16355 - GENERATOR SWITCHGEAR

City of San Diego, CWP Guidelines

PART 1 -- GENERAL

1.1 WORK OF THIS SECTION

A. The WORK of this Section includes providing generator switchgear to parallel the number and size of generators indicated. The generator switchgear and logic circuits shall be provided as a complete system necessary for the parallel operation, synchronization, and load control of generator sets.

1.2 RELATED SECTIONS

A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

1. Section 11500 Engine Generator
2. Section 16030 Electrical Tests
3. Section 16431 Short Circuit and Coordination Report

1.3 CODES

A. The WORK of this Section shall comply with the current editions of the following codes as adopted by the City of San Diego Municipal Code:

1. NFPA 70, National Electrical Code (NEC)

1.4 SPECIFICATIONS AND STANDARDS

A. Except as otherwise indicated, the current editions of the following apply to the WORK of this Section:

1. UL 1558
Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear

2. ANSI C37.13 Low-Voltage AC Power Circuit Breakers Used in Enclosures

3. ANSI C37.20 Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear Assemblies

4. ANSI C37.90 Relays and Relay Systems Associated with Electric Power Apparatus

5. ANSI C39.1 Requirements for Electrical Analog Indicating Instruments

6. ANSI C57.13 Requirements for Instrument Transformers

7. NEMA SG3 Low Voltage Power Circuit Breakers

1. SHOP DRAWINGS AND SAMPLES

A. The following shall be submitted in compliance with Section 01300:

1. Manufacturer's certification that the following items are rated to withstand or interrupt the bolted three-phase short circuit current indicated.

a. Bus bar bracing
b. Circuit breakers or fuses
c. Instrument transformers

2. Outline drawings showing all physical dimensions, weights and mounting details of the completely assembled equipment.

3. Schematic diagrams showing all the generator switchgear components and their interconnections. The drawings shall show all external connections.

4. Complete bill of material with data sheets on all major components.

5. Time-current curves for all circuit breakers, fuses, and relays.

6. Nameplate and switch escutcheon plate schedule.

7. Test procedures for final factory testing of the generator switchgear assembly.

1.6 OWNER'S MANUAL

A. The following shall be included in the OWNER'S MANUAL in compliance with Section 01300:

1. Manufacturer's installation instructions.

2. Operating Procedures:

a. Startup routine and normal operating instructions
b. Control, stopping, shutdown and emergency instructions
c. Special operating instructions

3. Maintenance Procedures

d. Routine maintenance
e. Adjustment and checking

4. Original manufacturer's parts list, illustrations, assembly drawings and diagrams required for maintenance.

5. Factory certification of manufacturer's functional test.

1.7 SERVICES OF MANUFACTURER

A. **Instruction of OWNER'S Personnel**: An authorized service representative of the generator switchgear manufacturer shall train the OWNER'S personnel in the

operation and maintenance of the generator switchgear, including step-by-step troubleshooting with necessary test equipment. The representative shall be familiar with the installed unit.

B. The representative shall have at least 2 years' experience in training. A resume for the representative shall be submitted to the CONSTRUCTION MANAGER.

C. Training shall be scheduled at least 3 weeks in advance of the first session.

D. Proposed training materials and a detailed outline of each lesson shall be submitted to the CONSTRUCTION MANAGER for review. Comments from the CONSTRUCTION MANAGER shall be incorporated into the material.

E. Training materials shall remain with the trainees.

F. The OWNER may videotape the training sessions for later use by the OWNER'S personnel.

G. The training shall last at least [5] days and shall address the following operations:

1. Engine generator normal startup and shutdown.

2. Engine generator emergency shutdown.

3. Automatic synchronization.

4. Manual synchronization.

5. Correct operation of key interlocks.

H. Training and reference materials for up to 7 persons shall be furnished. The OWNER will provide an area for classroom type training.

1.8 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. **Storage:** Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements. Products shall not be damaged, marred, or splattered with water, foam, plaster, or paint. Moving parts shall be kept clean and dry.

B. **Replacement**: Damaged materials or equipment, including face plates of panels and generator switchgear sections, shall be replaced or refinished by the manufacturer at no additional cost to the OWNER.

PART 2 -- PRODUCTS

1.1 GENERAL CONSTRUCTION

A. **Bus:** Power bus material shall be tin-plated copper. Bolts on all joints shall be high tensile strength. Bus shall be adequately braced to withstand the short-circuit current indicated. Minimum bracing level shall be not less the

[50,000][100,000][150,000][200,000] amps RMS symmetrical. Ground bus material shall be copper. Ground bus shall run the entire length of the switchgear.

B. **Arrangement:** The generator switchgear shall consist of indoor sectional enclosures arranged to house the specified system components, and shall consist, as a minimum, of the following basic sections or arrangements:

1. Generator Breaker and Control Sections
2. Distribution Breaker Sections
3. Master Control Section
4. Utility Section (if required)

C. **Enclosure:** Enclosures shall comply with the following:

1. The switchgear shall be free standing, NEMA 1, metal-enclosed type, consisting of front and rear removable panels. Hinged panel sections shall access all of the sub-panel mounted control equipment. End sections shall permit future additions without disturbing the initial installation. The switchgear shall be constructed of formed sections of smooth, rolled sheet steel, bolted together and reinforced where necessary with structural steel members. Doors and interior panels shall be constructed of 12 gauge, minimum, formed sheet steel. Hinges shall be the concealed type and shall allow the doors to swing through not less than 105 degrees from the closed position. Each door shall be furnished with a locking latch with keys removable in both the locked and unlocked position. All locks shall be keyed alike. Vents or louvers shall be provided, where required, to give adequate ventilation.

2. Steel channel anchoring sills shall be furnished with the switchgear. Provisions shall be made for top or bottom cable entry.

3. After welding is completed, all steel work shall be primed and coated in accordance with Section 09800. Finish shall be ANSI 61 light gray enamel.

2.2 GENERATOR CONTROL AND POWER SECTION

A. **Circuit breaker:** Circuit breakers shall comply with the following:

1. Generator switchgear shall be equipped with draw-out circuit breakers fused with current-limiting fuses as necessary. Draw out circuit breakers shall have stored-energy closing mechanisms and a 3-position, closed door, racking mechanism, as indicated for each breaker with capacities as indicated. Breakers shall have self-aligning fingers to engage the line and load primary disconnects. Each draw out mechanism shall support the breaker firmly from the fully-connected to the fully-disconnected positions. Interlocks shall prevent racking the breakers in or out when the breaker contacts are closed. A rejection system shall be provided in each breaker compartment to prevent the insertion of a breaker with inadequate short-circuit rating. Provisions shall be made to padlock each breaker when in the OPEN position to prevent unauthorized closing or racking of the breaker. All drawout breakers shall be equipped with a cell position switch to indicate breaker is in the connected position. Provide a shunt trip device in each electrically operated breaker and where required for system operation. Fused low-voltage power circuit breakers shall include integrally- or separately-mounted current-limiting fuse units coordinated with over-current trip devices so as to avoid

unnecessary blowing of the fuses. Fused breakers shall each include a blown fuse indicator which shall lock out the circuit breaker until the fuse is replaced and the device reset. Electrically-operated breakers shall have a close push-button on the escutcheon of the breaker.

2. Unless otherwise indicated, circuit breakers shall be provided with a microprocessor based trip unit. The unit shall provide remote communication with the system controls. Current sensing shall be true RMS type, and shall be immune to normal harmonics. Trip units shall have the following features:

   a. The trip unit shall be self contained. External power will not be required for operation when the breaker is in the closed position. Control power required will be obtained from current sensors mounted in the breaker.

   b. Rating plugs shall be provided to match the ampere rating of the circuit breakers, as indicated. The rating plugs shall house a long-life lithium battery to provide power to the trip unit LEDs for indicating circuit breaker trip and loss of control to the module.

   c. The trip unit shall provide protective functions indicated below. LED trip indicators and adjustable set points shall be provided for each of the protective functions. Settings shall be provided on a rotary switch for each protection function. Adjustment parameters shall be as follows:

      (1) Long delay
      (2) Short delay
      (3) Instantaneous pickup
      (4) Ground fault pickup
      (5) Long delay time

      I^2t time-current curve configurations shall be provided for the short delay and ground fault time delay settings.

   d. The trip unit shall be capable of simulated testing of all protection devices. The trip unit shall be provided with a integral test panel including a test selector switch, and test and trip unit reset pushbuttons.

   e. A status indicator, unit battery check indicator, pushbutton, and a trip reset switch shall be provided on the trip unit display.

B. **Protective Relays**: Protective relays shall be industrial grade of the type acceptable to the electric utility and shall be qualified to ANSI 37.90a. Settings shall be confirmed with utility. Solid state protective relay circuits shall be on glass epoxy printed circuit boards with double-sided gold contacts to plug into sockets with double-sided bifurcated contacts. Circuit boards shall be rigidly held in place and covered to provide additional protection. All printed circuit boards shall be coated with polyurethane for protection against physical contact and corrosive atmospheres. Adjustments shall be readily accessible for calibration and periodic testing. Unless otherwise indicated, protective relays shall be designed for semi-flush front-of-panel mounting and shall withstand vibration up to 2.5 G's at 52 to 72 hertz in any plane and withstand a shock of up to 15 G's in any plane. Protective relay power supply shall be 125V DC unless otherwise indicated. Protective relays shall be mounted in the generator control cabinet unless noted otherwise and shall include the following types:

1. ANSI Device Number 25 - Synchronizing Check Relay

   The synchronizing check function shall be accomplished by means of a solid state synchronism check relay, designed to permit circuit breaker closure after specified phase angle conditions have been verified and condition satisfied for a specified period of time. Panel thumbwheel switches shall be provided for setting of phase angle and time period requirements. Up to four contact sensing circuits shall be provided as an option to verify various line conditions. Contacts shall allow external control of the relay's response to various live and dead conditions. Phase angle shall be adjustable over a range of 1 to 99 degrees. Voltage acceptable limits shall be adjustable from 40 to 135 volts. Time delay shall be adjustable over a range of 0. 1 to 99 seconds. Relay shall be designed for behind-the-panel mounting.

2. ANSI Device Number 27/59-Under/Over Voltage Relay

   The under/over voltage detection system shall be accomplished by means of a solid state dual-purpose under and over voltage relay. Pickup settings shall be by front-panel single turn potentiometers, continuously adjustable over the input range. One potentiometer shall be provided for each timed and instantaneous function. Actual pickup shall be within 2 percent or 0. 5 volt of the setting, whichever is greater. Dropout shall be within 2 percent of actual, occurring in 50 milliseconds or less. Targets shall be provided to indicate trip. Four timing output contacts (one per function) with optional four instantaneous output contacts (one per function) shall be provided. Contacts shall be rated 1 amp resistive, 0.1 amp inductive, make, break, and carry.

3. ANSI Device Number 32 - Directional Power Relay

   Generator motoring or reverse power shall be detected by means of a solid state directional power relay. Directional relay shall provide an output signal when power flow in the tripping direction exceeds its overpower pickup point after a selected time delay. Time delay shall be adjustable from 0 to 2 seconds. Sensing output range shall be 60 to 300 watts at 120 volt, 3 phase, 3 element. Target shall be provided to indicate trip.

4. ANSI Device Number 46 - Reverse-phase, or Phase Balance, Current Relay

   Prolonged current unbalance shall be detected by means of solid state negative sequence overcurrent relay. Relay shall not be affected by frequency variations of plus or minus 10 percent from system nominal (60 Hz). Sensing input range shall be 3 to 5 amps nominal. Negative sequence per-unit voltage pickup setting shall be adjustable over 1 to 50 percent of range with an accuracy of plus or minus 5 percent of the selected value or plus or minus 10 percent of the minimum setting, whichever is greater. Output shall be time delay contact(s), with adjustable minimum and maximum trip timer settings. Timer shall be adjustable over a range of 1 to 99 corresponding to the integration of I_2^2dt, where I_2 is the negative sequence current. Contacts shall be rated 1 amp resistive, 0.1 amp inductive, make, break, and carry. Target shall be provided to indicated trip.

5. ANSI Device Number 47 - Phase Sequence Voltage Relay

   Phase failure, phase unbalance, and reverse phase sequence, shall be detected by means of solid state negative sequence voltage relay. Relay shall not be

affected by frequency variations of plus or minus 5 hertz from system nominal (60 hertz). Negative sequence voltage pickup setting shall be adjustable over 2 to 32 percent of range. Output shall be instantaneous contact(s). Contacts shall be rated 1 amp resistive 0.1 amp inductive, make, break, and carry. Target shall be provided to indicated trip.

6. ANSI Device Number 51 - AC Time/Overcurrent Relay

Phase and ground fault overcurrent shall be detected by means of a solid state time overcurrent relay. Time overcurrent relay shall provide either single or three phase current sensing to 12 amps and multiple timing characteristics for ease of coordination. A selector switch shall be provided to allow selection of the desired timing curve. Actual timing characteristics shall be selected by manufacturer based upon the results of the coordination study required by Section 16431. Time overcurrent pickup setting measuring accuracy shall be plus 2 percent of pickup setting. Time overcurrent pickup dropout ratio shall be better than 95 percent of pickup level. Three phase relays shall be provided with voltage restraints where required by the drawings. Outputs shall be timed and instantaneous contact(s). Contacts shall be rated 1 amp resistive, 0.1 amp inductive, make, break, and carry. Target shall be provided to indicated trip.

7. ANSI Device Number 81 - Over/Under Frequency Relay

Over and under frequency shall be detected by a single, dual purpose, solid state, under/over frequency relay. Input sensing circuit shall be operational over a range of 40 to 132 VAC at 40 to 70 Hz. Relay shall have an undervoltage inhibit adjustment which will allow continuous adjustment of the under voltage inhibit level for the sensed voltage range. A LED indicator shall be provided which will illuminate when the sensed voltage is less than the setting. Two independent frequency setpoints, each with thumbwheel selectors, shall provide selection of the desired setpoint frequency. When the sensed frequency goes outside the selected setpoint, the output relay shall be energized after an inverse time delay. When the frequency returns to within the "normal" limit, the output relay shall be reset instantaneously. Time delay shall be selected via thumbwheel. Output shall be timed contact(s). Contacts shall be rated 1 amp resistive, 0.1 amp inductive, make, break, and carry. Target shall be provided to indicate a trip.

8. ANSI Device Number 87 - Variable Percentage Differential Relay

Differential relay shall be variable percentage type specifically designed to provide selective, high-speed, differential protection for generators. Relay shall be available for either single-phase or three-phase currents as indicated. Differential inputs shall obtained from current transformers with nominal 5 amp secondaries. Pickup accuracy shall be within plus or minus 5 percent of the ideal characteristic. Dropout ratio shall be better than 95 percent of sensitivity setting. Sensing input range shall be switch selectable from 0.1 through 1.6 amps. Output relay contact shall be either normally open or normally closed as required by the application. Contact shall be rated 7 amps (resistive) continuous at 125 VDC or 120 VAC. The relay shall have the capability for plugging in auxiliary relays. Target shall be magnetically latched, manually reset.

9. ANSI Device Number 86 - Locking-Out Relay

The lock-out function shall be accomplished by means of a high speed, electric-trip, manual-reset lockout relay. Relay shall accommodate up to 10 decks of contacts. Trip coil shall be rated 125 VDC. Contacts shall have an interrupting rating of 3 amps resistive, 1 amp inductive, at 125 VDC with a short time rating of 60 amps and a continuous rating of 30 amps. Target shall be provided to indicate a trip. Relay shall be type tested to ANSI C37.90.

10. Multiple Circuit Interlock

    A solid state discriminator circuit shall be provided for first-up, first-on operation of the generator set. This device shall positively prevent more than one set from being simultaneously connected to a dead bus.

C. **Automatic Synchronizer**: The synchronizing function shall be accomplished by means of an auto-synchronizer that operates into the summing point of the electric governor. The auto-synchronizer shall employ a phase-locking method of synchronization. The synchronizer shall comply with the following requirements:

1. All circuitry shall be housed in a rugged semi-dust-tight enclosure suitable for panel mounting. The front panel shall contain all control devices which require adjustment for manual synchronization. External terminals shall be legibly marked. The output shall consist of relay contact closures to indicate when the voltage and phase angle are within the acceptance band, and whether the incoming generator is producing a frequency above or below the bus frequency.

2. Upon operator initiation, the module shall assume control and bring the frequency rapidly to the nominal value and close the generator circuit breaker with a minimum of system disturbance. Circuit breaker closure for an out-of-phase condition shall not occur.

3. The module shall contain a trip level control which shall inhibit operation of the circuit breaker unless the voltage of the incoming generator is above a preselected value. This value shall be continuously adjustable from 80 to 120 percent of nominal voltage.

4. The phase angle acceptance band shall be continuously adjustable between plus or minus 5 electrical degrees and plus or minus 15 electrical degrees.

5. Circuit breaker closure time compensation shall be continuously adjustable from 0.1 to 0.5 seconds.

6. The frequency comparator portion of the circuit shall be of the continuous or bistable type with special circuitry to prohibit a change of state for all phase angle conditions except zero electrical degrees; i.e., the frequency comparator relay shall change state only at the center of the phase angle acceptance band. The frequency comparator shall not operate on harmonics or subharmonics of the nominal frequency.

7. Module shall have a contact output for control of the remote generator breaker.

8. Slip frequencies from approximately 0 to 2 Hz shall be accommodated by adjustment of the delay and angle acceptance band controls.

9. The module shall operate at input voltages as low as 80 percent of nominal and shall be capable of operation at 135 percent of nominal voltage indefinitely. The unit shall be capable of meeting the dielectric and surge withstand voltage capabilities as set forth in the IEEE Standard 472 Test for Solid State Devices.

10. A fail-to-synchronize time delay shall be provided to terminate the operation of the synchronizer and initiate an external alarm circuit through electrically isolated contacts in the event the generators are unable to be synchronized within an adjustable period of time, ranging from 0 to 3 minutes.

11. The module shall be furnished with contact closures, breaker tripping devices, and all other external devices necessary for completing the installation of the synchronizing system.

D. **Generator Control Section:** A generator control cabinet shall be provided to protect, monitor, and control the operation of each generator set. Each generator control cabinet shall contain the following components:

1. Each generator control section shall be provided with the following equipment :

   a. Phase Overcurrent (51V) with voltage restraint -Protection Relay
   b. Directional Power (32) - Protection Relay
   c. Phase-Sequence Voltage (47) or
      Reverse-phase, or Phase-balance, Current (46) - Protective Relay
   d. Synchronizing Check (25) - Protection Relay
   e. Lockout (86) Relay
   f. Neutral Overcurrent (51G) - Protection Relay
   g. Wattmeter - Switchboard Instrument
   h. Varmeter - Switchboard Instrument
   i. Kilowatt-hour Meter - Meter
   j. Ammeter - Switchboard Instrument
   k. Ammeter 0-1-2-3 Switch - Meter Switch
   l. Voltmeter - Switchboard Instrument
   m. Voltmeter 0-1-2-3 Switch - Meter Switch
   n. Lockout/Reset-Off-Auto-Manual, Engine Selector Switch rotary switch
   o. Generator Breaker Control Switch rotary switch, spring return to center: TRIP-NORMAL-CLOSE
   p. Generator elapsed time meter
   q. Manual synchronizing switch: OFF-ON
   r. Over/under voltage relay (27/59) - protection relay
   s. Over/under frequency relay (81 o/u) - protection relay
   t. Generator differential (87) - protection relay
   u. Emergency stop pushbutton

2. The following components are supplied by the engine-generator manufacturer under Section 16350 and are shipped loose for installation under this section:

   a. Voltage regulator with speed adjust rheostat
   b. Series Boost circuit (if required), including generating winding current transformers.
   c. Engine speed control with speed adjust potentiometer or similar raise/lower device and load-sharing modules, electronic governor controls.
   d. VAR/Power Factor Controller.
   e. Under-frequency/overvoltage protective unit.

3. Each generator control section shall be provided with the following status indicating lights:

    a. "Ready to Load", green lens
    b. Generator Breaker status, (open, closed, and trip), green,red, red lenses
    c. Engine-generator locked out (flashing), amber lens

4. The following annunciator points shall be provided as a minimum (at least four additional, fully-equipped spare points shall also be provided):

    a. Engine Overspeed
    b. Engine Underspeed
    c. Engine Overcrank
    d. Engine Trouble (Alert)
    e. Engine Trouble (Danger)
    f. Fail to Synchronize
    g. Generator Protection Trip
    h. Breaker Overcurrent Trip
    i. Battery/Battery Charger Fail

E. **Distribution Breaker Sections:** Distribution breaker sections shall contain identical type circuit breakers as the generator circuit breakers. Quantity, size, and rating shall be as indicated.

F. **Master Control Section:** Master Control Section shall provide oversight monitoring and control of the Generator Switchgear as well as housing the Load Management System. It shall include the master synchronization instruments and logic, and system annunciation as follows:

1. The Master Control Section shall be provided with the following equipment:

    a. Over/Under Frequency (81 O/U) - Protection Relay
    b. Over/Under Voltage (27/59) - Protection Relay
    c. Synchronizing Check (25) - Protection Relay
    d. Lockout (86) - Auxiliary Relay
    e. Directional (32) - Protection Relay
    f. Ammeter - Switchboard Instrument
    g. Ammeter 0-1-2-3 Switch - Meter Switch
    h. Main Breaker Control Switch - Rotary Switch
    i. Visible Alarm Annunciation with Audible Alarm Horn
    j. Annunciator Test, Acknowledge, and Reset Pushbuttons
    k. Normal-Test, Test Mode Select Key Operator Switch
    l. Normal-Standby, Auto Mode Select - Rotary Switch
    m. Manual-Auto Synchronizing Control Select - Rotary Switch
    n. Voltage/Frequency Reset - Pushbutton
    o. Raise-Lower Generator Loading Control - Rotary Switch
    p. Automatic synchronizer

2. Master Control Section shall be provided with the following status indicating lights:

    a. "System Test", amber lens
    b. Main Breaker(s) status (open, close, and trip), green, red, red lenses
    c. "Control not in Auto" (flashing), amber lens

3. The following components are supplied by the engine-generator manufacturer under Section 11500 and shall be installed under this Section:

    a. Voltage/frequency protection

4. Provide a synchronizing swing panel, mounted in a door-in-door configuration such that the swing panel is integral and flush with the front door of the cubicle when not in use, and can swing out from the closed cubicle door for use during manual synchronizing. The swing panel shall include the following components:

    a. Bus totalizing wattmeter
    b. Bus ammeter
    c. Generator voltmeter
    d. Generator frequency meter
    e. Bus voltmeter
    f. Bus frequency meter
    g. Synchroscope, with "fast" and "slow" scale markings.
    h. Two Synchronizing lights for "dark lamp" synchronizing

5. The Load Management system shall provide the following functions:

    a. Automatic Sequencing. The Load Management System controller shall automatically add or delete generators from the system in response to increasing or decreasing loads. The controller shall also operate to detect a monitored preliminary problem with any operating unit and bring another unit (if available) on line prior to shutdown of the failing unit. Operation of the automatic sequencing shall be as follows:

        The sequence selection of the generator units shall be by means of keyboard input with the capability to designate all of the generator units into any possible sequence. The CRT display shall indicate the sequence selection of the generating units. The controller shall prompt the operator if any attempt is made to make an improper selection.

        The controller shall monitor the system load and as the load increases beyond a preset value the sequencer shall start and close on line the next unit in sequence. Conversely, as the load decreases below a preset value the sequencer shall unload and stop the last unit in sequence. There shall be a delay feature to override momentary system load changes.

        If a running generator unit develops a shutdown fault, the controller shall signal the next unit in sequence to start. If a running generator unit should develop a preliminary fault, the controller shall bring the next unit in sequence on line and then shut the faulted unit down after verifying that the remaining generating capacity is adequate.

        The sequence function shall skip any unit which is either not in "Auto" mode or is not available because of a fault condition. It shall also skip any unit which is on-line under manual control.

        It shall be possible to alter the generator sequence pattern while the system is in operation. The units in operation shall remain running while the sequence change is being made. After the sequence change has

been made the controller shall proceed adding the new sequenced units and then shedding the previously sequenced units.

Each unit that is on line shall share the system load equally with the other on line units. This shall be accomplished with the engine governor load share module.

b. Automatic Load Control.

The Load Management System controller shall also function to control designated system loads during standby operation. Should load demand increase more rapidly than another unit can be put on line, or a running unit sustain a shutdown fault, the controller shall shed sufficient load to bring demand down to the available generating capacity. The controller shall initiate load shedding by via digital communication signal. The controller shall also be able to add these loads again.

The loads shall be added and shed in a straight line type priority mode. Increments (or circuits) of load for shedding shall be as indicated. These increments shall be assigned sequential priorities. The loads shall be shed in order from lowest to highest priority on an overload condition. Between each point of load shed, the controller shall evaluate demand versus capacity and either continue shedding load or stop if the demand is less than the on line capacity. When the original generator capacity has been restored, the loads shall then be reconnected in the reverse order in which they were shed.

The designated loads available for shedding shall be capable of being arranged in either priority groups or singly, through the operator keyboard and screen, to match actual operational requirements. In addition, each load priority shall be capable of being redesignated.

c. Peak-shaving and load shedding control. The Load Management System controller shall sense and sum the total power requirements of the facility. When the power level supplied by the utility exceeds a preset power demand level for a time delay consistent with the utility demand interval or time of day (TOD), a signal shall initiate peak shaving mode of operation. When the demand interval, or TOD has expired, or the load reduced below the power demand setpoint for an adjustable time delay, the Load Management System controller shall restore peaking loads and terminate peak shaving mode of operation.

If while operating in the utility peak-shaving mode of operation, a normal commercial power source failure occurs, peak-shaving operation shall be automatically terminated.

G. **Utility Section:** Provide cabinet space, and metering accessories as required by San Diego Gas and Electric (SDG&E) current publications entitled "Service Guide" and "Underground Standards."

2.3 COMPONENTS

A. **Control Circuit Relays:** Relays used in control circuit logic shall have contacts rated 10 amps at 120 volts AC or 28 volts DC. Relays shall be enclosed in polycarbonate covers and color coded for operating control voltages.

B. **Instrument Transformers:** Potential transformers shall have 600 volt class insulation, 10 KV BIL, a minimum ANSI metering accuracy class of 0.3 at a W burden. Transformers shall have an appropriate primary to secondary ratio and shall be provided with primary current limiting and secondary fuses. Current transformers shall have 600 volt class insulation, 10 KV BIL, and a minimum ANSI C57.13 metering of accuracy class of 0.6 at a B-0.2 burden. The transformers will have an appropriate primary to secondary ratio, with a 0-5 ampere secondary output and shall be provided with secondary terminals incorporating short circuiting devices. Instrument transformers shall have barriers to prevent accidental contact by field personnel. Transformer's volt-ampere rating shall be as required for the indicated metering burden without overheating and without exceeding the permissible accuracy for the transformers.

C. **Switchboard Instruments:** All indicating meters shall be 4-l/2-inch square, semi-flush mounted switchboard type. The movement shall be taut-band with an accuracy of plus or minus 1 percent of full scale. The case shall be black. The scale shall be white with black markings. The length of the scale shall be greater than 7 inches over a deflection angle of 250 degrees. The meters shall be manufactured in accordance with applicable requirements of ANSI C39.1. and shall be appropriately scaled. Accuracy shall be within plus or minus 1 percent of full scale reading. Wattmeters shall be 2-element, 3-phase, 3-wire, 50/60 Hz, integral transducer type with a minimum 180 degrees scale.

D. **Switches:** Circuit breaker control and synchronizing switches shall be the rotary-cam type and contacts shall have positive wiping action of silver-to-silver contact buttons. Meter selector switches shall be heavy-duty four-position, snap-action, rotary type with wiping contacts. Switch contacts shall be rated 600 volts, 20 amperes continuous. Switches shall be provided with escutcheon plates and pistol-grip handles.

Voltmeter and ammeter switches shall have four positions with the escutcheon legend as follows:

Voltmeter	OFF	1-2	2-3	3-1
Ammeter	OFF	Phase A	Phase B	Phase C

E. **Watthour meter:** Watthour meter shall be 2 stator type for measuring 3 phase 3 wire or 3 phase 4 wire levels as indicated. Meter shall be transformer rated and switchboard mounted type (Type DS). Meter shall be rated TA 2.5 Class 10 and shall be provided with pointer-type registers. Meter shall be equipped with photo-electric pulse initiator, gear driven from the meter rotor shaft. Output shall be mercury-wetted, SPDT relay wired to external terminals.

2.4 DC POWER SOURCE

A. Provide two (2) Station Batteries for operation of protective relays and circuit breakers in the Paralleling Switchgear. The battery system shall be suitable for the application, provided with a suitable battery source selector, and each battery set shall incorporate the following features:

1. Nominal 125 VDC system, lead-acid Plante type. Ampere-hour capacity shall be determined by the supplier to fulfill the duty cycle(s) imposed. Supplier shall furnish calculations demonstrating adequacy of the system.

2. Provide a filtered, dual-rate, charger for the station battery. Charger shall be housed in a ventilated, wall-mount enclosure. It shall be capable of continuous charging duty, and shall be sized to completely recharge the battery within 16 hours after a full duty cycle while maintaining normal continuous loads.

3. Provide a floor mounted, two-tier rack for the station battery. It shall be coated with an acid resistant paint, and shall be seismically certified for the specified zone.

4. In addition to the normal continuous loads imposed by the switchgear and other connected devices, the design duty cycle shall be as follows:

   a. For all breakers in the Switchgear; Close, Trip, followed by a 1 minute period, then a Close, Open, Close, Trip. Cycle shall occur in a time period not to exceed 15 minutes. For the purposes of ampacity design, it is not necessary for the breakers to operate simultaneously.

2.5 NAMEPLATES, TOOLS AND SPARE PARTS

A. The WORK includes the following test equipment:

1. Breaker test kit, full capability
2. Test plugs for current test blocks
3. Test plug for protective relays

Test equipment shall be stored in tool boxes identified with the equipment number by means of stainless steel or solid plastic name tags attached to the box.

B. **Spare Parts**: The WORK includes the following spare parts:

1. One gallon of each finish paint used.

2. Fuses, one set of each size and type.

3. Card extender for each type of protective relay.

2.6 FACTORY TESTING

A. **Product Testing**: Products shall be tested at the factory for compliance with the indicated requirements and as follows:

1. Upon completion of manufacture, the generator switchgear system shall be functionally tested at the manufacturer's plant. Buses and power wiring shall be given a dielectric test of 2200V for one minute between live parts and ground, and between opposite polarities. The remaining wiring and the control circuits shall be given a similar dielectric test using 1500V. Further tests shall be as required by UL 1558. A certified factory test report shall be furnished to verify system factory testing.

B. **Witnesses:** The OWNER and the CONSTRUCTION MANAGER (at the option of either) reserves the right to witness factory tests. The CONTRACTOR shall notify the CONSTRUCTION MANAGER two weeks in advance of the testing date.

2.7 MANUFACTURERS

A. Products of the type or model number indicated shall be manufactured by one of the below listed manufacturers (or equal):

1. Switchgear assembly:

   Lloyd Controls
   Russelectric

2. Protective relays:

   Basler
   Brown-Boveri

3. Low voltage power air circuit breakers:

   General Electric, Type AKR
   Westinghouse, Type DS

4. Synchronizer:

   Basler
   Woodward

5. Locking-out relay:

   Electroswitch

6. Annunciator:

   Panalarm Series 90
   Ronan Series X12

7. Meters:

   Crompton Instruments
   YEW

8. Rotary switches:

   Electroswitch Series 24

9. Watt-hour meter:

   General Electric type V-63 or D5-63 with type D-72 pulse initiator
   Westinghouse

PART 3 -- EXECUTION

3.1 INSTALLATION

A. **Coordination Study**: Protective devices and circuit breaker protection shall be set in accordance with a coordination study required under Section 16431. The Contractor shall submit coordination study to CONSTRUCTION MANAGER for review 60 days prior to startup. The study shall be prepared in accordance with IEEE 242, Chapter 7, and signed by an Electrical Engineer registered in the State of California. The study shall verify selective tripping coordination of circuit interrupting devices from the incoming utility service down to the branch circuit protection of largest motor in each motor control center. The study shall include verification of CT ratios, generator protection equipment settings, and show damage curves of motors, generators, and cables.

3.2 FIELD TESTING

A. **General:** Products shall be field-tested for compliance with Section 16030. In addition protective relays shall be tested to verify settings prescribed under Section 16431.

B. **Performance Testing:** Performance testing shall be conducted at the conclusion of field testing to verify the following operations:

1. Engine generator normal startup and shutdown
2. Engine generator emergency shutdown
3. Automatic synchronization
4. Manual synchronization
5. The correct operation of key interlocks

** END OF SECTION **