state reverse power monitors shall be furnished to sense motorizing of a failing engine-generator set. Upon detection of a reverse power flow, the monitor shall signal the alarm circuit for immediate power disconnect of the generator and actuation of load dumping circuits, and energize the audible and visual alarm signals. Monitors shall automatically reset the open generator disconnect from the bus. An induction disc type reverse power relay with equivalent performance may be submitted for approval. The monitor shall have the following features:
   a. Accurate operation at power factors down to 0.2 lagging or leading.
   b. Minimum 10 A output contacts rated at 480 V.
   c. Circuitry arranged to continually sense the output power of the generator for magnitude and direction.
   d. Operate accurately over voltage range of 70% to 110% of rated voltage.
   e. Adjustable dial for trip power range.
   f. Test switch to simulate reverse power for periodic testing. Switch shall be arranged to cause sensing circuitry to measure reverse power.
3. Synchronizing Monitors: A solid-state generator-synchronizing monitor shall sense voltage, frequency, and phase angle of the generator to be paralleled.

The monitor shall compare the voltage of the bus with that of the unit to be paralleled and initiate corrective action to cause the voltage difference to be reduced to less than 5% of nominal. The monitor shall compare the frequency of the bus with that of the unit to be paralleled, and shall control the governor to cause the frequency of the unit to be paralleled to match within 0.2 Hz. The monitor shall also compare the phase angle of the bus with that of the unit to be paralleled and reduce the phase angle of the unit to be paralleled to a maximum of five electrical degrees at the instant the connection is made to the bus. Upon achievement of the appropriate phase angle, the generator circuit breaker shall close to parallel the unit. The monitor shall be mounted remotely in the control cabinet. Solid-state circuitry shall be used for all sensing and control functions. Interface circuits for control of voltage adjustment and circuit breaker closing shall be through enclosed electromagnetic relays.

4. Synchroscope:
   a. Furnish with a selector switch and manual means of paralleling engine-generator sets for override of the automatic system.
   b. Furnish with a synchronizing phase band limiter to sense and compare the phase angle difference in the generators, which are to be manually paralleled, and lock out the manual paralleling button within 15 degrees (electrical) of synchronism.
5. Load Demand Monitor:

   A load demand monitor shall sense the load connected to the bus, and establish the proper number of engine-generators to operate and maintain the connected load with a minimum on-line reserve generating capacity of 25% of the rating of a single engine-generator. The load monitor shall also disconnect a generator from the bus whenever the on-line reserve capacity exceeds 125% of a single generator set. The load demand monitor shall be adjustable to initiate the addition and removal of a generator from the main bus. The load monitor shall maximize reliability while maintaining sufficient capacity to sustain the load.
6. Frequency Monitor:

A frequency monitor with integral time delay shall initiate load dumping upon a reduction of the bus frequency to 57 Hz or less for a period of four seconds or more. Upon sensing a bus under-frequency, the system shall automatically shed the lowest priority load connected. This shed circuit shall override any manual load add activity and lock out the manual load add circuitry. Visual and audible alarms shall be energized upon sensing of bus under-frequency load dump.

8. Alarms:

   Provide individual visual signals plus a common audible alarm and silencing circuitry. Provide a test switch which will momentarily actuate the visual and audible alarms. The following conditions shall be monitored:

   a. Low Fuel Level Main Storage Tank shall be energized when the fuel oil level decreases to less than one-third of total capacity.
   b. Under-frequency failure.
   c. Controls not in automatic mode.
   d. Load shed circuit activation.

B. Control Logic:

   1. The control logic shall be distributed between the Master Control Cubicle and each Engine-Generator Control Cubicle such that each engine-generator is capable of starting and paralleling to the bus in the event of receipt of a start signal from any automatic transfer switch and failure of the Master Control Cubicle.

C. Control Power:

   Control power for the paralleling controls shall be derived from an inverter style battery power supply as specified in Section 26 23 00, LOW-VOLTAGE SWITCHGEAR.

D. Interconnecting Communications Protocol and Media: The paralleling switchgear shall be interconnected to the automatic transfer switches and the remote annunciator(s) by the existing VA fiber optic network, per the requirements of Section 27 15 00, COMMUNICATIONS HORIZONTAL CABLING. Provide all necessary CAT 6 cable, fiber optic media, raceways, hardware, software, and programming necessary to establish interconnection between the paralleling

switchgear and automatic transfer switches and the remote annunciator and control system. All equipment shall share a common open communications protocol.

## 2.6 ENGINE-GENERATOR CONTROL CUBICLE

A. Starting and Stopping Controls:

1. Each generator control cubicle shall be equipped with a dedicated PLC control with “Human-machine-interface” (HMI) encompassing the following functions with-in HMI screens.
2. A three-position, maintained-contact type selector switch with positions marked "AUTOMATIC," "OFF," and "MANUAL". Provide flashing amber light for the OFF and MANUAL positions.
3. A momentary contact push-button switch with positions marked "MANUAL START" and "MANUAL STOP."
4. Selector switch in AUTOMATIC position shall cause the engine to start automatically when a single pole contact in a remote device closes. When the generator's output voltage increases to not less than 90% of its rated voltage, and its frequency increases to not less than 58 Hz, the remote devices shall transfer the load to the generator. An adjustable time delay relay, 0 to 15 minute range, shall cause the engine-generator to continue operating without any load after completion of the period of operation with load. Upon completion of the additional 0 to 15 minute (adjustable) cool-down period, the engine-generator shall stop.
4. Selector switch in OFF position shall prevent the engine from starting either automatically or manually. Selector switch in MANUAL position shall cause the engine to start when the manual start push-button is depressed momentarily.
5. With selector switch in MANUAL position, depressing the MANUAL STOP push-button momentarily shall stop the engine after a cool down period.
6. A maintained contact, red mushroom-head push-button switch marked "EMERGENCY STOP" will cause the engine to stop without a cool down period, independent of the position of the selector switch.

B. Engine Cranking Controls:

1. The cranking cycles shall be controlled by timer that will be independent of the battery voltage fluctuations.

2. The cranking controls shall crank the engine through one complete cranking cycle, consisting of four starting attempts of 10 seconds each with 10 seconds between each attempt.
3. Total actual cranking time for the complete cranking cycle shall be 40 seconds during a 70-second interval.
4. Cranking shall terminate when the engine starts so that the starting system will not be damaged. Termination of the cranking shall be controlled by a self-contained, speed-sensitive switch. The switch shall prevent re-cranking of the engine until after the engine stops.
5. After the engine has stopped, the cranking control shall reset.

C. Supervisory Controls:
   1. Overcrank:
      a. When the cranking control system completes one cranking cycle, four starting attempts without starting the engine, the OVERCRANK signal light and the audible alarm shall be energized.
      b. The cranking control system shall lock-out, requiring a manual reset.
   2. Coolant Temperature:
      a. When the temperature rises to the predetermined first stage level, the HIGH COOLANT TEMPERATURE - FIRST STAGE signal light and the audible alarm shall be energized.
      b. When the temperature rises to the predetermined second stage level, which shall be low enough to prevent any damage to the engine and high enough to avoid unnecessary engine shutdowns, the HIGH COOLANT TEMPERATURE - SECOND STAGE signal light and the audible alarm shall be energized and the engine shall stop.
      c. Difference between the first and second stage temperature settings shall be approximately 12˚C.
      d. Permanently indicate the temperature settings near the associated signal light.
      e. When the coolant temperature drops below 70˚ F [21˚ C], the LOW COOLANT TEMPERATURE signal light and the audible alarm shall be energized.

3. Low Coolant Level: When the coolant level falls below the minimum level recommended by the manufacturer, the LOW COOLANT LEVEL signal light and audible alarm shall be energized.
4. Lubricating Oil Pressure:
    a. When the pressure falls to the predetermined first stage level, the OIL PRESSURE - FIRST STAGE signal light and the audible alarm shall be energized.
    b. When the pressure falls to the predetermined second stage level, which shall be high enough to prevent damage to the engine and low enough to avoid unnecessary engine shutdowns, the OIL PRESSURE - SECOND STAGE signal light and the audible alarm shall be energized and the engine shall stop.
    c. The difference between the first and second stage pressure settings shall be approximately 15% of the oil pressure.
    d. Permanently indicate the pressure settings near the associated signal light.
5. Overspeed:
    a. When the engine RPM exceeds the maximum RPM recommended by the manufacturer of the engine, the engine shall stop.
    b. Simultaneously, the OVERSPEED signal light and the audible alarm shall be energized.
6. Low Fuel Level - Day Tank:
    When the fuel oil level in the day tank decreases to less than the level at which the fuel oil transfer pump starts to refill the tank, the LOW FUEL DAY TANK light and the audible alarm shall be energized.
7. Low Fuel Level - Main Storage Tank:
    When the fuel oil level in the storage tank decreases to less than one-third of total tank capacity, the LOW FUEL-MAIN STORAGE TANK signal light and audible alarm shall be energized.
8. Reset Alarms and Signals:
    Overcrank, Coolant Temperature, Coolant Level, Oil Pressure, Overspeed, and Low Fuel signal lights and the associated audible alarms shall require manual reset. A momentary-contact silencing switch and push-button shall silence the

audible alarm by using relays of solid state devices to seal in the audible alarm in the de-energized condition. Elimination of the alarm condition shall automatically release the sealed-in circuit for the audible alarm so that it will be automatically energized again when the next alarm condition occurs. The signal lights shall require manual reset after elimination of the condition which caused them to be energized. Install the audible alarm just outside the generator room in a location as directed by the COR. The audible alarm shall be rated for 85 dB at 10 ft [3 M].

9. Generator Breaker Signal Indication:
    a. Green shall indicate when the generator circuit breaker is in the OPEN position, Red shall indicate when the generator circuit breaker is in the CLOSED position, and Yellow shall indicate when the generator circuit breaker is in the TRIPPED position.
    b. Simultaneously, the audible alarm shall be energized.

D. Monitoring Devices:
    1. A running time indicator, totaling not fewer than 9,999 hours, heavy duty, and an electric-type tachometer.
    2. Voltmeter, ammeter, frequency meter, kilowatt meter, manual adjusting knob for the output voltage, and the other items shown on the drawings shall be indicated on HMI display screen.
    3. Install potential and current transformers as required.
    4. Individual signal lights:
        a. OVER-CRANK
        b. HIGH COOLANT TEMPERATURE - FIRST STAGE
        c. HIGH COOLANT TEMPERATURE - SECOND STAGE
        d. LOW COOLANT TEMPERATURE
        e. OIL PRESSURE - FIRST STAGE
        f. OIL PRESSURE - SECOND STAGE
        g. LOW COOLANT LEVEL
        h. GENERATOR BREAKER
        i. OVERSPEED
        j. LOW FUEL LEVEL - DAY TANK

k. LOW FUEL LEVEL – MAIN STORAGE TANK

5. Lamp Test: The Lamp Test momentary contact switch shall momentarily actuate the alarm buzzer and all the indicating lamps.

E. Automatic Voltage Regulator:

1. Shall correct voltage fluctuations rapidly and restore the output voltage to the predetermined level with a minimum amount of hunting.
2. Shall include voltage level adjuster located inside the control cubicle.
3. Provide a 3-phase automatic voltage regulator immune to waveform distortion.

F. Buss Voltage Monitoring:

1. Generators shall not be dependent on the Master Control Compartment for monitoring of the buss voltage for parallel operation. Each generator is to monitor voltage separately to eliminate this potential single point of failure.

## 2.7 BUILDING 103 EPSS BUSS VOLTAGE MONITORING

1. Building 103's EPSS five generators are dependent on the control system's monitored value of the buss voltage for paralleling. This condition has created a single point of failure within the EPSS that prevents it from paralleling any of the five generators with the loss of one 3 amp fuse.
2. The contractor shall provide all the labor, materials, equipment, and design to provide buss voltage monitoring for each of the five generators within Building 103.

## 2.8 GENERATOR PARALLELING CONTROLS

A. The Generator paralleling controls shall be integral to the switchgear with a state of the art totalizing redundant Programmable Logic Controller (PLC) based system utilizing ladder logic with a graphical touch screen (HMI) interface Digital Paralleling Control System (DPCS) and digital control technologies for each generator (3) as well as the master system control panel. The generator paralleling controls shall perform automatic and manual operation, synchronization, load management, monitoring, and alarm annunciation functions of the paralleled engine generator system and control of the connected ATSs via the VA fiber optic network.

B. Each Generator Control panel section shall have the following components:

1. Generator controller PLC
2. Digital Synchronizer & Load Controller

3. HMI Touchscreen Display

4. The HMI to be provided with a removable key switch.

The generator engine speed governor and voltage regulator shall be compatible with the digital control components listed above.

C. The Master Controller shall have a Redundant PLC system that will oversee and coordinate the operation of the 3 generators, and remote ATS's. The Master Controller will have both hardwired and communication network interfaces to the remote ATS's. Below are the hardwired connection requirements from the paralleling gear to each ATS fed from the paralleling gear.

| **Hard Wire** | **MOD/BUSS** | **Operation** | **Wires Required** |
|---|---|---|---|
| Common Wire | N/A | N/A | 1, #12 AWG |
| Engine Start Signal | Engine Start Signal | Command | 2, #12 AWG |
| Closed on Normal | Closed on Normal | Status | 1, #12 AWG |
| Closed on Emergency | Closed on Emergency | Status | 1, #12 AWG |
| Emergency Available | Emergency Available | Status | 1, #12 AWG |
| Emergency not Available | Emergency not Available | Status | Shared with above, status On/Off |
| Normal Available | Normal Available | Status | 1, #12 AWG |
| Normal not Available | Normal not Available | Status | Shared with above, status On/Off |
| Remote Transfer to Emergency | Remote Transfer to Emergency | Command | 2, #12 AWG |
| Switch in Bypass | Switch in Bypass | Status | 1, #12 AWG |
| Load Shed to Normal | Load Shed to Normal | Command | 2, #12 AWG |
| Manual Re-Transfer Inhibit | Manual Re-Transfer Inhibit | Command | 2, #12 AWG |

| | | | |
|---|---|---|---|
| Spare | Spare | Spare | 2, #12 AWG |

D. The master controller shall have two (2) Remote Annunciation Panels [LED type] that shall fully duplicate the Master Operator Interface Panel with virtual monitoring (no control) capability to provide the total system and individual generators remote status, alarm and display functions. The locations of these Remote Annunciation Panels shall be Bldg. 40 Boiler Plant office and the Police Station, Building 100, first floor.

1. The remote annunciation shall be integrated with the existing Building 100 EPSS SCADA remote monitoring systems located at the Bldg. 40 Boiler Plant office and the Police Station, Building 100, first floor.

2. Malfunction of remote annunciator and control system or communication link shall not affect functions of the automatic transfer switches. Automatic transfer switch sensing, controlling, or operating functions shall not depend on remote annunciator and control system for proper operation.

E. GENERATOR PARALLELING CONTROLS MONITORING SYSTEM

1. The Monitoring System for the Digital Paralleling Control System shall provide real – time monitoring, operator control workstation and historical data logging functionality. The system shall have HMI touchscreen displays and a large format display located at the Master Control Cubicle/Compartment. The operator control workstation will include a customized interface that include the power one-line diagram screens, operator control functions, system status alarm and event viewing, system/communications diagnostics, and historical trending.

2. SCADA Server:

a. B-103A DPCS control and operation is required to be integrated into the updated existing Building 100 EPSS SCADA system. This shall include all the necessary software programming and graphical displays. Provide and install all patch panels and Ethernet cabling to optical switches required for an optical connection to the existing SCADA Server located in room FB-120 of building 100.

b. Existing B-103 DPCS control and operation is required to be updated. This shall include all the necessary software programming, hardware modifications, and graphical display modifications to reflect the new B-103 electrical distribution control configuration to final conditions at the completion of the project.

c. B-100 EPSS SCADA system shall be updated to include full integration and operational control of either B-103A DPCS or B-103 DPCS from any of the three control locations, B-103A paralleling switchgear, B-103 paralleling switchgear, and basement B-100, EB-120 Engineering Control Room.

3. DPCS Operator Control Workstation:

a. The Operator Control Workstation is to be a panel mounted industrial computer and display. The computer will be located inside the switchgear Master Control section with the display mounted on the door. The keyboard and mouse will be accessible via a door mounted Keyboard Box with a hinged shelf to operate from.

b. The Operator Control Workstation will incorporate graphic screens with animated device objects and symbols, plus real-time metering values to present the system information to the operators. The system will be developed to include the following list of graphical screens specific for the Operator Control Workstation (B-103A):

1) The Overview screen:

The overview screen shall include a summary overview One-Line diagram of the emergency power system. Additional screens shall be accessible via navigation links from this overview screen, included but not limited to the following:

(a) Generator Details – Metering and Status
(b) Generator Details – Value Trending
(c) Load Optimization
(d) Load Shed Control
(e) Load Add Control
(f) ATS System Overview and Metering
(g) ATS Overview by Location
(h) ATS One-Line by Location
(i) PLC Diagnostics
(j) Full System Generator Load Test
(k) Events Screen
(l) Alarm Screen
(m) Log-In Screen

2) Electrical One-line Screen(s):

The Electrical One-line screen(s) shall depict system configuration in a single line format and shall show detailed information for each section of the system attached.

Display system paralleling configuration and system status to include, but not limited to the following:

(a) Generator Breaker Status of generator sets, Open/Closed/Tripped

(b) Protective Relay Status

(c) Generator Status

(d) Real time power values of generator set(s) Voltage, Amps, kWatts, pF, kVars and Frequency.

(e) Real time power values of electrical loads on the main buss including Voltage, Amps, kWatts, pF, kVars and Frequency

(f) ATS Position Status

(g) Interactive one-line color, RED indicating on Emergency, Green indicating on Normal power

(h) Paralleling switchgear feeder breaker status, Open/Closed/Tripped

3) Manual Paralleling Control Screen:

Manual Paralleling Control Screen shall provide manual paralleling control capability over individual generator sets.

(a) Synchroscope- Graphical (real time 360-degree analog) with digital display.

(b) Manual Raising Lowering of voltage and frequency.

(c) Automatic voltage and frequency set points of generator.

(d) Real time power values of generator and generator bus.

(e) Generator Circuit Breaker Position/status.

(f) Ability to select which generator set to be paralleled.

(g) Manual closing of a generator Circuit Breaker

4) ATS Status Screen:

ATS Status Screen shall display status, electrical loads and provide control of each ATS connected to the system. ATS shall be equipped with proper features and accessories.

(a) Sources available

(b) ATS Connected to Normal

(c) ATS Connected to Emergency

(d) Engine Start Indication

(e) Load Shed Indication

(f) ATS Load Priority. Ability to change ATS priorities (password protected).

(g) Monitoring of Voltage, Amps, kWatts, kV-Amps, kVars, pF & Frequency

(h) ATS Manual Test

(i) Failure of communication link

5) Engine Generator Alarm and Shutdown Screen:

(a) Not in Auto

(b) Emergency Mode

(c) Generator Circuit Breaker Ground Fault Alarm

(d) Pre-High Coolant Temperature

(e) Pre-low Oil Pressure

(f) Low Coolant Temperature

(g) Low Battery Voltage

(h) Low Fuel Level Alarm

(i) Battery Charger Malfunction

(j) Engine Overcrank

(k) Engine Overspeed

(l) Engine Low Oil Shutdown

(m) Engine High Coolant Temp Shutdown

(n) Engine Low Coolant Level Shutdown

(o) Generator Circuit Breaker Tripped

(p) Generator Reverse Power

(q) Generator Under Voltage

(r) Generator Over Voltage

(s) Generator Under Frequency

(t) Generator Over Frequency

(u) Generator Loss of Excitation

(v) Generator Phase Reversal

(w) Alarm reset button

(x) Emergency Stop Button

6) Engine Generator Control and Setup Screen:

(a) Engine cool down timer setting.

(b) Cycle Crank attempts.

(c) Cranking time delay.

(d) Crank reset timer setting.

(e) Failure to synch timer setting.

(f) Number of actual crank attempts.

(g) Actual cool down timer left.

(h) Synch Mode Switch OFF, Auto, Check, Permissive.

(i) Cycle Crank logic enabled / disabled.

7) Configuration and Settings Screen:

The Configuration and Settings Screens shall provide access to view and edit set points and other information available as part of the DPCS System including, but not limited to, the following:

(a) Generator Start Delay

(b) Generator Cooldown time

(c) Load Demand Control parameters

(d) Load Shed Control parameters

(e) Engine priority, with Load Demand time delays (password protected).

(f) Load Demand pick-up and drop-out kW levels (password protected).

(g) Bus Load Optimization derating %, with Bus Load Optimization time delays (password protected).

(h) Scrolling system status: Emergency mode, Normal available, Generator(s) on-line, Generator(s) failure, Generator(s) available, Generator(s) synchronizer active, Generator(s) VAR Sharing active, Generator(s) Load Sharing active.

(i) Shall have Soft-load transition during Load Demand Mode (standby operation) when load sharing between engine generators, on all diesel generator sets. When a unit is in the Load Demand Mode and is being added, it shall soft- load on to the bus. If a unit is taken off-line normally under load demand operation, the units should gradually unload before the generator breaker is signaled to open.

(j) Shall have Bus Load Optimization.

8) The Alarm & Event Screen:

The Alarm & Event screen provides a list of active alarms within the system, and a separate list of the Alarm/Event historical log. The Alarm section lists the alarms that are currently in an alarm state for the entire system. A date & time stamp of the alarm occurrence is displayed along with a color code to indicate if the alarm is cleared or acknowledged. Operator can acknowledge and clear alarms of over 2000 different events. If the alarm is both acknowledged AND cleared it is removed from the list.

The Historical Event section provides a sequence of operations log for the entire system. The section includes both alarms and events together. Date & time stamped records are logged for each change of state of the alarm/event tag. This data can be filtered and exported to generate reports.

9) Generator Status Screen:

The Generator Status screen will be a popup window to view real-time data and status for the

respective generator. The screen will include, but not limited to, the following:

(a) Generator operating status (Not-In-Auto, Running, Online, Cooldown)

(b) Engine mechanical alarm status

(c) Day Tank Fuel level status

(d) Real-time metering values

(e) Generator Control Switch

(f) Remote Start Indication

(g) Engine Start Indication

(h) Cooldown Timer Indication

(i) Engine Status Water Temperature

(j) Oil Pressure

(k) Engine Runtime Hour (down to tenth of a second)

(l) Engine Available

(m) Engine Not Available

(n) Interactive Color Graphical One-Line Representation of:

i. Generator

ii. Generator Breaker Status

(o) Lockout Relay Status (86 Relay)

(p) Reverse Power Status (32 Relay)

(q) Synchronization Status (25 Relay)

(r) Generator Voltage

(s) Primary Buss Voltage

(t) KW Load

(u) Amperage Load

(v) Generator HMI Assisted Manual Synchronization

(w) Generator Alarm Status

(x) Generator Settings

10) Historical Trending Screen:

The Historical Trending screen will be a popup window to view historical analog data from

equipment. The screen will include adjustable parameters to display the desired trend data. Once established the screens and historical data can be saved or printed for reporting purposes. The screens shall include, but not limited to, the following:

1. Dual Three Phase Metering Screen: graphical analog (270 electrical degree) metering representation with digital display. Shall have capability to display metering for two generators at the same time or one generator and the bus at the same time. Screen shall display a graphical Synchroscope when one generator and the bus are selected. The following minimum metering data (parameters) for selected generator set and generator main bus totals shall be displayed:
   i. True RMS three phase Voltage, Amps, kWatts, kV-Amps, kVars, pF and Frequency.
   ii. Engine battery Voltage display.
   iii. Running Time Meter.
2. Single Three Phase Metering Screen: graphical analog (270 electrical degree) metering representation with digital display. Shall display the following minimum metering data for selected generator set or selected main bus.
   i. True RMS three phase Voltage, Amps, kWatts, kV-Amps, kVars, pF & Frequency
   ii. Engine battery Voltage display.
3. kW Trending Screen- to display kW trending of generator sets and main bus. The kW trend screen shall have the capability to enable or disable auto store. The Auto store feature when enabled will automatically store the trend screen onto compact flash card every five minutes.
4. Multiple Parameter Service Trending Screen: Capable of trending multiple parameters on one screen, comparing all generators/utilities, kW, kVars, voltage, current and frequency. Trending screen shall have the capability to enable or disable auto store. The operator shall

also have the ability to manual store any screen captures onto the flash memory card.

F. The Operator Control Workstation (Basement B-100, EB-120) shall include all the necessary software programming, hardware modifications, and graphical display modifications to fully duplicate the Master Control Cubicle HMI with virtual monitoring and control capability of the B-103 and B-103A DPCS systems.

## 2.9 PARALLELING CONTROLS SQUENCE OF OPERATION

A. Generator Control Panel – Control Switches and Indicator Lights

**Gen Available Light (GAVL)**
Lights to signal that the generator is available to start automatically.

**Ready To Load Light (GRTLL)**
Lights to signal that the generator is running at rated voltage and frequency.

**Auto Synch Light (GASL)**
Lights to signal that the generator automatic synchronizer is active.

**Gen Online Light (GOLL)**
Lights to signal that the generator is running and connected (breaker closed) to the Generator Bus.

**Gen Cooldown Light (GCDL)**
Lights to signal that the generator is offline and running in a Cooldown delay prior to shutting down.

**Alarm Light (GALML)**
Lights to signal that the generator control system has an active alarm.

**Breaker Open Light (GBOL)**
Lights to signal that the generator breaker is open.

**Breaker Closed Light (GBCL)**
Lights to signal that the generator breaker is closed.

**86 Light (86L)**
Lights to signal that the generator breaker lockout relay (86) has tripped.

**Generator-Control Switch RUN/OFF/AUTO (GCS)**
Switch allows the generator set to be manually started and run when placed in the RUN position. The OFF position shuts down the generator set immediately also preventing future engine starts. The AUTO position places the generator set under the control of the automatic start/stop

circuits.

**Emergency-Stop Pushbutton (ESTP)**
Pushbutton immediately shuts down the generator set by use of its air damper and opens the generator breaker. Place the GCS in the OFF position and reset the air damper on the engine before resetting the shutdown circuit and restarting the generator set.

**Circuit Breaker Control Switch OPEN/CLOSE (BCS)**
Switch allows the operator to manually trip or close the generator circuit breaker. The red light indicates that the circuit breaker is in the CLOSE position and the green light indicates the circuit breaker is in the OPEN position. Use the BCS switch to close the breaker only when the GSC is in the RUN position.

**86 Lockout Relay (86G)**
The 86 relay is automatically operated (tripped) by the generator breaker protection circuitry. Once operated, the 86 relay will trip and prevent closing (lockout) of the generator breaker. The blue light indicates that the 86 relay has tripped. The 86 relay requires manual

B. Manual Generator Operation:

1. The system will have manual parallel capability for each of the generators. The operator can perform this via the new Generator Control Panel (GCP). During normal system operation, the Generator Switchgear bus is de-energized with all the respective feeder breakers closed, and all generator breakers open.

2. A generator can be manually started by selecting the Generator Control Switch (GCS) to the RUN position. The generator will be started and ramp to rated voltage and frequency.

3. Each new GCP will have its own analog synchro-scope meter, plus internally its own synch-check (25) relay. Thus each generator can be synchronized independently without the need for a pre selection. Once at rated voltage and frequency the synchro-scope meter will be turned on for the operator’s viewing.

4. If the bus is not energized no voltage and frequency adjustments will be made, and the operator can use the Circuit Breaker Control Switch (BCS) to manually CLOSE the generator circuit breaker onto the dead bus (DB). The synch-check (25) relay will supervise the breaker closing operation and verify the DB condition before allowing the breaker to close.

5. If the bus is energized from another generator that is online, the digital controllers will then proceed to automatically adjust the voltage and frequency of the generator to bring the generator into synchronism with the bus. This will be maintained indefinitely until such time as the operator manually closes the generator breaker, or selects the GCS to the OFF position to stop the generator. The operator can use the Circuit Breaker Control Switch (BCS) to manually CLOSE the generator circuit breaker onto the energized bus. The synch-check (25) relay will supervise the breaker closing operation and verify the in-synch condition before allowing the breaker to close.

6. Once the generator breaker is closed the online generator will, if alone, maintain rated voltage and frequency, and deliver power to the load on the bus. If multiple generators are on-line then they will proportionally load share power to the load on the bus. The synch-check (25) relay will be turned off when the generator is online.

7. When the generator is online, the operator can use the Circuit Breaker Control Switch (BCS) to manually OPEN the generator circuit breaker. The generator operation will revert back to that described in para. 3, 4, and 5 above.

8. When the generator is online, if the operator selects the Generator Control Switch, (GCS) to the OFF position the generator circuit breaker will OPEN, the Lock-out (86) relay will TRIP, and the generator will run for a Cooldown period (typically 5 min.) then stop.

9. If at any time when the generator is running and the Emergency Stop button is pressed, the generator breaker will OPEN (if closed) and the generator will stop immediately without a Cooldown period.

C. Normal Operation:

1. During normal system operation, the Generator Switchgear bus is de-energized with all the respective feeder breakers closed, and generator breakers open. All three generators are in Automatic mode, and Available to start independently upon command from any connected ATS.

2. All the connected ATS’s are closed in their Normal position. The condition of Normal power available is sensed internally by each ATS.

3. Any of the three generators can be in OFF mode, if desired. This means that the generator will not start automatically. In this mode the operator can;

- Manually start the generator by selecting RUN mode
- Manually open/close the generator breaker (when it is running)

D. Emergency Operation:

1. A Power Failure is detected by an ATS sensing loss of Normal power at its Normal Source input. In the event of a Power Failure, the following emergency power restoration sequence occurs.

   a. Upon initiation of the automatic sequence, all engine-generators shall start. The first engine-generator to achieve 90% of nominal voltage and frequency shall be connected to the bus. All first priority loads shall be transferred to the bus upon sensing availability of power on the bus within 10 seconds. As the remaining engine-generators start, their respective synchronizers shall initiate control of voltage and frequency of the oncoming set with the bus. Upon synchronizing with the bus, the oncoming set shall be paralleled on the bus. Each time an additional engine-generator is added to the bus, the remaining ATS loads shall be transferred in priority sequence. This load add sequence is predetermined and programmed into the DPCS PLC load add ladder logic. This metered and calculated load add sequence shall continue until all loads are connected to the bus, based on system capacity. Circuitry and programming shall prevent the automatic transfer of loads to the bus until there is sufficient capacity to carry these loads. Provision shall be made to manually override the load addition circuits for supervised operation.

   b. Load demand sensing shall be furnished to ensure that sufficient generating capacity is connected to the bus to carry the load. The load demand sensing shall also ensure that not more than the required capacity plus a limited reserve is connected to the bus at any time. The system in conjunction with the load demand shall ensure high efficiency in the utilization of engine-generator sets and foremost assurance of maximum system availability and reliability.

   c. Load demand sensing shall ensure that the on line reserve capacity does not fall to less than 25% or exceed more than 125% of a single engine-generator. Upon sensing if the connected load exceeds the present limit for an established period of time, the next engine-generator will be started and paralleled. If upon sensing, the connected load is determined to be less than the preset limit for an

established period of time, the last engine-generator to be paralleled will be disconnected and shut down. Its controls will be automatically reset so that the engine-generator will be ready for next operation.

d. While engine-generator(s) are connected to the bus, and if the connected load exceeds the capacity of the online generators or bus, resulting in an overload condition or decrease in system frequency to 58 Hz or less, load dumping/shedding shall be initiated to reduce the connected load within the capacity, maximum 85% of generator output rating, of the available generator(s). The contractor shall work with the VA to program and set the priorities of the ATSs to sequence the load shed.

Similarly, with increased loading, the remaining engine-generator(s) shall be signaled to start and be paralleled to the engine-generator(s) already connected to the bus, and the load dump signal shall be automatically cancelled. With the increased capacity, load add functions shall resume. Upon restoration of the normal source of power supply, as defined in the automatic transfer switches for an adjustable period of 0 to 15 minutes, the loads shall be transferred back to the normal power source. Subsequently, the engine-generator shall be disconnected from the bus, run for an adjustable period of time up to 15 minutes maximum for cool down, and then shut down. All controls associated with operation of the engine-generator shall automatically reset for the next automatic operation.

e. Should the normal power return before the ATS detects Emergency power is available, the automatic emergency power restoration sequence is aborted and the ATS(s) remain in their Normal position thus restoring power to the loads.

f. Should any of the generators fail to start or close onto the bus, they shall be locked-out until manual reset.

E. Generator Load Bank Test:

1. The generator full load test provides a manual or time initiated function to connect one generator at the time to the automatic load bank.

a. The selected generator shall operate up to rated capacity for a determined period of time.

b. This function also shall be capable to connect generators to load bank with the purpose or regenerating the passive diesel particle filter of each generator.

F. Generator Operational Load Test:

1. The Generator Load Test function provides a manually initiated sequence that automatically transfers the emergency power system load onto the generators. The following outlines the sequence that is performed.

   a. Each available generator will independently start and the first generator coming to approximately 90% of its rated speed and voltage closes onto the dead bus via its generator breaker. A special provision in the control system prevents two or more generator breakers from closing on the dead bus at the same instant.

   b. The remaining generators automatically synchronize and parallel onto the generator bus.

   c. Sequentially the ATS's will be commanded to transfer to their Emergency position thus transferring the emergency system load onto the generators.

   d. The online generator(s) proportionally share the total generator bus load.

   e. After the Activation Delay, the Load Demand Control becomes active which may shutdown the lower priority generator(s).

2. Return to Normal power from a Generator Load Test the following outlines the sequence that is performed.

   a. Sequentially the ATS's will be commanded to transfer to their Normal position thus transferring the system load back to the utility.

   b. Once all the ATS Engine START signals have been de-activated, the generator breakers will open and the generators continue to run for a defined Cooldown period (typically 5 min.) before stopping.

G. ATS Manual Control:

1. The Power Monitoring and Control System (PMCS), in conjunction

with the Paralleling Switchgear Master PLC operation, will be integrated with the ATS Operator Controls located at the ATS Manual Control Cubicle/Compartment such that Manual operation of the ATS's can be performed both at the Paralleling Switchgear HMI Operator Workstation and at the ATS Manual Control Compartment.

2. The ATS Manual Control Cubicle/Compartment shall consist of individual ATS control switches (TEST EMERGENCY – AUTO – LOAD SHED) providing manual operational control, independent of the PLC based paralleling system or the Building 100 EPSS SCADA system.

## 2.10 BATTERY SYSTEM

A. Batteries:

1. Provide high discharge rate type maintenance-free nickel-cadmium batteries. Battery voltage shall be // 125 // 48 // volts nominal. Calculate the battery capacity based on the lowest ambient temperature in the room where it is to be installed. Include a safety margin of 50 percent for reserve capacity.

   a. Provide sufficient battery capacity 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 line-up of four or less breakers, or close the two largest breakers simultaneously in a line up 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.

2. Provide battery connector covers for protection against external short circuits.

3. Provide corrosion-resistant fiber glass battery boxes.

4. Batteries boxes shall be secured to a steel rack to prevent overturning during a seismic event. Battery rack shall also be secured to the floor.

B. Battery Charger:

1. Provide a charger of the full wave rectifier type utilizing silicon controlled rectifiers as the power-control elements. Construction

shall be modular with plug-in control units for easy replacement.

2. The charger shall maintain 1/2 of one percent voltage regulation from no load to full load for line voltage variation of 10 percent, and frequency variation of 3 Hz from 60 Hz.
3. The charger shall maintain a nominal float voltage of 1.4 vpc, and a nominal equalizing voltage of 1.5 vpc.
4. The charger shall be capable of continuous operation in an ambient temperature of 40 °C (104 °F) without derating. The charger shall be installed in a convection cooled NEMA Type 1 ventilated enclosure. The housing is to have a hinged front door with all equipment accessible from the front.
5. Provide both AC and DC transient protection. Charger shall be able to recharge a fully discharged battery without tripping AC protective devices. AC circuit breaker shall not trip under any DC load condition, including short circuit on output terminals.
6. The charger shall be capable of supplying the following demand simultaneously:
   a. Recharging a fully discharged battery in 12 hours.
   b. Supervisory panel and control panel.
   c. Steady loads (indicating lamps, relays, etc.).
7. The charger shall have fused AC input and DC output protection.
8. The charger shall not discharge the batteries when AC power fails.
9. The charger shall have the following accessories:
   a. On-off control switch with pilot light.
   b. AC power failure alarm light.
   c. High DC voltage alarm light.
   d. Low DC voltage alarm light.
   e. Ground detection switch and alarm light.
   f. DC ammeter - 2 percent accuracy.
   g. DC voltmeter - 2 percent accuracy: Float/equalize voltage marked in red on voltmeter.
   h. Provisions for activation of remote annunciation of trouble for the above conditions.

## 2.11 SURGE PROTECTIVE DEVICE

A. Refer to Section 26 43 13, SURGE PROTECTIVE DEVICES.

## 2.12 OTHER EQUIPMENT

A. Furnish tools and accessories required for circuit breaker and switchgear test, inspection, maintenance, and proper operation.

B. Circuit breaker removal equipment: Furnish a portable circuit breaker removal lift and carriage for installation and removal of circuit breakers.

## 2.13 CONTROL WIRING

A. Switchgear control wires shall not be less than No. 12 AWG copper 600 V rated. Install wiring complete at the factory, adequately bundled and protected. Provide separate control circuit fuses in each breaker compartment and locate for ease of access and maintenance.

## 2.14 NAMEPLATES AND MIMIC BUS

A. Nameplates: For Normal Power system, provide laminated black phenolic resin with white core with 12 mm (1/2 inch) engraved lettered nameplates next to each circuit breaker. For Essential Electrical System, provide laminated red phenolic resin with white core with 12 mm (1/2 inch) engraved lettered nameplates next to each circuit breaker. Nameplates shall indicate equipment served, spaces, or spares in accordance with one line diagram shown on drawings. Nameplates shall be mounted with plated screws on front of breakers or on equipment enclosure next to breakers. Mounting nameplates only with adhesive is not acceptable.

B. Mimic Bus: Provide an approved mimic bus on front of each switchgear assembly. Color shall be black for the Normal Power system and red for the Essential Electrical System, either factory-painted plastic or metal strips. Plastic tape shall not be used. Use symbols similar to one line diagram shown on drawings. Plastic or metal strips shall be mounted with plated screws.

## 2.15 RESISTIVE PERMANENT AUTOMATIC LOAD BANK

A. Rating

1. The total capacity of the load bank shall be rated 2000 KW at 480 Volts, 3-Phase, 3-Wire, 60 Hertz, 2404 Amps per Phase at unity Power Factor and 50 KW minimum load step resolution.

2. The load bank shall be designed for continuous duty cycle operation with no limitations. The load bank shall operate in an ambient temperature of -28°C to 49°C (-20°F to 120°F).

B. Material and Construction

1. The load bank shall be outdoor weatherproof construction, suitable for installation on a concrete pad or structural base. All exterior fasteners shall be stainless steel. The load bank shall include forklift channels in the base for lifting.

2. The load bank shall be constructed of heavy gauge aluminized steel per ASTM A463. Aluminized steel provides superior corrosion protection and extended service life, with a better tolerance to high heat exposure compared to the more common Galvanized steel.

3. The main input load bus, load step relays, fuses and blower/control relays shall be located within the load bank enclosure. A thermostatically controlled heater shall be located within the control section to provide protection to the control devices from the effects of moisture and condensation.

4. Airflow throughout the load bank shall be vertical. Ambient intake cooling air shall be drawn in at the base of the unit and heated air exhausted out the top. Intake openings shall be designed to prevent objects greater than 0.50″ diameter from entering the unit.

5. The load bank exhaust hood(s) shall be angled and include interior baffle plates to direct falling rain from the interior of the load bank. The exhaust hood(s) shall be constructed of non-corrosive aluminized steel or aluminum.

6. The load bank enclosure shall have a baked polyester powder coated finish with a film thickness of 2.8 +/- 0.4 Mils per coat.

7. Load elements shall be contained in multiple resistor cases or trays. Each can be removed in it's entirety as a unit for inspection or service.

C. Resistive Load Elements

1. Load elements shall be Avtron Helidyne™, helically wound chromium alloy rated to operate at approximately ½ of maximum continuous rating of wire. Elements must be fully supported across the entire length within the air stream by segmented ceramic insulators on stainless steel rods. Element supports shall be designed to prevent a short circuit to adjacent elements or to ground.

2. The change in resistance due to temperature shall be minimized by maintaining conservative watt densities.

3. The overall tolerance of the load bank shall be –0% to +5% KW at rated voltage. A –5%, +5% rating allows the load bank to deliver less than rated KW and shall not be used. The load bank must deliver full rated KW at rated voltage.

D. Cooling

1. The load bank shall be cooled by integral TEFC or TEAO motor(s) which is direct coupled to the cooling fan blade. The fan motor must be electrically protected against overload using a motor overload device and short circuit protected using three (3) current limiting fuses with an interrupting rating of 200K A.I.C.

2. The fan blade is to be an airfoil design constructed from aluminum or non-corroding material.

3. An integral control power transformer shall be provided to supply 120V, 1 phase, 60 Hz to the load banks control and motor starter

circuitry. Transformer primary and secondary control circuits shall be fuse protected.

E. Protective Devices

1. A differential pressure switch(s) shall be provided to detect air loss (one for each stack). The switch(s) shall be electrically interlocked with the load application controls to prevent load from being applied if cooling air is not present.
2. An over-temperature switch shall be provided to sense the load bank exhaust in each vertical heater case assembly. The switch shall be electrically interlocked with the load application controls to remove load from being applied in the event of an over temperature condition.
3. To provide for major fault protection, branch fuses shall be provided on all three phases of switched load steps above 50KW. Branch fuses shall be current limiting type with an interrupting rating of 200K A.I.C.
4. The exterior of the load bank shall have appropriate warning/caution statements on access panels.

F. Control Panel

1. The control panel shall be a remote 19″ rack mounted panel housed in a NEMA 4 type wall mount enclosure. The control panel shall contain the following manual controls:
   a. Power ON/OFF switch
   b. Blower START/STOP pushbuttons.
   c. Master load ON/OFF switch.
   d. Load step switches for ON/OFF application of individual load steps.
2. Control panel visual indicators shall be as follows:
   a. Power ON indication light.
   b. Blower ON light.
   c. Blower/Air FAILURE light.
   d. OVERTEMPERATURE light.
3. A standard remote load dump circuit shall be provided as part of the load bank control circuit. Provisions shall be provided to remove the load bank off-line from the operation of a remote normally closed set of auxiliary contacts from a transfer switch or other device. In the event of the remote contact opening, all load is removed.

4. A Normal (Utility) Power Loss Sensing Relay circuit shall be provided as part of the load bank control circuit. In the event of normal (utility) power loss, the load bank shall be set off-line and all load is to be removed from the generators.

5. An Automatic Load Step Controller shall be provided for maintaining a minimum of 30% load on each generator set during all generator operations. The controller shall monitor the connected downstream loads and will automatically add or subtract load steps in response to building load changes as to maintain a minimum 30% load level on all the generator sets during all generator operations. The controller includes an initial time-delay circuit, and automatic time delayed load step application circuit. A remote contact closure is required for activation and transfer of control. A separate current transformer shall be supplied loose for mounting and sensing of downstream loads.

6. The load bank shall have a digital monitoring system with real-time data logging software. The monitoring system shall provide a 3-line extra-bright LED display of Voltage, Current, Frequency and Power Measurements. System shall utilize communicator EXT type software which provides PC based real- time monitoring and also automated data acquisition from an optical IrDA port. An IrDA/USB adapter shall be provided for plug and play convenience.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

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

B. Anchor switchgear with rustproof bolts, nuts, and washers not less than 13 mm (1/2 inch) diameter, in accordance with manufacturer’s instructions, and as shown on drawings.

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

D. Interior Location. Mount switchgear on with a section over the trough concrete slab. Unless otherwise indicated, the house keeping pad shall be at least 100 mm (4 inches) thick. The top of the concrete slab shall be approximately 100 mm (4 inches) above finished floor. Edges above floor shall have 15 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 100 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches)

above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

## 3.2 ACCEPTANCE CHECKS AND TESTS

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

1. Visual Inspection and Tests:
    a. Compare equipment nameplate data with specifications and approved shop drawings.
    b. Inspect physical, electrical, and mechanical condition.
    c. Confirm correct application of manufacturer's recommended lubricants.
    d. Verify appropriate anchorage, required area clearances, and correct alignment.
    e. Verify that circuit breaker sizes and types correspond to approved shop drawings.
    f. Verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.
    g. Confirm correct operation and sequencing of key-type mechanical interlock systems.
    h. Vacuum-clean switchgear enclosure interior. Clean switchgear enclosure exterior.
    i. Inspect insulators for evidence of physical damage or contaminated surfaces.
    j. Verify correct shutter installation and operation.
    k. Exercise all active components.
    l. Verify the correct operation of all sensing devices, alarms, and indicating devices.
    m. Verify that vents are clear.
2. Electrical tests:
    a. Perform insulation-resistance tests on each bus section.
    b. Perform insulation-resistance test on control wiring; do not perform this test on wiring connected to solid-state components.
    c. Perform phasing check on double-ended switchgear to ensure correct bus phasing from each source.

B. Prior to the final inspection for acceptance, a technical representative from the electric utility company shall witness the testing of the equipment to

assure the proper operation of the individual components, and to confirm proper operation/coordination with electric utility company's equipment.

## 3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the switchgear is in good operating condition and properly performing the intended function.

## 3.4 TEMPORARY HEATING

A. Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

## 3.5 WARNING SIGN

A. Mount on each entrance door of the of enclosure switchgear room, approximately 1500 mm (5 feet) above grade or floor**,** a clearly lettered warning sign for warning personnel. The sign shall be attached with rustproof metal screws.

## 3.6 ONE LINE DIAGRAM AND SEQUENCE OF OPERATION

A. At final inspection, an as-built one line diagram shall be laminated or mounted under acrylic glass, and installed in a frame mounted in the switchgear room or in the outdoor switchgear enclosure.

B. Furnish a written sequence of operation for the switchgear and connected line side/load side electrical distribution equipment. The sequence of operation shall be laminated or mounted under acrylic glass, and installed in a frame mounted in the switchgear room or in the outdoor switchgear enclosure.

C. Deliver an additional four copies of the as-built one line diagram and sequence of operation to the COR.

## 3.7 AS-LEFT TRIP UNIT SETTINGS

A. The trip unit settings shall be set in the field by an authorized representative of the switchgear manufacturer per the approved Overcurrent Protective Device Coordination Study in accordance with Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY.

B. The trip unit settings of the main breaker(s) shall be reviewed by the electric utility company to assure coordination with the electric utility company primary fusing. Prior to switchgear activation, provide written verification of this review to the COR.

C. Post a durable copy of the "as-left" trip unit settings in a convenient location in the switchgear room. Deliver four additional copies of the settings to the COR. Furnish this information prior to the activation of the switchgear.

## 3.8 INSTRUCTION

A. Furnish the services of a factory-trained technician for two, 4-hour training periods for instructing personnel in the maintenance and operation of the switchgear, on the dates requested by the COR.

**END OF SECTION 26 23 00**