marathon™
Thomson Power Systems

SUGGESTED SPECIFICATION

Paralleling Low Voltage Switchgear

CSI FORMAT

SECTION 262313

Specification No. ES027 – Series 2400-MU-LV-UL1558

Table of Contents

***Specification writer's notes**:*

a) This suggested specification is intended for typical Paralleling Switchgear. The typical control scheme consists of the following main characteristics:

- *Multiple generator applications*
- *Low Voltage*
- *UL 1558 Certification*
- *Automatic Standby Operation*
- *Closed Transition Transfer (Soft-Load) Operation*
- *Utility Parallel Generation Operation*
- *Prime Power Operation*

For paralleling switchgear specifications of different types, contact Thomson Power Systems for alternate sample specifications as available.

*b) Included in this suggested specification are sections identified as **"Alternates"**. These sections provide the specifying engineer many design options, which allow for system customizing.*

Note:

The following information is provided by Thomson Power Systems as a guide only for use by specifying engineers in designing generator paralleling switchgear systems. All system designs and installations must be done in accordance with all applicable electrical regulation codes and practices as required. Please contact Thomson Power Systems for any additional information.

SECTION 262313 – PARALLELING LOW-VOLTAGE SWITCHGEAR

1 PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Specification for metal-clad paralleling switchgear and associated control systems for paralleling multiple generators on a load bus and for distributing power in AC systems.

2. It is intended for the complete paralleling switchgear and generator system to operate in the following modes:

Specification writer's note: Delete reference to any section which is not applicable to the application.

a. The system shall respond to a failure of the utility service by starting and paralleling the specified number of generators to restore power to the facility.

b. The system shall respond to the failure of a generator by shedding selected loads and restoring normal operation to the extent possible within the capacity of the available source(s).

c. The system shall perform a closed transition soft-load power transfer between operating generators and the utility supply once the utility power source has been restored.

d. The system shall perform a closed transition soft-load power transfer between the utility power source and selected generators when performing a system load test.

3. All work defined within this specification shall be the responsibility of the paralleling switchgear manufacturer, unless specifically defined as provided and or installed by others.

B. The unit shall be manufactured in accordance with this specification and applicable UL, CSA, IEC, NEMA, and ANSI standards.

C. Supplier shall be responsible for ensuring the compatibility of all components of the unit.

D. The contractor shall furnish and install a complete power generation system in accordance with local bylaws, the national electrical code, specification and contract drawings.

E. Include all components, commissioning and services specified or required to provide and install a complete and operable system.

F. The paralleling switchgear package shall include:

Specification writer's note: Delete reference to any section which is not applicable to the application.

1. Auto Start Engine Controls.

2. Engine Protection.

3. Generator (Electrical) Protection.

4. Automatic and Manual Paralleling (Phase and Voltage Matching).

5. Automatic and Manual KW Load Control:

   a. Standalone - Isochronous Operation.

   b. Paralleling - Isochronous kW Load Sharing.

6. Automatic and Manual Voltage Control:

   a. Standalone - Constant Voltage.

   b. Paralleling - Isochronous kVAR Load Sharing.

7. Generator Circuit Breaker.

8. Distribution Breaker(s) or Load Connections

G. The switchgear supplier shall be responsible for ensuring the compatibility of the interface between the paralleling switchgear and the generator, including but not limited to engine components, governor equipment and automatic voltage regulation components.

1.2 APPROVAL SUBMITTALS

A. Two sets of the following information shall be supplied for Bid submittal:

1. Physical Layout (Plan view).

a. Anchoring Details.

b. Shipping Splits.

c. Cable Entry/Exit Locations.

d. Cable Connection Sizes.

e. Bus Duct Entry/Connection Detail.

f. Provision for Future Expansion.

2. Nameplate Drawing.

3. Single Line Diagram.

4. Schematic Drawings.

5. Bill of Material.

6. Major Component Datasheets.

7. Sequence of Operation.

B. The following shall be shipped with the equipment:

1. Two sets of As Built Drawings and Sequence of Operation.

2. Hardcopy of all Component Manuals.

3. O&M Manual on CD-ROM including:

a. As Built Drawings.

b. Bill of Materials.

c. Sequence of Operation.

d. Component Manuals.

4. Software on CD-ROM including:

a. Operating System Software.

b. Recovery CD.

c. Remote Access Software.

d. HMI Software - Runtime and Configuration File.

e. HMI/PLC Programming Software.

f. PLC Configuration / Programming Files.

1.3 CODES & STANDARDS

A. The paralleling switchgear shall be designed, manufactured, tested and listed to the following safety standards:

1. UL1558 Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.

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

B. The utility grade protection relays are to be designed in accordance with to the following performance standards:

1. IEEE C62.41.1-2002 IEEE Guide on the Surge Environment in Low Voltage (1000V and less) AC Power Circuits.

2. IEEE C37.90-1989 IEEE Standard for Relays and Relay Systems Associated with Electrical Power Apparatus.

3. IEEE C37.90.1-1989 IEEE Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.

4. IEEE C37.90.2-1995 IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from

Transceivers.

5. IEEE C37.90.3-2001 IEEE Standard Electrostatic Discharge Tests for Protective Relays.

6. IEC 61000-4-2 (2001-04) Electromagnetic compatibility (EMC)-Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test.

7. IEC 61000-4-3 (2001-03) Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, and electromagnetic field immunity test.

8. IEC 61000-4-4 (2004-07) Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test.

9. IEC 60255-5 (2000-12) Electrical Relays - Part 5: Insulation coordination for measuring relays and protection equipment - Requirements and tests.

10. IEC 60255-6 (1988-12) Electrical relays - Part 6: Measuring relays and protection equipment.

11. IEC 60255-22-2 (1996-09) Electrical relays - Part 22: Electrical disturbance tests for measuring relays and protection equipment - Section 2: Electrostatic discharge tests.

12. IEC 60255-22-3 (2000-07) Electrical relays - Part 22-3: Electrical disturbance tests for measuring relays and protection equipment - Radiated electromagnetic field disturbance tests.

13. IEC 60255-22-4 (2002-04) Electrical relays - Part 22-4: Electrical disturbance tests for measuring relays and protection equipment - Electrical fast transient/burst immunity test.

14. IEC 60255-22-6 (2001-04) Electrical relays - Part 22-6: Electrical disturbance tests for measuring relays and protection equipment - Immunity to conducted disturbances induced by radio frequency fields.

15. IEC 60255-25 (2000-03) Electrical relays - Part 25: Electromagnetic emission tests for measuring relays and protection equipment.

16. IEC 60068-2-3 (1984) Environmental testing - Part 2: Tests.

1.4 QUALITY

A. The switchgear shall be designed and manufactured in a facility, which is registered to an ISO 9001:2008 quality system. The supplier shall have a minimum of 35 years experience designing and manufacturing power generation control equipment.

B. Only new materials and components shall be used and of current manufacture. The paralleling switchgear shall be free of defects in material and workmanship.

1.5 WARRANTY

A. The equipment shall be free of defects in material, workmanship and operation.

B. The switchgear shall be warranted against defective components, workmanship and operational flaws for the period of one year from the date of startup, not to exceed 18 months after shipment.

C. Date of startup shall be when the manufacturer's representative completes the site startup or when the equipment is put into operation, whichever occurs first.

D. Date of shipment shall be shipment from the supplier or completion of manufacturer in the event the equipment is held at the owner's request.

1.6 PROJECT CONDITIONS

A. The paralleling switchgear shall be installed with ambient temperatures between 0 degrees and +40 degrees Celsius, relative humidity from 0-95% non-condensing, and altitude not exceeding 6600 ft (2200M).

2 PART 2 – PRODUCTS

2.1 SWITCHGEAR MANUFACTURERS

Specification writer's note: Insert text to suit the applicable manufactures for this equipment

A. Thomson Power Systems

B.

C.

2.2 SWITCHGEAR RATINGS

A. Nominal system phase voltage: 480V

B. System Neutral: solid neutral, 3 phase 4 Wire

C. Main bus continuous amp: As indicated on drawings

D. Short circuit current rating: As indicated on drawings

E. Brace switchgear components to withstand mechanical forces for symmetrical fault current as indicated on drawings.

2.3 SWITCHGEAR CONSTRUCTION

A. The switchgear shall be a modular assembly using standard off the shelf parts.

B. The enclosure shall consist of a 14 gauge steel angle or channel framework and be of adequate strength and rigidity to endure normal conditions of use and to support all equipment mounted within. Bolt-on steel panels and hinged doors will form the outer shell of the enclosure.

C. The switchgear assembly shall be rated NEMA 1 (IP20) for indoor use.

Specification writer's note: For NEMA 2/NEMA 3R rated enclosure applications use "Alternate" as required.

"Alternate" The completed assembly shall be mounted in a NEMA 2

enclosure complete with door gasketting and drip hood.

“Alternate” The completed assembly shall be mounted in a NEMA 3R enclosure suitable for outdoor application with controls mounted on an interior door. Exterior door shall provide additional protection against outside environment and vandalism.

D. The enclosure will be ventilated as required to prevent overheating while operating at its maximum rated current.

E. The switchgear enclosure shall include:

1. Front hinged access doors on control and circuit breaker compartments.

2. Locking three point latching handles on control compartments.

3. Knurled knobs on circuit breaker compartment doors.

4. Removable rear access covers.

5. Separate isolated compartments for control and power components (circuit breakers and bussing).

6. Screw type lugs suitable for use with copper or aluminum conductors.

7. Shipping splits to allow for handling and installation.

8. Removable lifting eyes.

9. Terminal blocks for connections across shipping splits.

F. The switchgear shall be designed to allow the following to occur while the circuit breaker compartment door is closed and secured:

1. Racking the circuit breaker (connected/test/disconnected).

2. Manually charging the circuit breaker.

3. Access to the circuit breaker open and close pushbuttons.

4. Access to the circuit breaker trip unit.

5. Viewing of the circuit breaker rating plate and mechanical targets.

G. The installation shall allow for front and rear access to the switchgear. The contractor shall work with the switchgear supplier to coordinate any special requirements (limited access, side access panels, etc).

H. SEISMIC ANCHORING

1. The Switchgear shall be designed and constructed to withstand seismic events when correctly anchored to the building structure.

2. The Switchgear assembly shall comply with the relevant section of the International Building code standard IBC 2006 and shall be type tested on a shaker table to ACC 156 standard.

3. The Switchgear shall successfully withstand a seismic event with a spectral acceleration of 342%.

4. Specific Switchgear anchoring detail drawings shall be furnished by the Switchgear supplier to the contractor for compliance of seismic ratings.

5. Switchgear supplier shall provide a seismic certificate of compliance upon request.

I. ENCLOSURE FINISH

Specification writer's note: modify the paint color as required for the specific application.

1. The surface shall be free of nicks and abrasions and all sharp edges broken in preparation for painting the surface. The surface shall then be prepared with iron phosphate treatment and primer. The final coat to be UL approved electrostatically applied powder coat ASA 61 Grey.

2. Interior component mounting panels shall be similarly painted gloss white.

J. SWITCHGEAR LOAD BUS MATERIAL

1. The bus shall be made of tin plated round-edge high conductivity copper. Provide a full length tin plated copper ground bus sized per ANSI standards to withstand a phase to ground fault. The bus

design shall be a type tested design, braced to withstand the rated fault current.

K. SHIPPING AND HANDLING

1. The switchgear shall be provided with shipping splits as necessary.

2. The drawings shall clearly indicate shipping split locations.

3. The switchgear shall be factory assembled to ensure fit; separated prior to shipping and provided with all necessary bus links and hardware to allow the switchgear to be re-assembled at site.

4. DIN rail mounted screw type terminal blocks shall be provided for all interconnect wiring to be re-joined across the shipping split(s).

5. Ensure the switchgear is suitably arranged to allow for handling and installation based on the planned site conditions (i.e. alternate construction, lifting provision and/or additional shipping splits, etc).

L. CABLE ENTRY/EXIT / CONNECTIONS

Specification writer's note: Insert or modify the following text to suit the specific cable entry/exit locations and connection method required for the specific application.

1. The switchgear shall be fitted with steel, non-removable top and bottom plates. Cable entry, number of cables and cable size will be as noted on the contract drawings.

2. The switchgear shall be provided with screw type lugs suitable for use with copper or aluminum conductors, for all phase, neutral and ground connections.

3. Ensure cable entry/exit locations and cable connections are based on the planned installation and site conditions.

M. CIRCUIT BREAKERS

Specification writer's note: Insert or modify the following text to suit the applicable circuit breaker ratings (e.g. trip/close coil voltages) for the specific application.

1. Circuit breakers shall be certified to ANSI C37.13 / UL1066

standards.

2. The following features shall be included:

   a. Electronic Trip Unit.

   b. Four Position Draw-out (connected, test, disconnected, removed).

   c. Stored Energy Mechanism.

   d. Field Installable Accessories.

   e. Anti-Pumping Interlock.

   f. Spring Charge Motor - 120Vac.

   g. Close Coil - 120Vac.

   h. Trip Coil - 24Vdc.

   i. 4a/b Auxiliary Contacts.

   j. 1a/b Bell (trip) Alarm Contact.

3. Generator synchronizing circuit breakers shall be equipped with 24Vdc under voltage releases as a failsafe backup to the trip coil; to be operated in the event of generator failure or loss of control power.

4. Circuit breakers which accept an auxiliary power source to enable communications and indication while not conducting shall be connected to the maintained source of control power.

5. Circuit breakers equipped with ground fault shall also be equipped with separate indicators to flag which function caused the trip L, S, I or G.

6. Circuit breakers are to lockout out when tripped and be equipped with a manual reset button.

7. Draw-out circuit breakers are to be equipped with a cradle rejection feature, factory set, to prevent circuit breakers with dissimilar features from being inadvertently interchanged during

maintenance.

8. Circuit Breaker Ratings:

   a. Type: 635V.

   b. Continuous Current: ____A.

   c. Interrupting Rating: ____KA @ 635 VAC, 50/60Hz.

   d. Short-time Withstand Ratings: ____KA @ 635 VAC, 50/60Hz.

   e. Breaking Time: 30 milliseconds max.

   f. Closing time: 80 milliseconds max.

   g. Mechanical Endurance: 10,000 C-O operations <4000A/5000 C-O operations 4000A and above.

N. INSTRUMENT TRANSFORMERS

Specification writer's note: Insert or modify the following text to suit the applicable CT and PT ratings required for the specific application.

1. Voltage Transformers:

   a. For~~both~~ the generator~~and utility supplies,~~, provide ANSI rated 600V class voltage transformers as indicated on contract drawings.

   b. PT Ratio: As required.

   c. Accuracy Class: ANSI metering class 0.6.

   d. Thermal rating: 100 / 150VA.

   e. Voltage transformers supplying meters shall meet the 0.6 accuracy class based on the total circuit burden.

2. Current Transformers:

   a. For~~both~~ the generator ~~and utility supplies,~~supply, provide (3) ANSI rated 600V class current transformers.

b. CT Ratio: Sized to suit.

c. Accuracy Class: ANSI metering class 0.3 minimum

d. Relay Class: C20 minimum.

e. Current transformers supplying meters shall meet the 0.3 accuracy class based on the total circuit burden.

f. Current transformers supplying protective relays shall be of a ratio and relay class suitable to ensure proper coordination and operation of the protection relays during a fault condition based on the switchgear short-circuit current rating.

O. CONTROL FUSES

1. Separate control fuses shall be provided for:

a. Metering and Protection Circuits.

b. Circuit Breaker Control Power.

c. Automatic Voltage Regulator.

2. AC Fuses shall be UL listed HRC type with a 200KA interrupting rating @ 600Vac. Fuses provided on DC circuits shall have a suitable DC rating. Fuses shall be installed in dead front holders. Fuse holders shall be ganged together to form 1, 2 or 3 pole units to ensure that the complete circuit is isolated when the fuses are removed.

P. TERMINAL BLOCKS

1. All field wiring connection points shall be via DIN rail mounted screw clamp style terminal blocks. The terminals shall be clearly identified with individual marking plates.

2. Control Terminals: UL listed, 4mm Sq., 40A, 600V rated. Range (1) 22 - 10AWG or (2) 20 - 14AWG minimum.

3. CT Terminals: UL listed, 6mm Sq., 45A, 600V rated. Range (1) 22 - 8AWG or (2) 18 - 12AWG minimum. And furnished complete with switchable shorting bars.

4. A minimum of 10% spare terminals shall be provided.

Q. CONTROL WIRING

1. Wire shall be SIS switchboard type, UL approved, 600V, 105'C, FT1 / VW-1, stranded tinned-copper wire.

2. All connections to bus, circuit breakers, PT circuits and DC supply connections to be #14AWG minimum.

3. CT secondary wiring to be #10AWG.

4. Devices like low current high density PLC IO and annunciators which benefit from a smaller wiring harness may be wired using #18AWG minimum, if permissible.

5. All wiring within the control compartment shall be located in wire ways with removable covers. Wire run external to the wire ways shall be neatly bundled, mechanically affixed to the structure, and suitably wrapped to prevent abrasion. The wire ways shall be mechanically fastened inside the enclosure by means of screws or rivets (adhesive alone is not acceptable), except on doors.

6. Wiring shall be identified at both ends by means of heat-shrink type wire markers with indelible ink marking.

R. NAMEPLATES AND LABELING

Specification writer's note: Insert or modify the following text to identify specific nameplate colors and sizing required for the specific application.

1. Warning labels shall be posted on the face of compartment doors that allow access to live components.

2. All internally mounted devices shall be labeled with a designation matching the drawings.

3. Door mounted components shall be suitably labeled to convey their function to operations personnel. The nameplates shall be engraved, laminated plastic, black text on a white background and secured using adhesive tape.

4. Nameplates shall be detailed on the approval drawings.

5. The equipment shall bear rating plates in accordance with the

certification.

2.4 GENERATOR PARALLELING CONTROL & MONITORING SYSTEM

A. Individual Generator Control and Monitoring Panel

1. POWER GENERATION CONTROLLER

a. The paralleling switchgear system shall include a Power Generation Controller which shall provide the following control and monitoring features for each supplied generator:

Auto Engine Start Control.

Engine Control & Protection.

Automatic Synchronizer.

Generator kW & kVAR Load Sharing.

Generator Power Metering (Utility grade).

Generator Protective Relaying (Utility grade).

Utility Power Metering (Utility grade).

Utility Protective Relaying (Utility grade).

Communication Ports.

b. The Power Generation Controller shall be an Intelligent Electronic Device (IED) which shall have a unique Internet Protocol (IP) Address for programming/configuring. Every Power Generation Controller shall be accessible from any locally or remotely operator interface terminal in the system.

c. Each Power Generation Controller shall be specifically programmed/configured from the Switchgear supplier to meet the required operating and performance requirements of the system as specified.

d. Customer supplied engine generator set shall be capable of

the following performance criteria to ensure proper of operation of the Power generation Controller synchronizing and load sharing functions:

Engine Governor: Engine speed (i.e. frequency) to be set at 100% nominal operating frequency with +-0.25% steady state regulation performance from no-load to full load operation and shall accept a 0-10Vdc or 0-500HZ PWM remote speed signal bias input for synchronizing and load control.

Generator Automatic Voltage Regulator: Generator voltage to be set at 100% nominal operating voltage with +-0.5% steady state regulation performance no-load to full load operation and shall accept a +-0-9Vdc remote voltage signal bias input for synchronizing and load control.

e. The Power Generation Controller shall be capable of controlling up to 16 generator sets on a common system via Ethernet communication network.

f. The Power Generation controller shall be certified to Industrial control equipment standards CSA C22.2 no 14 and UL508.

g. Auto Start Engine Control

Provide auto start engine control. The control must be programmable and include a standard feature set that allows it to be applied to all makes of engines.

The control shall include off-auto-run mode selection. Engine control timers (start delay and cool down).

The Power Generation Controller shall have capability to be used without the auto start engine control featured enabled for applications using genset mounted auto start controllers.

h. Engine Control/Protection

Engine control & protection maybe provided in the paralleling switchgear or directly on the engine-generator set.

The control shall provide inputs for oil pressure, coolant temperature, oil temperature, fuel level, battery voltage and magnetic pickup (RPM).

The control shall be fully programmable to support the following engine requirements. Pre-programmed functions shall be provided for:

Run/Fuel Output.

Crank Output.

Energize to Stop Output.

Control Not in Auto.

Common Alarm.

Common Shutdown.

i. As a minimum the following list of standard alarms shall be provided, based on NFPA110 Level 1 requirements.

Overcrank Shutdown.

High Engine Temperature Shutdown.

Low Oil Pressure Shutdown.

Over speed Shutdown.

Loss of Speed Signal Shutdown.

Emergency Stop Shutdown.

Low Battery Voltage Alarm.

High Battery Voltage Alarm.

Battery Charger AC Fail Alarm.

Low Engine Temperature Alarm.

High Engine Temperature Alarm.

Low Oil Pressure Alarm.

Low Fuel Level Alarm.

Control Not in Auto Alarm.

EPS Supplying Load.

j. Display of oil pressure, coolant temperature, oil temperature, fuel level, battery voltage and RPM. Operation modes and timer count downs shall keep the operator informed of current operational status.

k. All alarms are to be fully programmable including (contact open/close to alarm, high/low limits, transient delays, latching/self-reset, alarm/shutdown, etc).

l. It is the responsibility of the switchgear supplier to coordinate the engine-generator interface and provide any additional protection functions the generator manufacturer deems essential to ensure the protection of the generator.

m. Dedicated analog outputs shall be provided for interface to the governor and voltage regulator; scaled to work with the specific controller. It is the responsibility of the switchgear supplier to ensure compatibility and coordinate the interface to the governor and voltage regulator supplied with the generator.

n. Engine Monitoring

A CANbus or RS485 port supporting the SAE J1939 Engine Communications or Modbus protocol shall provide a direct communication interface between the paralleling switchgear and the electronic engine controls.

o. Auto Synchronizer

The Power Generation Controller shall provide a voltage and speed matching Automatic Synchronizer for each generator set. It shall be compatible with the

engine's electronic governor and generators automatic voltage regulator. It shall monitor the voltage, frequency and phase angle of the incoming generator to the load bus, and provide automatic power switching device closure signal when in synchronism.

The automatic synchronizer function shall provide two independent gain and stability adjustments for optimal synchronizing performance at un-loaded and loaded gen set conditions.

The automatic synchronizer shall be provided with voltage matching control outputs for interface to the generators voltage regulator.

Synchronizing shall have a sync check function which shall utilize 3-phase voltage sensing on both incoming and load sources. The synchronizers sync check function shall have reverse phase sequence protection, adjustable tolerances for voltage, slip frequency/ phase matching and shall also take into account the health of both supplies as determined by the protection relays.

Set points for dynamics shall be digitally adjustable at the switchgear or from a remote located operator interface terminal.

p. Generator kW & kVAR Load Sharing

The Power Generation Controller shall provide automatic kW and kVAR load sharing for each generator set.

Automatic kW and kVAR load sharing on isolated generator busses shall be isochronous (non-droop) and data shall be shared via high-speed Ethernet communication link between Power Generation Controllers.

Precise frequency and voltage control shall be provided to maintain nominal levels when load sharing on isolated busses.

The Power generation Controller shall provide base-

loading kW and kVAR control of each generator set when paralleled to the utility supply or designated generator supplies

Base-loading controls shall have adjustable loading and unloading kw ramp rates with programmable set points for zero power transferring and utility import/export kw Levels.

q. Generator Power Metering

Revenue accurate metering per ANSI C12.20 revenue class 0.5 accuracy shall be provided and include:

The Power Generation Controller shall sample data at a rate of 800 samples per cycle on each phase of the generator supply.

Instantaneous: RMS Voltage, RMS Current, Power Factor, Active Power (KW), Reactive Power (KVar) and Apparent Power (KVA).

Energy: KW/Hr, KVar/Hr, KVA/Hr.

Graphically represent harmonic content in percentage up to the 32nd harmonic.

Graphically represent the complete simultaneous set of 3-phase AC voltage and current waveforms on the generator and utility supply.

Graphically represent a synchroscope function by displaying the incoming and bus AC waveforms with slip frequency and voltage magnitudes.

Graphically represent the 3-phase voltage and current vectors in a dynamic Phasor diagram

The same totalized metering data shall be provided for the system load.

r. Generator Protective Relaying

Protection functions shall be utility grade. Utility grade

indicates tested in accordance with the applicable IEEE and IEC standards listed.

Protective relaying algorithms shall utilize single cycle calculations to drive relays outputs.

As a minimum the following IEEE protection elements shall be included:

25 Sync Check.

27 Under Voltage.

32 Reverse Power.

40 Reverse Reactive Power.

51 Timed Over current.

50/51G Ground Over current.

59 Over Voltage.

81 Over & Under Frequency.

Specification writer's note: For applications requiring generator differential protections use "Alternate" as required.

"Alternate" 87G Generator Differential Over current.

Provide all set points and time delays required to ensure the system operates smoothly and without compromise during adverse conditions.

All set points, time settings, and control selections shall be digitally adjustable at the switchgear and over the communication network.

s. Utility Power Metering

Revenue accurate metering per ANSI C12.20 revenue class 0.5 accuracy shall be provided for one utility supply input to the power generation controller and shall include the following:

The Power Generation Controller shall sample data at a rate of 800 samples per cycle on each phase of the utility supply.

Instantaneous: Utility RMS Voltage, RMS Current, Power Factor, Active Power (KW), Reactive Power (KVar) and Apparent Power (KVA).

Utility Energy: KW/Hr, KVar/Hr, KVA/Hr.

Graphically represent harmonic content of utility supply in percentage up to the 32nd harmonic.

Graphically represent the complete simultaneous set of 3-phase AC voltage and current waveforms on the generator and utility supply.

Graphically represent a synchroscope function by displaying the incoming and bus AC waveforms with slip frequency and voltage magnitudes.

Graphically represent the 3-phase voltage and current vectors in a dynamic Phasor diagram

t. Utility Protective Relaying

Protection functions shall be utility grade. Utility grade indicates tested in accordance with the applicable IEEE and IEC standards listed.

Protective relaying algorithms shall utilize single cycle calculations to drive relays outputs.

As a minimum the following IEEE protection elements shall be included for the utility supply:

25 Sync Check.

27 Under Voltage.

32 Reverse Power.

40 Reverse Reactive Power.

51 Timed Over current.

59 Over Voltage.

81 Over & Under Frequency.

Provide all set points and time delays required to ensure the system operates smoothly and without compromise during adverse conditions.

All set points, time settings, and control selections shall be digitally adjustable at the switchgear and over the communication network.

u. Communication Ports

The Power Generation controller shall provide the following hardware interface ports for each generator set:

Ethernet (2) -1 Gbps

USB (4) –USB 2.0

VGA Port

DVI Port

RS232/485

KB/MS

Audio

v. CUSTOMER INTERFACE OUTPUT CONTACTS

The following standard output contacts for customer use shall be provided as a minimum:

Gen#.. Run Contact: Quantity 1 auxiliary contact shall be provided. The auxiliary contact shall be supplied with a rating of 6A, 120/240VAC, 6A, 28Vdc resistive, Form C.

Gen#.. Common Alarm Contact Quantity 1 auxiliary contact shall be provided per generator. The auxiliary contact shall be supplied with a rating of 6A, 120/240VAC, 6A, 28Vdc resistive, Form C.

Gen#.. Common Shutdown Contact Quantity 1 auxiliary contact shall be provided per generator. The auxiliary contact shall be supplied with a rating of 6A, 120/240VAC, 6A, 28Vdc resistive, Form C.

System Common Alarm Contact Quantity 1 auxiliary contact shall be provided. The auxiliary contact shall be supplied with a rating of 6A, 120/240VAC, 6A, 28Vdc resistive, Form C.

Breaker Aux Contact Quantity 1 auxiliary contact shall be provided for each supplied breaker. The auxiliary contact shall be supplied with a rating of 6A, 120/240VAC, 6A, 28Vdc resistive, Form C.

B. Master System Control and Monitoring Panel

1. GRAPHICAL USER OPERATOR INTERFACE DISPLAY

a. A panel mounted industrial PC shall be provided as the centralized point for monitoring, control and configuration of the system.

b. The system shall have minimum 17", true color, 1280x 1024 resolution, 2.2GHZ dual core processor (min), NEMA 1 touch screen TFT LCD display with LED backlight for clear viewing in well lit rooms.

c. The display shall be shielded from EMI or RFI interference. The power supply shall be wide-range and equipped with a filter to ride through induced noise, sags or swells that will occur during starting or switching of inductive loads connected to the same source of supply.

d. The panel PC shall have ruggedized Solid State Disk drive (SSD) with EWF routines enabled for reliable, corruption free data.

e. The display shall communicate with the following subsystems

and display available data including operating modes, alarms, metering data, historical event logs, alarm logs and trend graphs:

Utility Metering & Protection

Generator Metering & Protection

Engine-Generator Status

Engine Parameters

f. The ability to monitor data, control and modify the system configuration shall be available over the communication network.

g. The display shall have easy to read graphic display objects. A combination of animation and color change shall be used to convey information. An alarm banner shall be provided to draw operator attention to current active alarms.

h. The system shall support multiple levels of security:

No Access.

View Only.

Control and Basic Set points (Operator).

Full System Configuration Access (Technician).

i. The system shall include set points and time delays required to ensure the system operates without compromise during adverse conditions.

j. Operator Interface Display Menus: Set points, time settings, and control selections shall be digitally adjustable at the switchgear and over the communication network and the following main programming menus shall be provided:

~~2.~~ System Overview / Single Line. This screen will include a dynamic single line drawing of the electrical system including circuit breaker positions, transfer switch position, generator and utility status, and V, I, F,

KW for the generators and generator ~~and utility supply.~~bus.

Generator Control. Access to often used operator controls and set points including~~import/export setpoints, mode selections,~~ start/stop, reset, etc.

Generator Data. Detailed metering data, trend graphs, engine data and status.

~~4.Utility Data Screen. Detailed metering, trend graphs and status.~~

Setup Screen(s). To provide access to one time setup and seldom used control selections and set points. The setup screens shall be logically grouped (generator, utility, power metering, synchronizing, digital IO, etc).

Alarm Screen. Date and time stamped summary of currently active alarms.

Alarm History. Historical alarm log summary of all alarms that have occurred. The log shall be date and time stamped and retain a minimum of 100 records.

Trend Graph. User configurable trend graphs to track and record AC metering data. Trend graphs shall be provided for each generator~~ and utility supply circuit breaker~~. Each trend graph shall be configurable and capable of monitoring up to 8-channels of data per graph.

User configurable screen 1 & 2. The control shall include the facility to allow the user to create at least two custom screens.

2. PROGRAMMABLE LOGIC CONTROL

a. The system control shall be factory programmed and tested to provide the operations described. The programmable logic shall allow the program to manipulate outputs and operating modes based on the status of inputs, control bits and analog parameters contained within the database.

3. SOFTWARE

a. The Operating system software shall be installed and configured and the OS license shall be supplied along with a backup CD allowing re-installation (i.e. Windows 7). PC's shall be provided with a recovery CD-ROM that will re-install the OS and reset the system to the as built or as commissioned state.

4. COMMUNICATION NETWORK

a. All of the following standard means of communications shall be supported by the control system. The system is to be factory configured for one of the following options; to be determined to suit the application.

b. A 1Gbps Ethernet port configured for access via the Internet. All monitoring, control and configuration features available locally shall be presented in the same format to a remote station viewable through a web browser.

c. A 1Gbps Ethernet port configured for ModbusTCP protocol. Information shall be mapped into a Modbus data table for access over Ethernet via the ModbusTCP protocol.

d. A 1Gbps Ethernet port configured to send e-mail via SMTP. The power generation system shall be capable of paging or emailing notification on events (i.e. alarm occurrence, start or stop, etc).

e. An RS485 serial port configured for ModbusRTU slave protocol. Information shall be mapped into a Modbus data table for access via a serial connection.

5. REMOTE SIGNALING

a. The following hardwired interface points shall be supplied to signal the customers BMS system. These same signals shall be available via the communication network.

b. Dry contact outputs:

c. Generator Run (per gen).

d. Generator Circuit Breaker Position (per gen).

~~d.~~e. Generator Alarm (per gen).

~~e.~~f. Generator Shutdown (per gen).

~~4.Generator Circuit Breaker Position (per gen).~~

~~5.Generator Transfer Circuit Breaker Position.~~

~~6.Utility Transfer Circuit Breaker Position.~~

~~7.Elevator Pre/Post Transfer.~~

~~j.~~g. System Common Alarm.

~~k.~~h. Load Shed/Add.

~~l.~~i. Discrete inputs shall be included for:

~~1.~~j. ATS Utility Fail/ Auto Mode ~~Peak Shave Start Input.~~Standby Start.

~~n.~~k. Test Initiate.

~~o.~~l. Analog output signals shall be included for:

~~p.~~m. Generator Kilowatts (per gen).

~~2.Utility Kilowatts.~~

~~7.~~6. CONTROL POWER

a. The paralleling switchgear shall derive its maintained source of control power from the 24Vdc engine cranking batteries whenever engine-generator sets are supplied with battery starting systems per unit.

b. The System control and common logic shall be supplied from a best battery selector and back-up station battery/charger to ensure overall system operation is maintained as long as power is available from any genset.

c. Supply an integral charger and gel-cells fed from a customer

supplied 120Vac maintained branch circuit. The supply is to be connected into the best battery selector to ensure a maintained source of control power for common logic.

d. Supply a separate 24Vdc station supply consisting of a 24V, 10A battery charger, (2) 12V, 70AH flooded lead-acid batteries connected in parallel. The supply is to be connected into the best battery selector to ensure a maintained source of control power for common logic. The supply shall be equipped with an alarm contact and be monitored by the power generation system.

e. Provide a power supply mounted internal to the switchgear to convert 120Vac from a UPS supply to 24Vdc. The output of the power supply is to be fed into the best battery selector to ensure a maintained source of control power for common logic.

C. Description of System Operation

1. AUTOMATIC STANDBY OPERATION

~~A.The standby mode shall support both closed transition soft load transfer and open transition transfer (break-before-make transfer) with an adjustable neutral position timer.~~

~~b.~~a. Utility failure shall be detected by the remote automatic transfer switches or incoming utility supply line side switchgear protective relays.

~~c.~~b. The engine start signal from the transfer switches or utility protective relays shall feed into the system control of the paralleling switchgear. When any transfer switch or utility protective relay signals an engine start, after a time ~~***Utility failure start sequence (closed transition):*** The system control shall monitor the utility supply voltage; upon sensing an out-of-limits condition and after a time delay~~delay, the control shall initiate engine starting.

~~d.~~c. A programmable start sequence shall allow the operator to define the starting position for each generator.

~~e.~~d. A selection shall be provided to start the generators based on the following logic:

~~f.~~e. Scramble start all generators.

~~g.~~f. Start 'n' units.

~~h.~~g. Start the required number of generators based ~~the demand prior to the outage.~~on remote transfer switches reporting a power failure.

~~i.~~h. Once the first generator is up to speed and voltage and after a warm-up delay it will close onto the dead bus.

~~j.~~i. If for any reason the first generator fails to close onto the dead bus the control will rotate through giving each available generator an opportunity to close onto the generator bus.

~~k.~~j. Once the first generator is online subsequent generators will synchronize and close onto the generator bus.

~~l.~~k. A fail to sync timer shall trigger an alarm if a generator does not synchronize within the allotted time. If a spare unit is available it will be started and the failed unit will index to the back of the start sequence.

~~l.Programmable logic shall be provided to allow the system to be tailored to transfer based on:~~

~~1.Generator bus is energized.~~

~~2.'n' generators are on line.~~

~~3.'n' generators or max transfer delay time.~~

~~4.On line capacity is greater then or equal to the demand prior to the outage.~~

~~J.~~l. ~~With the required generators on line the utility transfer circuit breaker will trip and the generator transfer circuit breaker will close.~~The load will automatically transfer off the failed utility supply onto the generator bus when the generator bus is energized and within limits for voltage and frequency. The generators are now supplying the essential building load.

m. ~~A neutral position delay will be inserted between the utility circuit breaker opening and the generator circuit breaker~~

~~closing if the load bus voltage has not decayed below the neutral delay voltage setting prior to the generator circuit breaker opening. The neutral delay timer will monitor the voltage on all 3-phases of the load and the time and voltage settings shall be adjustable.~~The paralleling switchgear is to be interlocked with the remote transfer switches or load distribution circuit breakers to provide orderly staging of the loads to protect the system from overload. The transfer permit and load dump signals shall be generated by the inherent load shed/add feature of the system control.

~~s.~~n. The remote transfer switches or transfer pair circuit breakers shall include a neutral position that allows the transfer operation when only one source of power is available.

~~t.~~o. Utility retransfer sequence: ~~When the utility supply returns and remains within limits for the duration of the~~The remote transfer switches or utility protective relay will sense when utility has returned within limits and after a retransfer delay ~~the controls will synchronize the generator bus~~will retransfer to the utility supply. The re-transfer sequence will be either an open or closed transition transfer sequence as selected by system operators (refer to following section "*Closed Transition Transfer*" for details). ~~The utility transfer circuit breaker will close. The control will switch to Var/PF and~~Once the retransfer sequence has been completed and all generators or un-loaded, their engine start signals will reset. When all transfer switches or utility breakers have retransferred, ~~the load control mode. The generators Var output will be ramped and held at a fixed point (0.8pf lagging) and the generators will be soft unloaded at a controlled rate. Once the generators have been unloaded the generator transfer circuit breaker will trip, the generator breakers will trip and the generators will~~generators will trip off line and continue to run for a cooldown period.

2. CLOSED TRANSITION TRANSFER (SOFT-LOAD) OPERATION

Specification writer's note: Delete this section if it is not applicable to the application.

a. The transfer control logic switch shall be capable of either open or closed transition operation as selected by operator interface control switch.

b. Closed Transition Operation: The transfer control shall automatically transfer the connected load to the generator supply in the event of a utility supply failure or when a “load test” mode is activated. The connected load shall automatically re-transfer back to the utility supply when utility power is restored or when a “load test” mode is terminated. All power transfers shall utilize closed transition (i.e. “make-before-break”) switching logic with automatic soft load ramping when both sources of power are available. When only one source of power is available (e.g. during a utility power failure condition), the transfer control logic shall automatically revert to open transition (i.e. “break-before-make”) operation.

c. Open Transition Operation: The transfer control shall automatically transfer the connected load to the generator supply in the event of a utility supply failure or when a “load test” mode is activated. The connected load shall automatically re-transfer back to the utility supply when utility power is restored or when a “load test” mode is terminated. All power transfers shall utilize an open transition (i.e. “break-before-make”) switching logic. The circuit breakers shall be electrically interlocked to prevent the utility and generator supplies from being interconnected.

d. Manual Operation: The transfer circuit breakers are not automatically operated. They may be tripped via the built-in trip pushbuttons and closed via the close pushbuttons. In manual mode, the close pushbuttons are electrically interlocked to prevent accidental paralleling of the generator and utility supplies.

e. Utility Power Restoration Condition: Once the utility supply is restored to above preset levels of rated voltage on all phases and phase balance is normal, the transfer controls initiate a utility return delay timer.

f. Once the utility return time delay period expires, automatic synchronizing of the generators to the utility source shall be initiated. Once all the generators speed and phases are matched to that of the utility, the utility transfer circuit breaker shall be closed. The generator’s kW load is then unloaded at a controlled ramp rate and the generator circuit breaker shall be tripped open when a generator unloaded set point is reached to complete the soft-load transfer.

g. Once the generators are transferred off load a cooldown delay time period shall be initiated, and once it expires, the engine start contacts are opened allowing the generators to shut off.

h. The load shall immediately retransfer to the utility supply (if within acceptable limits) should the generator supply fail prior to expiry of the utility return delay timer.

i. Load test may be initiated at the transfer switch, or remotely via optional communication link to the transfer controller.

j. When an on-load test mode is activated by system operator or from an automatic on-load exercise mode, a contact shall close to initiate starting of the selected generator sets.

k. Once the generators attain nominal voltage and frequency levels a warm-up time delay period shall be initiated. Following expiry of the warm-up delay timer, automatic synchronizing of the generators to the utility source shall be initiated.

l. Once the all the generator's speed and phase are matched to that of the utility supply, the generator transfer circuit breaker shall be closed. The generator's kW load is then increased at a controlled ramp rate. Once the utility supply has been unloaded, the utility circuit breaker shall be tripped open. The generators shall operate on load until the load test is terminated.

m. If all operating generators should fail during load testing, an open transition transfer to the utility supply shall immediately be initiated.

n. When the load test is terminated, automatic synchronizing shall be initiated. Once the generators speed and phase are matched to that of the utility, the utility transfer circuit breaker is closed. The generator's kW load is then unloaded at a controlled ramp rate and the generator circuit breaker is tripped open to complete the soft-load transfer.

o. The generator sets shall continue to operate following a load transfer for a cooldown delay period, and then a contact shall open to stop the generator set.

p. Closed Transition Operation Failure Condition : If all operating generators fail to unload 30 seconds after the utility circuit breaker closes, the generator transfer circuit breaker shall be tripped open to complete the transfer to the utility source.

q. If the utility supply fails to unload 30 seconds after the generator circuit breaker closes, the utility transfer circuit breaker shall be tripped open to complete the transfer to the generator source.

r. If the transfer control was transferring power from the generator source to the utility source and the generator switching device failed to open, an auxiliary trip relay shall trip open the utility circuit breaker to immediately separate the two power sources.

s. If the transfer control was transferring power from the utility source to the generator source and the utility switching device failed to open, an auxiliary trip relay shall trip open the generator circuit breaker to immediately separate the two power sources.

t. The original source (i.e. prior to the transfer sequence) shall remain on load, separated from the other source. An alarm light and transfer controls shall indicate a failure condition which must be reset before the transfer switch shall re-attempt subsequent transfers.

u. Should a circuit breaker fail to close for any reason within a 5 minute time period, an alarm light and alarm relay contact shall be activated.

3. UTILITY PARALLEL GENERATION OPERATION

Specification writer's note: Delete this section if it is not applicable to the application.

a. An On/Off/Auto selection shall be provided to allow for a manually initiated Utility Parallel Generation operation or to automatically Utility Parallel Generation based on:

b. Utility Demand Set points.

c. Time Schedule.

d. Peak Shave Start Input (contact closure).

e. Utility Parallel Generation *start sequence*: When Utility Parallel Generation is initiated the generators will start in the order selected. The number of generators required will be determined by the demand.

f. Once the first generator is up to speed and voltage and after a warm-up delay it will close onto the dead bus.

g. If for any reason the first generator fails to close onto the dead bus the control will rotate through giving each available generator an opportunity to close onto the generator bus.

h. Once the first generator is on line, the controls will synchronize the generator bus to the utility supply and the generator transfer breaker will close. Subsequent generators will synchronize and close onto the generator bus. As each generator closes onto the bus the control will ramp the generators load and VAR output levels to their respective set points.

i. Generator Base Load Mode; In this mode the generator output is maintained at a fixed set point, adjustable 40 - 100% of the generator rated output. A minimum utility import set point may be programmed to override the base load set point if necessary and prevent exporting power to the utility grid.

j. Utility Import/Export Mode. In this mode a fixed KW set point shall be established for the utility supply. The generators KW output shall vary to maintain the utility set point. The controls will limit the generator output to maintain operation within the allowable range.

k. VAR/PF Control Mode; When paralleled with the utility supply the generators shall be operated at a fixed power factor, adjustable 0.8 lagging to unity.

l. Utility Parallel Generation *stop sequence*: When Utility Parallel Generation mode is terminated, the generators will soft unload at a controlled rate. Once the generators have been unloaded the generator transfer circuit breaker will trip, the generator breakers will trip and the generators will continue to run for a cooldown period.

m. Utility fail during parallel operation: The intertie protection will operate to immediately separate the two sources. A utility fail during parallel operation alarm shall be annunciated along with indication of the protection element that initiated the trip (i.e. 27, 59, 81, 32, 67).

n. A preset operator selection shall determine whether the system bears to the generator supply or to the utility supply in the event of a disturbance which causes the intertie protection to operate:

o. If trip utility is selected the controls will immediately trip the utility transfer circuit breaker if a disturbance is detected on the utility grid and revert to the standby mode of operation. If the utility remains within limits as determined by the utility intertie protection relay for the duration of the retransfer timer the system will resynchronize the generator supply to the utility supply and resume Utility Parallel Generation operation.

p. If trip gen is selected the controls will immediately trip the generator transfer circuit breaker if a disturbance is detected on the utility grid. After the two supplies have separated, if the utility supply has failed as determined by the transfer control voltage and frequency settings, standby operation will ensue. The utility transfer circuit breaker will trip and the generator transfer circuit breaker will close.

q. If the utility disturbance does not trigger the transfer to generator sequence a reclose timer will be initiated. Upon expiration the generator will either resynchronize to the utility supply if it is within the allowable tolerances to permit parallel operation as determined by the utility intertie protection relay. If it is not within these tolerances the generator start will be relinquished, the generator breakers will trip and the generators will continue to run for a cooldown period. The generators will remain ready to start, to resume Utility Parallel Generation operation when the utility returns to within limits or if required due to further degradation of the utility supply.

r. A reclose counter (adj. 1 - 10) will be provided to prevent endless short-term cycling if the utility experiences a period of instability. The reclose count will self-reset if the generators do not trip again for the duration of the self-reset delay (0 - 24Hrs). If the generator supply cycles on/off in rapid succession tripping the reclose counter; a maximum PG trip

reclose count exceeded alarm will be annunciated and the automatic Utility Parallel Generation operation will be locked out until the count is manually reset or the self-reset delay expires.

4. PRIME POWER OPERATION

Specification writer's note: Delete this section if it is not applicable to the application.

a. An On/Off/Auto selection shall be provided to allow for manually initiating prime power operation or to automatically peak shave based on:

b. Time Schedule.

c. Prime Power Start Input (contact closure).

~~a.~~d. Prime power start sequence: When the start sequence is initiated the prime selected generator (the generator selected as #1 in the start sequence) runs continuously.

~~b.~~e. A programmable start sequence shall allow the operator to define the starting position for each generator.

~~c.~~f. A selection shall be provided to start the generators based on the following logic:

~~d.~~g. Scramble start all generators.

~~e.~~h. Start 'n' units.

~~3.Start the required number of generators based on remote transfer switches reporting a power failure.~~

~~g.~~i. Once the first generator is up to speed and voltage and after a warm-up delay it will close onto the dead bus.

~~h.~~j. If for any reason the first generator fails to close onto the dead bus the control will rotate through giving each available generator an opportunity to close onto the generator bus.

~~i.~~k. Once the first generator is online subsequent generators will synchronize and close onto the generator bus.

~~G.~~l. A fail to sync timer shall trigger an alarm if a generator does not synchronize within the allotted time. If a ~~spare~~standby unit is available it will be started and the failed unit will index to the back of the start sequence.

~~H.The remote transfer switches will automatically transfer off the failed utility supply onto the generator bus when they detect the generator bus is energized and within limits for voltage and frequency. The generators are now supplying the essential building load.~~

m. The paralleling switchgear is to be interlocked with the ~~remote transfer switches~~load contactors and breakers or to a customer load management system to provide orderly staging of the ~~transfer switches and~~load during startup to protect the system from overload. The ~~transfer permit and load dump~~load permissive signals shall be generated by the inherent load shed/add feature of ~~the~~ paralleling switchgear.

~~l. system control.~~

~~J.The remote transfer switches are to include a neutral position that allow the transfer switches to be dumped (immediately transferred off the generator supply to the neutral position). If the utility is within limits a dumped transfer switch shall transfer to the utility supply after the neutral delay period.~~

n. ~~*Utility retransfer sequence:* The remote transfer switches will sense when utility has returned within limits and after a retransfer delay will retransfer to the utility supply. Once retransferred their engine start signals will reset. When all transfer switches have retransferred~~ Prime Power Orderly Shutdown sequence*:* When the start sequence is terminated the system will perform an orderly shutdown. Each load stage will be sequentially shed in order of priority. Once all load stages have been shed the generators will trip off line and continue to run for a cooldown period.

~~M.A fail to sync timer shall trigger an alarm if the system does not synchronize within the allotted time. A closed transition transfer fail selection will be provided to allow the operator to select whether the control alarms and waits for operator intervention or defaults to open transition transfer if this situation occurs.~~

~~p.~~o. Load demand starting: If load demand starting is enabled after a minimum run time the generators will be started and stopped based on kW load demand. The order in which the generators start and stop will be based on the programmed start sequence. Two set points and delays shall be provided for starting subsequent generators to allow for slow and fast rising load conditions.

~~q.~~p. Surplus generators being removed from the bus shall be soft unloaded, tripped off line and continue to run for a cooldown period.

~~r.~~q. Generator failures: In either load demand starting or 'n' unit start modes, non-running (spare) generators will be started to replace failed or failing generators. If a generator shuts down on a fault, load shedding will be initiated if required, and the next non-running generator in the start sequence will be started and synchronized to the bus. If a generator develops an alarm the next non-running generator will be started and synchronized to the bus. Once the replacement generator is on line the failing generator will be indexed to the back of the start sequence; it will still be available if required.

~~A.~~r. Gen Test Mode: When a test is initiated at the paralleling switchgear the generators will start per the programmed start sequence (based on a simulation of all remote transfer switches or utility incoming sources reporting a power failure). After a warm-up delay the generators will synchronize to the generator bus. ~~Once the required generators are on line the controls will synchronize the generator bus to the utility supply and thegenerator transfer circuit breaker will close.~~ The generators will ~~soft load until the utility is off loaded at which point the utility transfer circuit breaker will trip (at a predetermined minimum import level). The generators are now supplying the essential building load.~~run on the bus unloaded until the test is terminated.

~~B.~~s. ~~If a generator fails during the test, the test will be terminated and the load retransferred to the utility supply.~~A load test may be performed using the test switch provided at each of the remote transfer switches. The transfer switches will signal engine start initiating the utility power fail sequence.

5. 7/14/28/365 DAY EXERCISE TIMER

~~A.~~a. The system is to include a programmable timer to automatically initiate the test ~~and/or peak shave modes~~mode of operation. The test time and duration shall be programmable and the following four types of schedules shall be selectable.

b. Weekly - performed once every 7 days.

c. Bi-weekly - performed once every 14 days.

d. Monthly - performed once every 28 days.

e. Calendar - based on set dates and times programmed into the 365 day calendar.

f. The timer shall include an automatic shift to account for daylight savings time.

6. LOAD SHED/ADD CONTROL

a. Load shed shall be enabled only when the generators are supplying the essential load. The load control will monitor both system load and frequency to provide fast response to overload conditions.

b. Provide one load shed/add stage per generator.

c. On a utility power failure the system shall shed non-essential loads prior to closing the generators onto the bus.

d. The load shed/add contacts will re-energize as each generator closes onto the bus signaling the loads may be reconnected.

e. When a stage is shed due to overload (or frequency dip) it will remain shed until manually reset by the operator or until the system retransfers to the utility supply. Load shed activity shall be logged and alarmed.

f. The load shed output is via dry contacts to directly trip load contactors, circuit breakers or to a customer load management system.

7. MANUAL OPERATION

a. Switches, pushbuttons and pilot lights shall be provided for each generator and circuit breaker. The controls shall be interlocked to allow safe manual operation of the generation system in the event the graphical user interface fails or the system fails to operate automatically.

Generator Controls:

Emergency Stop Pushbutton.

Run Mode Pushbutton.

Off Mode Pushbutton.

Auto Mode Illuminated Pushbutton.

Reset Pushbutton.

Sync & Close Pushbutton.

Generator Running Light.

Generator Alarm Light.

Generator Shutdown Light.

b. Circuit Breaker Controls:

Circuit Breaker Close Pushbutton.

Circuit Breaker Trip Pushbutton.

Circuit Breaker Open Light.

Circuit Breaker Closed Light.

3 PART 3 - EXECUTION

3.1 FACTORY TESTING

The switchgear switch shall be factory tested prior to delivery to the purchaser. The following tests shall be conducted by qualified factory personnel:

A. Visual Inspection: Electrical and Mechanical inspections to verify installed components are of correct ratings; meet the requirements of the project specifications and to ensure regulatory and quality requirements are met.

B. Mechanical Tests: As a minimum, the following mechanical tests shall be performed on the switchgear:

1. Power Conductor/Bus Bar Torque Verification

2. Verification of Bus Bar Bracing Mechanical Fasteners Tight

3. Verification of Breaker Racking Mechanical Interlock

4. Verification of Breaker Manual Operation

5. All Mechanical Fasteners/Wire Connections Tight

C. Electrical Tests: As a minimum, the following electrical tests shall be performed on the switchgear:

1. Verification of Power Metering (all Sources & Loads via secondary current injection)

2. Verification of Protective Relaying Functions (all Sources & Loads via secondary current injection)

3. Verification of Synchronizing & Load sharing (governor & AVR analog output monitoring)

4. Verification of Engine Control Functions (Logic & Adjustment/Setting All Timers & Sensors)

5. Verification of Remote Communication signals to remote

connected devices.

6. Manual Operation Mode Function Test-All manually operated devices including breaker control

7. Automatic Sequence of Operation Function Test-Normal Operation of unit & System control operating sequences-3 Complete Cycles

8. Dielectric Test

D. Final Inspection: As a minimum, the following final inspection tasks shall be performed on the switchgear:

1. Calibration Label/Equipment labels Installed & Correct

2. All safety/warning labels attached

3. All wiring straight, neatly bundled and adequately protected.

4. All options supplied as specified

5. Switchboard interior & exterior is clean, no paint imperfections

6. Final Documentation is Enclosed (Drawing, O&M Manual)

E. The switchgear manufacturer shall provide upon request of the project engineer, four (4) copies of certified Factory Test Reports for the switchgear supplied.

3.2 INSTALLATION

A. The contractor shall install the system in accordance with manufacturer's recommendations and local building code.

B. Prepare a level surface for placement of the switchgear.

C. Re-assemble the switchgear as necessary across any shipping splits, including reconnection of bus and control wiring.

D. Once the switchgear is installed and assembled ensure the switchgear is square and level and all doors swing correctly and draw out components slide freely.

E. Install all interconnect wiring between the switchgear and external systems (engine, building auxiliaries, etc); including communication network wiring.

F. Clean the switchgear inside and out as required in preparation for operational testing and commissioning.

G. Ensure any required auxiliary sources of supply are connected.

H. If space heaters are provided ensure they are connected and the thermostats set appropriately to prevent condensation.

I. Following installation, but prior to Switchgear energization, the contractor shall be responsible for completion of the following items.

1. Verification of correct power cabling phasing and phase rotation, prior to energization

2. Power Conductor Torque Verification

3. Meggar Testing of All Power Cabling Interconnected to Switchboard.

4. Visual Inspection: Electrical and Mechanical inspection to verify the installation is correct as recommended by the switchgear manufacturer and as per NEC/CEC requirements. Confirmation of correct switchgear voltage, current and withstand ratings as is required for the application

5. A complete system short-circuit analysis and coordination study for all protective devices shall be provided. An independent testing firm shall perform on site inspection, set-up and testing of all protective devices. Each protective device shall bear the testing firm certification label to verify the testing was completed and the results accepted. As a minimum the label must include the date, the tester's initials and a contract or ID number that may be traced back to the verification record.

3.3 FIELD TESTING & COMMISSIONING

A. A factory trained field service technician or Service Company approved by the switchgear supplier shall confirm proper operation of the system after verification of the installation by an independent

testing firm. Schedule and witness testing activities shall be coordinated with the project engineer, site contractor, and owner as required in advance of the testing.

B. As a minimum, the following tests shall be performed on the switchgear by a factory trained field service technician or Service Company approved by the switchgear supplier:

1. Verification of correct power cabling phasing and phase rotation, prior to synchronizing testing

2. Verify that all Protective Relays have been pre-tested and settings are correct as per the coordination study prior to equipment testing.

3. Verification of Synchronizing & Load sharing

4. Verification of Engine Control Functions (Logic & Adjustment/Setting All Timers & Sensors)

5. Verification of Remote Communication signals to remote connected devices.

6. Manual Operation Mode Function Test-All manually operated devices including breaker control)

7. Automatic Sequence of Operation Function Test-Normal Operation of unit & system control operating sequences-3 Complete Cycles

8. Final Documentation is updated as maybe required (Drawing, O&M Manual)

9. Qualified factory-trained field service personnel shall provide upon request of the project engineer four (4) copies of field test reports noting any deficiencies that require corrective action.

4 PART 4 - POST INSTALLATION

4.1 TRAINING

A. Provide for two (2) 8-hour days of training sessions at the end-users facility for maintenance and operations. Classes to include covering annual maintenance, troubleshooting, and typical operating procedures.

B. The switchgear supplier shall provide the capability to provide a technical training course at their factory for service/maintenance/operating personnel and provide details including costs, time required, technical ability, prerequisites, etc.

4.2 MAINTENANCE CONTRACTS

A. Maintenance contract price shall be based upon the performance of scheduled preventive maintenance during overtime hours. Emergency repairs shall be made during normal or overtime hours, as needed.

B. The maintenance contract shall include preventive maintenance. All preventive maintenance included in the contract shall be performed at the time frames and dates as dictated by the owner. Additionally, all schedules of preventive maintenance work shall be approved by the owner prior to work being conducted.

C. All emergency work shall have a guaranteed maximum response time of 8 hours.

D. The switchgear supplier shall promptly replace any and all parts used during the contract period at no charge to the owner including site time, site transportation, and site expenses.

4.3 SPARE PARTS

A. The following spare parts are to be provided to the customer for the paralleling switchgear upon acceptance of the power generation system. Quantity ( ) noted shall be provided for each different model and rating.

1. PLC: One (1) spare PLC Card identical in every way to the PLC's used for this system.

2. Pilot Lights: Six (6) spare indicating lights for circuit breaker position

3. Fuses: 10 (10) spare fuses for every type of fuse used in the system.

4. Circuit Breaker: One (1) spare breaker for each frame size used in the switchgear lineup.

5. Control Switch: One (1) circuit breaker pistol grip handle for breaker control.

B. Touchup Paint: 1 0.5 pint (250 mL) container of paint matching color of switchgear.

C. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

4.4 SERVICE PERSONNEL

A. The switchgear manufacturer shall provide qualified service personnel, consisting of factory-trained field service personnel dedicated to the start-up and maintenance of the equipment.

B. The manufacturer shall provide a toll-free number to reach qualified support person 24 hours/day, 7 days/week, 365 days/year. If emergency service is required, on-site response time shall be eight hours or less within 200 miles.

END OF SECTION 262313