

SECTION 26 33 53
STATIC UNINTERRUPTIBLE POWER SUPPLY

SPEC WRITER NOTE:

Delete between // - // if not applicable to project. Also delete any other item or paragraph not applicable to the section and renumber the paragraphs.

This specification is typically used for large multi-module static UPS systems. It can be edited for smaller single-module UPS systems.

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of the static uninterruptible power supply, indicated in this section as UPS.

1.2 RELATED WORK

- //A. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirement for seismic restraint for nonstructural components.//
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- C. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible fault currents.
- E. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.
- //F. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.//
- G. Section 26 24 13, DISTRIBUTION SWITCHBOARDS: For low-voltage switchboard required for maintenance bypass of multiple module UPS.
- H. Section 26 26 00, POWER DISTRIBUTION UNITS FOR STATIC UNINTERRUPTIBLE POWER SYSTEMS: Power distribution units connected to the output of a UPS.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. UPS shall be thoroughly tested at the factory to assure that there are no electrical or mechanical defects.
- B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
 - 1. UPS shall be factory full-load tested to meet the requirements specified using a test battery (not the battery to be supplied with the system) with AC input power and with battery power for a minimum of 8 hours, with meter readings taken every 30 minutes. Should a malfunction occur, the problem shall be corrected and the test shall be repeated. The tests shall encompass all aspects of operation, such as module failure, static bypass operation, battery failure, input power failure and overload ratings.

1.5 SUBMITTALS

- A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, plan, front, side, and rear elevations, accessories, and device nameplate data.
 - c. Provide detailed and project-specific system diagram, showing maintenance bypass, UPS module(s), battery cabinet(s) and batteries, major circuit protective devices, interconnecting power and control wiring, key-type mechanical interlocks, and connections to power sources and loads, as applicable. Indicate whether interconnections are factory-provided/factory-installed, factory-provided/field-installed, or field-provided/field installed.

SPEC WRITER NOTE: Include the following paragraph for projects in seismic areas of moderate-high, high and very high seismicities as listed in Table 4 of VA Handbook H-18-8, Seismic Design Requirements.

Coordinate with the structural engineer.

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

2. Manuals:

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

- 1) Wiring diagrams shall have their terminals identified to facilitate installation, maintenance, and operation.
- 2) Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnection between the items of equipment.
- 3) Provide a clear and concise description of operation, which gives, in detail, the information required to properly operate the UPS, including but not limited to bypass switchboard, UPS, key-type mechanical interlocks, remote devices, emergency power off buttons, fire alarm interface, and other components as applicable.

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

- 1) Include complete "As Installed" diagrams that indicate all pieces of equipment and their interconnecting wiring.
- 2) Include complete diagrams of the internal wiring for each piece of equipment, including "As Installed" revisions of the diagrams.
- 3) The wiring diagrams shall identify the terminals to facilitate installation, maintenance, operation, and testing.

3. Test Reports:

a. Submit certified factory design and production test reports for approval.

- b. Two weeks prior to the final inspection, submit certified field test reports and data sheets to the //Resident Engineer// //COR//.
- 4. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the UPS conforms to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the UPS has been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata), form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. Institute of Engineering and Electronic Engineers (IEEE):
 - C57.110-08.....Recommended Practice for Establishing Transformer Capability When Supplying Nonsinusoidal Load Currents
 - C62.41.1-02.....Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits
 - C62.41.2-02.....Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
 - 450-20.....Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications
 - 485-20.....Sizing Lead-Acid Batteries for Stationary Applications
- C. International Code Council (ICC):
 - IBC-18.....International Building Code
- D. National Electrical Manufacturers Association (NEMA):
 - PE 1-12.....Uninterruptible Power Systems - Specification and Performance Verification
- E. National Fire Protection Association (NFPA):
 - 70-23.....National Electrical Code (NEC)

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. System Capacity: Unless stated otherwise, the parameters listed are under full rated output load at a minimum of 0.9 power factor, with batteries fully charged and floating on the DC bus and with nominal

input voltage. Overall //kVA, // //kW, //non// //N+1// redundant, at 40 °C.

- B. Battery Capacity: Discharge time to end voltage: //15// //240// minutes, at 25 °C (77 °F). Battery shall be capable of delivering 125 percent of full rated output load at initial start-up.
- C. System Bus Bracing: Braced for amperes symmetrical interrupting capacity as shown on drawings.
- D. AC Input:
1. Voltage //208// //480// volts line-to-line.
 2. Number of phases: 3-phase, 3-wire, plus ground.
 3. Voltage Range: Plus 10 percent, minus 15 percent, without affecting battery float voltage or output voltage.
 4. Frequency: 60 Hz, plus or minus 5 percent.
 5. Total harmonic current distortion (THD) reflected into the primary line: //5// //10// percent maximum.
- E. AC Output

SPEC WRITER NOTE: If the output voltage is 120/208 V and the same voltage is not available for the static bypass and maintenance bypass, an external transformer will be required in the bypass distribution system.

1. Voltage //208// //480// volts line-to-line, //120// //277// volts line-to-neutral.
2. Number of phases: 3-phase, //3-wire// //4-wire//, plus ground.
3. Voltage regulation:
 - a. Balanced load: Plus or minus 1.0 percent.
 - b. 100 percent load imbalance, phase-to-phase: Plus or minus 3 percent.
4. Frequency: 60 Hz.
5. Frequency regulation: Plus or minus 0.05 percent.
6. Harmonic content (RMS voltage): 5 percent maximum total harmonic distortion with 100% nonlinear load.
7. Load power factor operating range: 1.0 to 0.8 lagging.
8. Phase displacement:
 - a. Balanced load: Plus or minus 1 degree of bypass input.
9. Overload capability (at full voltage) (excluding battery):
 - a. 125 percent load for 10 minutes.
 - b. 150 percent load for 1 minute.

F. Voltage Transient Response:

1. 100 percent load step: Plus or minus 5 percent.

2.2 UPS

A. General Description: UPS module shall consist of a rectifier/charger unit and a 3-phase inverter module unit with their associated transformers, synchronizing equipment, input and output circuit breakers, and accessories as required for operation.

B. Rectifier/Charger Unit: Rectifier/charger unit shall be solid state and shall provide direct current to the DC bus.

1. Input Circuit Breaker: Rectifier/charger unit shall be provided with an input circuit breaker. The circuit breaker shall be sized to accept simultaneously the full-rated load and the battery recharge current.

2. Sizing: Rectifier/charger unit shall be sized for the following two simultaneous operating conditions:

- a. Supplying the full rated load current to the inverter.
- b. Recharging a fully-discharged battery to 95 percent of rated ampere-hour capacity within ten times the discharge time after normal AC power is restored, with the input protective device closed.

C. Inverter Unit: Inverter unit shall be a solid-state device capable of accepting power from the DC bus and providing AC power within specified limits.

1. Output Overload: The inverter shall be able to sustain an overload as specified across its output terminals.
2. Synchronism: The inverter shall normally operate in phase-lock and synchronism with the bypass source.
3. Modular Construction: Each control logic printed circuit board shall be electrically and physically packaged on an individual plug-in module with separate indication and adjustments.
4. Output Circuit Breaker: The output circuit breaker shall be capable of shunt tripping and shall have interrupting capacity as specified. Circuit breaker shall have provision for locking in the "off" position.

SPEC WRITER NOTE: Include option below for three-phase, four-wire with neutral output.

//5. Output Transformer: The inverter output transformer shall be similar to the input transformer and shall be capable of handling up to //K-13// nonlinear loads as described in IEEE C57.110.//

SPEC WRITER NOTE: For single module UPS system, the option below shall be deleted.

//6. Modular Inverter Isolation: Each inverter in the UPS shall have fault sensing and static isolation as well as an output protective device, to remove a faulted module from the system without affecting the critical load bus beyond the stated limits. The protection system shall have control logic capable of isolating only the faulted module, and shall not shut down the entire UPS upon a fault in one module. Open protective devices shall be indicated by an alarm and indicator light.//

- D. External Protection: UPS module shall have built-in self-protection against undervoltage, overvoltage, overcurrent and surges introduced on the AC input source and/or the bypass source. The UPS system shall sustain input surges without damage in accordance with IEEE C62.41.1 and IEEE C62.41.2. The UPS shall also have built-in self-protection against overvoltage and voltage surges introduced at the output terminals by paralleled sources, load switching, or circuit breaker operation in the critical load distribution system.
- E. Internal Protection: UPS module shall be self-protected against overcurrent, sudden changes in output load and short circuits at the output terminals. UPS module shall be provided with output reverse power detection which shall cause that module to be disconnected from the critical load bus when output reverse power is present. UPS module shall have built-in protection against permanent damage to itself and the connected load for predictable types of failure within itself and the connected load. At the end of battery discharge limit, the module shall shut down without damage to internal components.

2.3 STATIC BYPASS TRANSFER SWITCH

- A. A static bypass transfer switch shall be provided as an integral part of the UPS and shall consist of a static switch and a bypass protective device or bypass switch. The control logic shall contain an automatic transfer circuit that senses the status of the inverter logic signals and alarm conditions and provides an uninterrupted transfer of the load to the bypass AC power source, without exceeding the transient limits

specified herein, when a malfunction occurs in the UPS or when an external overload condition occurs.

1. Static Bypass Transfer Switch Disconnect: A disconnect shall be incorporated to isolate the static bypass transfer switch assembly so it can be removed for servicing. The disconnect shall be equipped with auxiliary contacts and provision for padlocking in either the "on" or "off" position.

SPEC WRITER NOTE: This paragraph is for single-module UPS. Delete for multi-module UPS.

//2.4 MAINTENANCE BYPASS - SINGLE-MODULE UPS

- A. A maintenance bypass switch shall be provided as an integral part of the UPS and located within the UPS module. The maintenance bypass switch shall provide the capability to continuously support the load from the bypass AC power source while the UPS is isolated for maintenance. The maintenance bypass switch shall be housed in an isolated compartment inside the UPS cabinet. Switch shall contain a maintenance bypass protective device and a module isolation protective device.
- B. The maintenance bypass switch shall provide the capability of transferring the load from the UPS static bypass transfer switch to maintenance bypass and then back to the UPS static bypass transfer switch with no interruption to the load.//

SPEC WRITER NOTE: This paragraph is for multiple-module UPS. Delete for single-module UPS. For multi-module UPS systems, specify separate maintenance bypass switchboard in Section 26 24 13, DISTRIBUTION SWITCHBOARDS.

//2.5 MAINTENANCE BYPASS - MULTIPLE-MODULE UPS

- A. A maintenance bypass switchboard shall be provided. At the minimum, the bypass switchboard enclosure, bussing, and circuit breakers shall meet the requirements of Section 26 24 13, DISTRIBUTION SWITCHBOARDS. Additionally, the bypass switchboard shall contain key-type mechanical interlocks, control wiring, and accessories as needed for proper operation with the UPS. The maintenance bypass switchboard shall provide the capability to continuously support the load from the bypass AC power source while the UPS is isolated for maintenance.
- B. The maintenance bypass switch shall provide the capability of transferring the load from the UPS static bypass transfer switch to

maintenance bypass and then back to the UPS static bypass transfer switch with no interruption to the load.//

SPEC WRITER NOTE: This paragraph is for single-module UPS. Delete for multi-module UPS.

//2.6 MODULE CONTROL PANEL - SINGLE-MODULE UPS

A. The UPS module shall be provided with a LCD control/indicator panel. Meters, controls, alarms, system diagnostics, mimic screen showing one-line diagram of the system, and indicators for operation of the UPS shall be on this panel.

1. Module Meters:

- a. Meters shall have 1 percent accuracy.
- b. The following functions shall be monitored and displayed:
 - 1) Input voltage, phase-to-phase (all three phases).
 - 2) Input current, all three phases.
 - 3) Input frequency.
 - 4) Battery voltage.
 - 5) Battery current (charge/discharge).
 - 6) Output voltage, phase-to-phase and phase-to-neutral (all three phases).
 - 7) Output current, all three phases.
 - 8) Output frequency.
 - 9) Output kilowatts.
 - 10) Elapsed time meter to indicate hours of operation, 6 digits.
 - 11) Bypass voltage, phase-to-phase and phase-to-neutral (all three phases).
 - 12) Output kilovars.
 - 13) Output kilowatt hours, with 15-minute interval.

2. Module Controls:

- a. Module shall have the following controls:
 - 1) Alarm test/reset function.
 - 2) Module input protective device trip function.
 - 3) Module output protective device trip function.
 - 4) Battery protective device trip function.
 - 5) Emergency Power Off (EPO) pushbutton, with guard.
 - 6) Control power off switch.
 - 7) Static bypass transfer switch enable/disable selector switch.

3. Module Alarm Indicators:

- a. Module shall have indicators for the following alarm items. Any one of these conditions shall turn on an audible alarm and the appropriate summary indicator. Each new alarm shall register without affecting any previous alarm.
- 1) Input AC power source failure.
 - 2) Input protective device open.
 - 3) Output protective device open.
 - 4) Overload.
 - 5) Overload shutdown.
 - 6) DC overvoltage.
 - 7) DC ground fault.
 - 8) Low battery.
 - 9) Battery discharged.
 - 10) Battery protective device open.
 - 11) Cooling fan failure.
 - 12) Equipment overtemperature.
 - 13) Control power failure.
 - 14) Charger off.
 - 15) Inverter off.
 - 16) Emergency off.
 - 17) UPS on battery.
 - 18) Load on static bypass.
 - 19) Static bypass transfer switch disabled.
 - 20) Inverter output overvoltage, undervoltage, overfrequency, and underfrequency.
 - 21) Bypass source overvoltage, undervoltage, overfrequency, and underfrequency.
 - 22) Bypass source to inverter out of synchronization.
 - //23) Input transformer overtemperature.//
 - //24) Inverter transformer overtemperature.//

SPEC WRITER NOTE: This paragraph is used with multi-module UPS. Delete for single module UPS.

//2.7 SYSTEM CONTROL CABINET - MULTI-MODULE UPS

- A. The UPS shall be provided with a LCD control/indicator panel. Meters, controls, alarms, system diagnostics, mimic screen showing one-line diagram of the system, and indicators for operation of the UPS shall be on this panel. The system control cabinet shall communicate with each

UPS module, the static bypass transfer switch and its bypass disconnect, the UPS input and output circuit breakers, and the UPS maintenance bypass switchboard.

1. Module Meters:

- a. Meters shall have 1 percent accuracy.
- b. The following functions shall be monitored and displayed:
 - 1) Input voltage, phase-to-phase (all three phases).
 - 2) Input current, all three phases.
 - 3) Input frequency.
 - 4) Battery voltage.
 - 5) Battery current (charge/discharge).
 - 6) Output voltage, phase-to-phase and phase-to-neutral (all three phases).
 - 7) Output current, all three phases.
 - 8) Output frequency.
 - 9) Output kilowatts.
 - 10) Elapsed time meter to indicate hours of operation, 6 digits.
 - 11) Bypass voltage, phase-to-phase and phase-to-neutral (all three phases).
 - 12) Output kilovars.
 - 13) Output kilowatt hours, with 15-minute interval.

2. Module Controls:

- a. Module shall have the following controls:
 - 1) Alarm test/reset function.
 - 2) Module input protective device trip function.
 - 3) Module output protective device trip function.
 - 4) Battery protective device trip function.
 - 5) Emergency Power Off (EPO) pushbutton, with guard.
 - 6) Control power off switch.
 - 7) Static bypass transfer switch enable/disable selector switch.

3. Module Alarm Indicators:

- a. Module shall have indicators for the following alarm items. Any one of these conditions shall turn on an audible alarm and the appropriate summary indicator. Each new alarm shall register without affecting any previous alarm.
 - 1) Input AC power source failure.
 - 2) Input protective device open.
 - 3) Output protective device open.

- 4) Overload.
- 5) Overload shutdown.
- 6) DC overvoltage.
- 7) DC ground fault.
- 8) Low battery.
- 9) Battery discharged.
- 10) Battery protective device open.
- 11) Cooling fan failure.
- 12) Equipment overtemperature.
- 13) Control power failure.
- 14) Charger off.
- 15) Inverter off.
- 16) Emergency off.
- 17) UPS on battery.
- 18) Load on static bypass.
- 19) Static bypass transfer switch disabled.
- 20) Inverter output overvoltage, undervoltage, overfrequency, and underfrequency.
- 21) Bypass source overvoltage, undervoltage, overfrequency, and underfrequency.
- 22) Bypass source to inverter out of synchronization.
- //23) Input transformer overtemperature.//
- //24) Inverter transformer overtemperature.////

SPEC WRITER NOTE: Delete this paragraph if remote monitoring panel is not in scope of project.

//2.8 REMOTE MONITORING PANEL

- A. A wall-mounted remote monitoring panel shall be provided to monitor system status.
- B. Indicators: Minimum display shall include the following indicators:
 1. Load on UPS.
 2. Load on battery.
 3. Load on bypass.
 4. Low battery.
 5. Summary alarm.
 6. New alarm (to alert the operator that a second summary alarm condition has occurred).
- C. Audible Alarm.

SPEC WRITER NOTE: Delete system control cabinet reference for single-module UPS systems.

- D. Any single indicator shall also turn on the audible alarm. An audible alarm test/reset button and lamp test/reset button shall be included. This reset button shall not affect nor reset the alarm on the //module control panel// //system control cabinet.//

2.9 BATTERY SYSTEM

- A. General: A storage battery with sufficient ampere-hour rating to maintain UPS output at full capacity for the specified duration shall be provided for each UPS module.
- B. Battery Type: Lead calcium.
- C. Battery Construction: The battery shall be of the valve-regulated, sealed, non-gassing, recombinant type.

SPEC WRITER NOTE: Choose between a battery cabinet or a battery rack.

- //D. Battery Cabinet: The batteries shall be furnished in a battery cabinet matching the UPS. The battery cabinet shall be provided with smoke and high temperature alarms.//
- //E. Battery Rack: Battery rack shall be steel and shall be protected with electrolyte-resistant paint. No more than three tiers are allowed.//
- F. Battery Cables: Battery-to-battery connections shall be stranded cable with proper cable supports.
- G. Battery Disconnect: Each battery cabinet or rack shall have a fused disconnect switch or circuit breaker, lockable in the "off" position, provided in a NEMA 1 enclosure.

SPEC WRITER NOTE: Fire codes may dictate spill control and neutralization means for battery systems, dependent on type and volume of electrolyte. Occupancy separation and ventilation may also be required. Determine requirement and specify appropriately. Coordinate neutralization materials cabinet location with architectural drawings.

- //H. Electrolyte Spill Containment and Neutralization: Provide spill control and neutralization means integral to the battery cabinet or battery rack assembly. Provide spare neutralization materials in a manufacturer's cabinet.//

PART 3 - EXECUTION**3.1 INSTALLATION**

A. The UPS shall be set in place, wired, and connected in accordance with the approved shop drawings and manufacturer's instructions.

//B. In seismic areas, UPS shall be adequately anchored and braced per details on structural contract drawings to withstand the seismic forces at the location where installed.//

3.2 ACCEPTANCE CHECKS AND TESTS

A. An authorized representative of the UPS manufacturer shall technically supervise and participate during all of the field adjustments and tests. Major adjustments and field tests shall be witnessed by the //Resident Engineer// //COR//. The manufacturer's representative shall certify in writing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer's recommendations.

B. Perform manufacturer's required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:

- a. Compare equipment nameplate data with specifications and approved shop drawings.
- b. Inspect physical, electrical, and mechanical condition.
- c. Verify appropriate anchorage, required area clearances, and correct alignment.
- d. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.
- e. Verify grounding connections.
- f. Vacuum-clean enclosure interior. Clean enclosure exterior.
- g. Verify the correct operation of all alarms and indicating devices.
- h. Attach a phase rotation meter to the UPS input, output, and bypass buses, and observe proper phase sequences.
- i. Check and test controls for proper operation.
- j. Check doors for proper alignment and operation.
- k. Check and test each protective device for proper mechanical and electrical operation.

//l. Verify protective device overcurrent trip settings against approved coordination study.//

//m. Confirm correct operation and sequencing of key-type mechanical interlock systems.//

2. Load Test: The UPS shall be load tested for a continuous 24 hour period by means of resistive load banks, sized for full rated output load and provided by the UPS manufacturer. The UPS shall be continuously tested at 1/2 load for 8 hours, 3/4 load for 8 hours and full load for 8 hours. If a failure occurs during the burn-in period, the tests shall be repeated. Instrument readings shall be recorded every half hour for the following:
- a. Input voltage and current (all three phases, for each module).
 - b. Input and output frequency.
 - c. Battery voltage for each module.
 - d. Output voltage and current (all three phases, for each module).
 - e. Output kilowatts for each module.
 - f. Output voltage and current (all three phases).
 - g. Output kilowatts.

SPEC WRITER NOTE: Delete emergency source testing requirements if no emergency source is available.

3. Full Load Burn In Test: The UPS shall undergo an additional full load burn-in period of 24 continuous hours by means of resistive load banks, sized for full rated output load and provided by the UPS manufacturer. If a failure occurs during the burn-in period, the tests shall be repeated. Instrument readings shall be recorded every half hour as above. The following tests shall be performed:
- a. With the UPS carrying full rated output load and supplied from the normal source, switch //100 percent// //50 percent// of load bank capacity on and off a minimum of five times within the burn-in period.
 - //b. With the UPS carrying maximum continuous design load and supplied from the emergency source, repeat the switching operations described above.//
4. Full Load Battery Burn In Test: The UPS shall undergo a full load battery test by means of resistive load banks, sized for full rated output load and provided by the UPS manufacturer. If a failure occurs during the battery discharge time, the tests shall be repeated. Instrument readings shall be recorded every half hour as above.

- a. With the UPS carrying full rated output load and operating on battery power, switch //100 percent// //50 percent// of load bank capacity on and off a minimum of five times within the battery discharge time.
5. Battery Discharge and Recharge Test: With the battery fully charged, the UPS shall undergo a complete battery discharge test to full depletion followed by a full recharge. Instrument readings shall be recorded every minute during discharge for the following:
- a. Battery voltage and current// for each module//.
 - b. Output voltage and current (all three phases)// for each module//.
 - c. Output kilowatts// for each module//.
 - d. Output voltage and current (all three phases).
 - e. Output kilowatts (system).
 - f. Output frequency.

3.3 FOLLOW-UP VERIFICATION

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

3.4 ONE LINE DIAGRAM AND SEQUENCE OF OPERATION

- A. At final inspection, an as-built one line diagram shall be laminated or mounted under acrylic glass, and installed in a frame mounted near the UPS.
- B. Furnish a written sequence of operation for the UPS and connected line side/load side electrical distribution equipment. The sequence of operation shall be laminated or mounted under acrylic glass, and installed in a frame mounted near the UPS.
- C. Deliver an additional four copies of the as-built one line diagram and sequence of operation to the //Resident Engineer// //COR//.

3.5 INSTRUCTION

- A. Furnish the services of a factory-trained technician for one 4-hour training period for instructing personnel in the maintenance and operation of the UPS, on the dates requested by the //Resident Engineer// //COR//.

---END---