

SECTION 26 3353 – STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. On-line, double-conversion, static-type, UPS units. UPS systems shall be designed with modular assemblies that allow user flexibility for operation as a fixed capacity system or as a modular redundant system. Systems may be deployed with various combinations of hardware and software scalability for growth and application flexibility. Key system features and accessories may include:
  - a. UPS module(s) containing Rectifier(s), Inverter(s), Battery Charger(s), Static Bypass, and associated Control and Monitor Panel.
  - b. Battery string(s) in UPS enclosure or in external Line-and-Match Battery Cabinets.
  - c. Surge suppression.
  - d. Line-and-Match and/or sidecar-type accessory cabinets for transformer, maintenance bypass, parallel tie and distribution applications.
  - e. Non-matching wall mounted or floor standing maintenance bypass cabinets or multi-module parallel tie cabinets.
  - f. Battery monitoring.

B. Related Sections:

1. Division 26 Section "Grounding and Bonding for Electrical Systems".
2. Division 26 Section "Low Voltage Electrical Power Conductors and Cables".

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated. Include data on features, components, ratings, and performance.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement. Include wiring diagrams.
- C. Factory Test Reports: Comply with specified requirements.
- D. Field quality-control reports.
- E. Operation and Maintenance Data:
- F. Warranties.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 and marked for intended location and application.
- B. UL Compliance: Listed and labeled under UL 1778.
- C. NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.
- D. Comply with most current edition of the Northwestern University Design Standards.

1.4 PROJECT CONDITIONS

- A. ***(Delete This Paragraph If Not Required)*** [Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by the University or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
  - 1. **Notify the University's Chief Electrician no fewer than seven days in advance of proposed electrical service interruptions.**
  - 2. **Indicate method of providing temporary utilities.**
  - 3. **Do not proceed with interruption of electrical service without the University's Chief Electrician's written permission.**
  - 4. **The University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.**
  - 5. **Comply with NFPA 70E.]**
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for equipment, including clearances between equipment and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
  - 1. Ambient Temperature: Not exceeding 40 deg C.
  - 2. Altitude: Not exceeding 6600 feet (2010 m).

1.5 WARRANTY

- A. Comply with Division 1 requirements.
- B. Special Battery Warranties:
  - 1. Comply with Division 1 requirements.
  - 2. UPS System warranty: one year.
  - 3. UPS manufacturer warrants, that the VRLA Battery Products are free from defects in material and workmanship. A battery will not be considered defective or nonconforming if it has delivered at least eighty percent (80%) of its rated capacity during the Warranty Period.
  - 4. If a Warranted Item is defective, manufacturer will refurbish or replace such defective Warranted Item (including the costs of providing diagnosis, service, and labor).
  - 5. The Battery Warranty period shall be:

- a. Battery Labor: Twelve (12) months from the date of product installation.
  - b. Batteries two hundred (200) watts per cell and greater,; Thirty-six (36) months from the date of installation or forty-two (42) months from the manufacturing date code listed on the battery.
  - c. Batteries less than two hundred (200) watts per cell and greater, twenty-four (24) months from the date of installation or thirty (30) months the manufacturing date code listed on the battery.
- C. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within special warranty period.
- 1. Special Warranty Period: **[Ten]** years from date of factory startup completion or from the date that the system was energized and placed into service.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURED SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. Eaton Corporation.
  - 2. Liebert Corporation.
  - 3. Mitsubishi.

### 2.2 OPERATIONAL REQUIREMENTS

- A. Automatic operation includes the following:
- 1. Normal Conditions: Load is supplied with power flowing from the normal power input terminals through the system with full ability to provide voltage regulation and battery backup if required.
  - 2. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the system shall provide voltage regulation and/or battery backup as required.
  - 3. If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.
  - 4. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.
  - 5. If the battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to float-charge mode.
  - 6. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal AC supply circuit without disturbance or interruption.
  - 7. If a fault occurs in the system supplied by the UPS, and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal AC supply circuit for fault clearing.

8. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
9. If the battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:

1. System shall have the ability to be manually transferred to bypass for maintenance or service without disturbance or interruption to the connected load.

C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions in subparagraphs below without interrupting supply to the load during switching:

1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS AC input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS AC supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal UPS AC supply terminals are energized and the load is supplied through either the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

D. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance.

1. Ambient Temperature for Battery: 77+/- 9 Deg F (25 +/- 5 deg C).
2. Relative Humidity: 0 to 95 percent, non-condensing.
3. Altitude: Sea level to 4000 feet (1220 m).

### 2.3 PERFORMANCE REQUIREMENTS

A. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:

1. Inverter is switched to battery source.
2. Steady-state ac input voltage deviates from +10% to -15% from nominal voltage.
3. Steady-state input frequency deviates up to +/- 5 percent from nominal frequency.
4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
5. Load is 100 percent unbalanced continuously.

B. Minimum Duration of Supply: 10 minutes with full-rated output kW.

C. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state AC input voltage varies between +10% and -15% from nominal.

- D. Overall UPS Efficiency: All systems shall be available with energy saving operating modes that minimize losses without compromising power quality or reliability. Maximum efficiency shall be achieved during normal operating conditions.
1. Equal to or greater than 99% for 3 phase 480V systems rated between 20 - 3,000 kW.
  2. Equal to or greater than 97% for 3 phase 208V systems rated between 12 – 60 kW.
  3. Equal to or greater than 96% for 1 phase systems rated 3 -15kW.
- E. Maximum Acoustical Noise: 65 dBA, emanating from any UPS component under any condition of normal operation, measured 1meter from nearest surface of component enclosure.
- F. Maximum Energizing Inrush Current: Six times the full-load current.
- G. Maximum AC Output-Voltage Regulation for Loads up to 100 Percent Unbalanced: Plus or minus 2 percent over the full range of battery voltage.
- H. Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.
- I. Limitation of harmonic distortion of input current to the UPS shall be as follows: Input current total harmonic distortion (THD) shall be less than 3% at nominal line voltage and 5% nominal source impedance.
- J. Maximum Harmonic Content of Output-Voltage Waveform: 1% total harmonic distortion (THD) for linear loads, 5% THD for 100% non linear loads crest factor of 3.1 without de-rating.
1. Linear load: Output voltage THD of less than 1% for 100% linear load.
  2. Non-linear load: Output voltage THD of less than 5% for 100% non-linear load.
- K. Minimum Overload Capacity of UPS at Rated Voltage:
1. Double Conversion mode: The unit shall maintain voltage regulation for 102% to <110% of resistive/inductive load for 10 minutes, 111% to <125% for 60 seconds, and 126% to 150% for 10 seconds, >151% for 300ms.
  2. Stored energy mode (typically on battery): The unit shall maintain voltage regulation for 102% to <110% of resistive/inductive load for 10 minutes, 111% to <125% for 60 seconds, and >126% for 300ms
  3. Energy Saver System operation: Continuous = 110%. Transient = 1000% peak current for 10ms.
  4. On bypass (single UPS systems): Continuous = 125%. Transient = 1000% peak current for 10ms.
- L. Maximum Output-Voltage Transient Excursions from Rated Value:
1. 4% with 50ms recovery from 100% load step for 3phase systems > 20kW.
  2. 6% with 50ms recovery from 100% load step for 3phase systems < 20kW.
- M. Input Power Factor: 0.95 - 0.99 lagging at rated load.
- N. EMI Emissions: Comply with FCC Rules and Regulations and with 47 CFR 15 for Class A equipment.

2.4 UPS SYSTEMS

- A. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.
- B. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.
- C. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.
- D. Input surge withstand capability to protect rectifier-charger, inverter, controls, and output components: The UPS shall be in compliance with IEEE 587 (ANSI C62.41), category A & B (6kV).

2.5 RECTIFIER-CHARGER

- A. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.
- B. Output Ripple: Limited to less than 0.5 percent of rated current peak-to-peak.
- C. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources. Rectifier restarts and walks in and gradually assumes the battery recharge and inverter loads. Adjustable up to 30 seconds and is visibly displayed on the front panel.
- D. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life.

2.6 INVERTER

- A. Description: Pulse-width modulated, utilizing IGBT's with sinusoidal output.

2.7 STATIC BYPASS TRANSFER SWITCH

- A. Description: The static bypass shall consist of a fully rated, continuous duty, naturally commutated static switch for high-speed transfers.
- B. Switch Rating: Continuous duty at the rated full UPS load current, minimum.

2.8 BATTERY

- A. Description: Valve-regulated-lead-acid (VRLA) units factory assembled in an isolated compartment of UPS cabinet or in an external battery cabinet complete with battery disconnect switch. Batteries shall be arranged for drawout removal from cabinet for testing and inspecting.
- B. *Battery Capacity/Run Time:* \_\_\_\_\_ . **[edit per project requirements]**
- C. *Special Environmental Conditions:* \_\_\_\_\_ . **[edit per project requirements]**
- D. *Battery Bus Configuration:* \_\_\_\_\_ . **[edit per project requirements]**

- E. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces based on the seismic zone where they are installed.
- F. DC-rated circuit breaker in each battery cabinet to allow multiple battery strings to be serviced independently of each other; ensuring backup power is always available to the UPS. Circuit breaker features UVR trip auxiliaries for system EPO and UPS sensing of battery breaker.
- G. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. UPS Manufacture OEM models.
  - 2. C&D Technologies, Inc.
  - 3. EnerSys.
  - 4. Northstar Battery.

## 2.9 MAINTENANCE BYPASS/ISOLATION SWITCH

- A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.
  - 1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
  - 2. Switch shall electrically isolate other UPS components to permit safe servicing.
- B. Comply with NEMA PB 2 and UL 891.
- C. Switch Rating: Continuous duty at rated full UPS load current.
- D. Mounting Provisions: Matching system cabinet.
- E. Key interlock requires unlocking maintenance bypass/isolation switch before switching from normal position with key that is released only when the UPS is bypassed by the static bypass transfer switch. Lock is designed specifically for mechanical and electrical component interlocking.

## 2.10 CONTROLS AND INDICATIONS

- A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.
- B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.
- C. Indications: Plain-language messages on a digital LCD. (***edit list for project requirements***)
  - 1. Quantitative indications shall include the following:
    - a. Input voltage, each phase, line to line.
    - b. Input current, each phase, line to line.

- c. Bypass input voltage, each phase, line to line.
  - d. Bypass input frequency.
  - e. System output voltage, each phase, line to line.
  - f. System output current, each phase.
  - g. System output frequency.
  - h. DC bus voltage.
  - i. Battery current and direction (charge/discharge).
  - j. Elapsed time discharging battery.
  - k. Time remaining on discharge.
2. Basic status condition indications shall include the following:
    - a. Normal operation.
    - b. Load-on bypass.
    - c. Load-on battery.
    - d. Inverter off.
    - e. Alarm condition.
3. Alarm indications shall include the following:
    - a. Bypass AC input overvoltage or undervoltage.
    - b. Bypass AC input overfrequency or underfrequency.
    - c. Bypass AC input and inverter out of synchronization.
    - d. Bypass AC input wrong-phase rotation.
    - e. Bypass AC input single-phase condition.
    - f. Battery system alarm.
    - g. Control power failure.
    - h. Fan failure.
    - i. UPS overload.
    - j. Battery-charging control faulty.
    - k. Input overvoltage or undervoltage.
    - l. Input circuit breaker tripped.
    - m. Input wrong-phase rotation.
    - n. Approaching end of battery operation.
    - o. Battery undervoltage shutdown.
    - p. Maximum battery voltage.
    - q. Inverter fuse blown.
    - r. Inverter inductor overtemperature.
    - s. Inverter overtemperature.
    - t. Inverter output overvoltage or undervoltage.
    - u. UPS overload shutdown.
    - v. Inverter output contactor open.
    - w. Inverter current limit.
4. Controls shall include the following:
    - a. Inverter on-off.
    - b. UPS start.
    - c. Battery test.
    - d. Alarm silence/reset.
    - e. Output-voltage adjustment.
- D. Dry-form "C" contacts shall be available for remote indication of the following conditions:



1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

#### 2.11 MONITORING/CONTROL BY REMOTE COMPUTER

- A. Coordinate remote monitoring and control communication module package with the University's SCADA network for successful transmission and remote readout of monitoring data and UPS Control. Connect remote monitoring communication module to the University's SCADA network through appropriate network interface unit. The manufacturer shall wire between all communications capable devices within the equipment, including electronic meters with the same protocol and wire to a set of easily accessible terminal blocks.
- B. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" paragraphs. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:
  1. SCADA interface units for data transmission via Modbus TCP/IP.

#### 2.12 EMERGENCY MODULE OFF

- A. Emergency-Power-Off Switch: Capable of local operation by means of activation by red pushbutton under protective cover on UPS module control panel.
- B. Provisions for a remote emergency power off function by means of activation by external dry contacts which completely removes power from the critical bus.

#### 2.13 MAINTENANCE BYPASS/ISOLATION SWITCH CABINET

- A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.
  1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
  2. Switch shall electrically isolate other UPS components to permit safe servicing.
- B. Switch Rating: Continuous duty at rated full UPS load current.
- C. Mounting Provisions:
  1. Matching cabinet for right or left side location as required with factory integrated interlocking scheme.
  2. Wall mounted or free-standing enclosures as required with key interlocks and a solenoid key release unit or OEM provided equivalent as approved by the University.
- D. Bypass Interlock requirements: Interlock scheme shall insure proper user operation of the systems without the risk of damage or load loss.

2.14 BATTERY MONITORING

- A. BASIC BATTERY MONITORING: Subject to compliance with requirements, the UPS shall contain a battery management system which has the following features:
1. The battery management system shall provide battery time remaining while operating in normal mode and battery mode. Battery time available information shall be displayed real-time, even under changing load conditions. Upon commissioning, battery runtime information shall be available.
  2. The battery management system shall automatically test the battery system to ensure that the battery is capable of providing greater than 80% of its rated capacity. Testing the batteries shall not jeopardize the operation of the critical load. Upon detection of the battery string(s) not capable of providing 80%, the UPS system will alarm that the battery needs attention/replacement. The battery test shall be able to detect the following:
    - a. Open battery string
    - b. Shorted battery string (current limit)
    - c. Battery capacity (runtime) less than 80% of "new" battery capacity
- B. COMPREHENSIVE BATTERY MONITORING: For external stationary battery plants, optional per/cell Battery Monitoring shall be available. Per/Cell battery monitoring will track and trend key performance metrics for each battery that includes the following:
1. Cell voltage.
  2. Cell Ohmic value (impedance).
  3. Cell terminal temperature.
  4. Optional ambient temperature.
  5. Optional string discharge current.
- C. Battery Monitoring shall be wired and shall provide a web or client based user interface to configure and review systems settings, alerts, and reports through the SCADA network. Storage and management options shall be available that allow all installed systems to be managed from a single account.

2.15 SOURCE QUALITY CONTROL

- A. Factory test complete UPS system before shipment. Use simulated battery testing. Include the following:
1. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
  2. Full-load test.
  3. Transient-load response test.
  4. Overload test.
  5. Power failure test.
- B. Report test results.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Equipment Mounting: Examine UPS system before installation. Reject equipment that is moisture damaged or physically damaged. Examine elements and surfaces to receive UPS for compliance with installation tolerances and other conditions affecting performance of the Work. Comply with requirements for installation as specified by supplier.
- B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- C. Connections: Interconnect system components. Make connections to supply and load all circuits according to manufacturer's wiring diagrams unless otherwise indicated.
- D. Grounding Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 – 250 requirements.
- E. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- G. Identify components and wiring according to Division 26 Section "Identification for Electrical Systems."

3.2 CONNECTIONS

- A. Provide all communications wiring between remote metering and communication modules and the University's SCADA system. Verify that each UPS address for microprocessor-communication packages corresponds to SCADA network requirements

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
  - 1. Manufacturer's Field Service: Engage a factory employed service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
  - 1. Comply with manufacturer's written instructions.
  - 2. Inspect interiors of enclosures, including the following:
    - a. Integrity of mechanical and electrical connections.
    - b. Component type and labeling verification.
    - c. Ratings of installed components.
  - 3. Test manual and automatic operational features and system protective and alarm functions.

4. Test communication of status and alarms to remote monitoring equipment.
5. OPTIONAL Provide load bank to be used during system startup by Manufacturer to verify the following:
  - a. Transfer to and from bypass.
  - b. Transfer to and from battery power.
  - c. Operation of inverter with load for a minimum of 30 minutes.
  - d. Verification of battery discharge. Record results.

C. The UPS system startup will be considered completed and accepted until the UPS passes all tests and inspections. Warranty term will begin following successful factory startup completion.

D. Record of Start up Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of start up tests, inspections, and retests.

E. Prepare start up test and inspection reports, submit to NU Electric Shop.

#### 3.4 DEMONSTRATION

- A. Engage a factory-authorized representative to train the University's maintenance personnel to adjust, operate, and maintain the UPS. Provide eight (8) hours of classroom and hands-on training.

**END OF SECTION 26 3353**