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**SECTION 16282****UNINTERRUPTED POWER SUPPLY (UPS) 3-PHASE****TABLE OF CONTENTS**

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## **PART 1 GENERAL**

### **1.1 INTENT**

- .1 This Section 16282 describes the requirements for the design, fabrication, inspection, testing, delivery, and installation, testing and commissioning of Uninterrupted Power Supply (UPS) for major loads.

### **1.2 RELATED REQUIREMENTS**

- .1 Contract Drawings including Single Line Diagrams (SLD) and Control Schematic Drawings.
- .2 Division 1 – Start-up and Commissioning
- .3 Division 1 – Demonstration and Training
- .4 Division 1 – Operation and Maintenance Materials
- .5 Division 1 – Close-out documents (Record documents)
- .6 Section 16010 – Electrical General Requirements.
- .7 Section 16050 – Basic electrical materials and methods.
- .8 Refer to all other Divisions of the Specifications and these documents to determine their effect upon the work of this section.
- .9 All sections of Divisions 1 to 16 inclusive form part of the Contract Documents. Refer to Section 16010 for general electrical requirements related to this work.

### **1.3 REFERENCES**

- .1 Refer to the latest edition of the following standards
- .2 CSA International
  - .1 CAN/CSA-C813.1, Performance Test Method for Uninterruptible Power Supplies.
- .3 National Electrical Manufacturers Association (NEMA)
- .4 Ontario Electrical Safety Code (OESC), including Electrical Safety Authority (ESA) amendments and published bulletins.

### **1.4 SUBMITTALS**

- .1 Submit in accordance with Section Division 1 - Submittal Requirement.
- .2 The equipment supplier/manufacture shall provide a "specification compliance report" for the equipment. The report shall provide details which demonstrate that all the clauses of

the specification, and contract drawings requirements are met. In case there is any deviation(s) then it shall be mentioned in the "specification compliance report", and it shall be reviewed by the Consultant.

- .3 Product Data: include information as follows:
  - .1 Catalogue information.
  - .2 Shipping weight.
  - .3 Schematic diagram showing interconnection of rectifier, inverter, battery, bypass switch, meters, controls and indicating lamps.
  - .4 Description of system operation, referenced to schematic diagram, for:
    - a. Manual control during initial start-up and load transfer to bypass and back to inverter output.
    - b. Inverter.
    - c. Bypass.
  - .5 Estimate with supporting data for Mean Time to Repair factor (MTTR).
  - .6 Full load kVA output at 0.8 % lagging power factor.
  - .7 Efficiency of system at 25%, 50%, 75% and 100% rated load.
  - .8 Type of ventilation: natural or forced.
  - .9 Battery:
    - a. Number of batteries/cells.
    - b. Maximum and minimum voltages.
    - c. Type of battery.
    - d. Type of plates.
    - e. Catalogue data with battery/cell trade name and type.
    - f. Size and weight of each battery/cell.
    - g. Battery charge and discharge curves of voltage, current, time and capacity.
    - h. Derating factor for specified temperature range.
    - i. Nominal ampere hour capacity of each battery/cell

- j. Maximum short circuit current.
  - k. Maximum charging current expected for fully discharged condition.
  - l. Recommended low voltage limit for fully discharged condition.
  - m. Expected life.
- .10 Inverter:
- a. Type and catalogue number.
  - b. DC current at minimum battery voltage to produce full load AC output.
- .11 Rectifier:
- a. Type and capacity, with catalogue number.
  - b. Battery charging sequence.
  - c. Current-time data for Silicon Controlled Rectifier (SCR) protective devices.
  - d. Guaranteed noise level.
  - e. Estimated life.
  - f. Metering.
  - g. Alarms.
- .12 Minimum five (5) years manufacturer's field experience with UPS of similar ratings including engineering expertise, manufacturing facilities and listing of UPS units manufactured and installed during last 5 years including model, customer, location and installation dates.
- .13 Approved for use in Canada, having CSA, ULC label.
- .14 Heat losses at no load, 25%, 50%, 75% and 100% of rated output, in kW.
- .15 Cooling air required in m<sup>3</sup>/s.
- .16 List of recommended spare parts, tools and instruments with catalogue numbers and current prices.
- .17 Typical operation and maintenance manual.
- .18 Description of factory test facilities.
- .19 Manufacturer's maintenance capabilities including:

- a. Willingness to undertake maintenance contract.
  - b. Number of trained personnel available.
  - c. Location of trained personnel and repair facilities.
- .20 Manufacturer's written installation recommendations.
- .4 Shop Drawings:
  - .1 Submit shop drawings in accordance with Division 1 – Submittal Requirements and Section 16010 – General Electrical Requirements.
  - .2 Submit drawings stamped and signed by professional engineer registered or licensed in Province of Ontario, Canada.
  - .3 Submit electronic shop drawings and product data to the Consultant. Include an electronic copy of all shop drawings with each submission.
  - .4 Include outline schematics showing arrangement of cubicles, meters, controls, recommended aisle spaces, battery rack, battery arrangement and dimensions.
- .5 Operation and Maintenance Manual:
  - .1 Submit Operation and Maintenance (O&M) Manual in accordance with Division 1 requirements.
  - .2 Operation and Maintenance Data: submit operation and maintenance data for uninterruptible power systems (UPS) for incorporation into manual.
  - .3 Operation and Maintenance Manual to include:
    - a. Operation and maintenance instructions concerning design elements, construction features, component functions. Detailed instructions to permit effective operation, maintenance and repair
    - b. Technical data:
      - (a) Approved shop drawings. Schematic diagram of components, controls and relays
      - (b) Characteristic curves for automatic circuit breakers and protective devices.
      - (c) Project data.
      - (d) Technical description of components. Illustrated parts lists with parts catalogue numbers.
      - (e) Certified copy of factory test results

(f) Parts lists with names and addresses of suppliers.

.6 Maintenance Materials: Submit maintenance materials

.1 4 sets of each type and size of fuses used.

.2 4 sets indicating lamps.

#### 1.5 PROTECTION OF SYSTEMS

.1 Circuit breakers in system used to isolate it from load and from mains for safe working on equipment, and for manual blocking of bypass automatic control to prevent inadvertent operation of bypass during Work on inverter.

.2 Automatic circuit breakers and protection included in:

.1 AC input to rectifier.

.2 Battery input.

.3 Bypass circuit input.

.4 Inverter output.

.3 Surge suppressors:

.1 To protect system against supply voltage switching transients.

.2 To protect internal circuits where necessary against voltage transients.

.4 Current limiting devices, with panel front indication of device operation, to protect inverter SCR's.

.5 Suitable devices, with panel front indication of device operation, to protect rectifier diodes.

.6 Failure of circuit or component not to cause equipment to operate in dangerous or uncontrolled mode.

#### 1.6 QUALITY ASSURANCE

.1 Submit for approval records, indicating and recording instruments calibration certificates, including meters installed as part of system, in accordance with Division 1 - Submittal Procedures.

#### 1.7 CSA COMPLIANCE

.1 Product manufactured shall conform to CSA Standards and have applied CSA or equivalent approved listing mark recognized by the Electrical Safety Authority (ESA).

## 1.8 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 1 requirements and manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements: Crating:
  - .1 Adequately enclosed and protected from weather and shipping damage by use of minimum 12 mm plywood with vapour barrier inside.
  - .2 For rail or sea shipment use double layer of vapour barrier and 19 mm plywood covering.
  - .3 Subassemblies may be packed separately.
  - .4 Label crates:
    - a. Shipping address.
    - b. Weight and dimensions.
    - c. Serial number of unit and brief description of contents.
    - d. Stencilled with durable paint on at least two sides of each crate.
  - .5 List of contents:
    - a. In weatherproof envelope stapled on outside of each crate.
    - b. Copy placed inside each crate.
  - .6 Store materials off ground and protected from exposure to harmful weather conditions and at temperature conditions recommended by manufacturer.

## 1.9 WARRANTY

- .1 For the work of this Section 16282 Uninterruptible Power Systems (UPS) and its batteries the warranty period is 24 months from the date of commissioning of the equipment/ Certificate of Substantial Performance. Refer to Division 1 for detailed requirements.

## PART 2 PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

- .1 Eaton 93PM (Base design)
- .2 Schneider Galaxy VS

- .3 Vertiv Libert APM2

## 2.2 SYSTEM DESCRIPTION

- .1 Two (2) independent 80kVA/kW UPS systems,
- .2 Each UPS system to have single Input 600VAC, 3P/3W, Output 600VAC, 3P/4W. Li-Ion Batteries c/w Battery Monitoring System, around 20 minutes backup time at full load, External maintenance by-pass c/w input and output isolation transformers, (1) network card and (2) relay cards for monitoring and control.
- .3 Each UPS system to include UPS cabinet, Battery cabinet, and Maintenance By-Pass/transformer cabinet, front access only, max allowed overall footprint of 3 cabinets total to be 82"W x 42"D to fit into existing UPS room.
- .4 System to consist of:
  - .1 Input, Output Cubicle.
  - .2 Rectifier, Invertor, Battery Cubicle.
  - .3 Bypass/Isolate Switch
  - .4 Controls and meters.
  - .5 Li-Ion Batteries
  - .6 Transformers
- .5 Ensure system uses normal power supply mains and battery to provide continuous, regulated AC power to isolated load. Refer to the contract drawings for voltage, current, Hz, KVA ratings.
- .6 Equipment: capable of operating continuously and unattended.
- .7 Ensure that Uninterruptible Power Systems (UPS) is compatible with equipment that it feeds and with source from which it is fed.
- .8 UPS Supplier shall provide all the required batteries, its support, and battery cabinet(s).
- .9 The equipment shall meet the Seismic requirements for Water and Wastewater facilities. The equipment and major components shall be suitable for and certified by Seismic testing to meet all applicable Seismic requirements of the latest Ontario Building Code. The manufacturer shall provide anchor bolts of sufficient size and number adequate for the seismic conditions.

## 2.3 PERFORMANCE

- .1 Normal operation:



- .1 System operates on mains power when mains voltage is within +/-[10] % of nominal value and mains frequency is between 59.5 and 60.5 Hz.
- .2 System performance and reliability:
  - a. Consider any deviation from the required output power waveform as failure in UPS.
  - b. Submit estimate, with supporting calculations, of Mean Time Between Failures (MTBF) expressed in hours.
- .2 Battery operation:
  - .1 System transfers automatically to battery operation.
    - a. When manually selected at control panel.
    - b. When mains power fails.
    - c. When mains voltage varies more than 10 % from nominal or mains frequency varies more than 0.5 Hz from 60 Hz.
    - d. When mains power is restored and mains voltage is within 10 % of nominal and mains frequency is within 0.3 Hz of 60 Hz, system automatically resynchronizes with mains;
    - e. Slew rate of frequency during transition period of system output automatically synchronizing with mains and return to its internal frequency to be set between 0.5 to 1.0 Hz per second.
  - .3 Internal Static Bypass operation:
    - .1 Ensure system can be bypassed for maintenance purposes, automatically by manual selection at control panel to connect load directly to AC mains. Transfer without load interruption and leaving inverter energized.
    - .2 Load transfer from mains back to system automatically by manual selection at control panel when maintenance completed.
    - .3 Automatic transfer of load to mains in not more than 1/4 cycle including sensing with inverter left energized but disconnected from load in case of:
      - a. Inverter overloaded.
      - b. Short circuit in load.
    - .4 Automatic retransfer of load to system without load interruption when above conditions disappear.
    - .5 Automatic transfer of load to mains in not more than 1/4 cycle including sensing and shutdown of inverter in case of inverter internal malfunctions.

- .6 Automatic transfer of load to mains without load interruption and inverter shutdown in case of:
  - a. Over temperature harmful to system.
  - b. Loss of forced ventilation.
  - c. Low voltage of DC supply to inverter.
- .7 Bypass capable of closing onto and withstanding momentary fault current of 800% of rating for 0.01 s.

## 2.4 UNINTERRUPTIBLE POWER SYSTEM

- .1 Refer to the contract drawings for voltage, current, Hz, KVA ratings of UPS and its loads.
- .2 Input power:
  - .1 Refer to the contract drawings for voltage, current, Hz, KVA ratings of UPS Normal supply from AC mains.
  - .2 Emergency supply from other AC mains.
- .3 Output power:
  - .1 Refer to the contract drawings for voltage, current, Hz, KVA ratings of UPS
  - .2 Overload capability: 125% of rated full load current at [0.8] power factor and rated voltage for 10 minutes.
  - .3 Frequency - nominal 60 Hz:
    - a. Adjustable from 58.5 to 61.5 Hz.
    - b. Maximum variation from set value under load changes, including transients, 0.3 Hz maximum.
    - c. Drift from set value - after two months normal operation within ambient temperature range of 0 degrees to 40 degrees C, not to exceed 0.6 Hz.
  - .4 Duration of full load output after mains failure not less than 30 minutes
  - .5 Output voltage control:
    - a. Continuously adjustable on load at least 5% from rated value.
    - b. Voltage regulation: voltage not to change by more than 2% as load increases gradually from zero to 100%, or for specified duration of full load after mains failure.

- c. Transient voltage change not to exceed +/-10% of rated voltage upon 50% sudden load change, loss or return of AC input voltage to system when fully loaded or transfer of full load from inverter to bypass and vice versa, and return to normal within 3 Hz.
- d. Harmonics over entire load range:
  - (a) Total RMS value not to exceed 5% RMS value of total output voltage.
  - (b) Single harmonic not to exceed 3% of total output voltage.
- e. Proper angular phase relation maintained within 4 electrical degrees at up to 20% load unbalance.
- .6 Efficiency: Overall system efficiency at rated load with battery fully charged not less than 75 %.
- .7 Interference suppression:
  - a. If UPS equipment generates electromagnetic rf interference at levels which adversely affects other equipment in vicinity, install suppression circuits or shielding as required to eliminate such interference.
  - b. If harmonics reflected back to mains from rectifier adversely affect other loads connected to same bus, install suppression circuits to prevent that condition.

## 2.5 ELECTRICAL REQUIREMENTS

- .1 In accordance with Section 16010 – Electrical general requirements.
- .2 Bring out test points to protected coded pin jacks at convenient locations to permit testing without hazard, including:
  - .1 Inverter output ahead of output switch, 3 phase.
  - .2 Mains power 3 phase.
  - .3 Voltage across each SCR.
  - .4 Points requiring monitoring for on-site alignment, for determination of faulty sub-assemblies or printed circuit cards, including indication of oscillator pulse and operation of voltage control.
- .3 No battery other than main battery incorporated in design.
- .4 Wires number tagged or colour coded with same designation on drawings. Tags: non deteriorating type.
- .5 Variable resistors: fine adjustment, rheostat type.

- .6 Phasing marked on input and output terminals, viewed from front of equipment:
  - .1 Left to right.
  - .2 Top to bottom.
  - .3 Front to back.
- .7 Indicator lamps: long life LED, Push-to-Test type.
- .8 Solid state circuits used where more reliable than mechanical timers or control relays.
- .9 Standard components available from commercial sources used throughout, with 10 years minimum shelf life.
- .10 Arrangement to permit easy removal of defective components to facilitate servicing, by replacing with stock spares.
- .11 Small components, related to specific function, removable plug-in modular sub-assembly or printed circuit card.
- .12 Heavy sub-assemblies easily accessible, or slide on runners of anti-friction material, and have flexible leads and bolted connections.
- .13 Components and sub-assemblies accurately made for interchangeability.

## 2.6 ENCLOSURE

- .1 Dead front free standing sheet steel 2.5 mm (Gauge 12) minimum thick, CSA Enclosure 1.
- .2 Access from front only.
- .3 Meters, indicating lamps (LED Type) and controls group mounted in panel front.
- .4 Panel front enclosed by hinged doors to prevent tampering and to protect instruments and controls during shipping.
  - .1 Doors formed wrap-around type, rigid, to open and close smoothly, locking type handle with minimum 2 keys.
  - .2 Hinges to permit doors to be lifted off cubicle.
- .5 Cubicle height: 1.8 m maximum.
- .6 External cable connections at top of cubicle through bolted plate for drilling at site to suit.
- .7 Ambient temperature range during operation -20 degrees C to +40 degrees C. Natural or forced ventilation as required.

- .1 For forced ventilation power from inverter output and fan directly driven by single phase motor mounted on vibration isolators.
- .2 Each enclosure to have redundant fans, with fan failures alarmed. Air inlet and outlet openings protected with screens and metal guards.
- .8 Disposable air filters on fan cooled enclosures. Method of attachment and opening locations to make removal convenient and safe.
- .9 Maximum operating sound level not to exceed 80 db(A) as measured on sound level meter with A weighting and slow response, at distance of 1.8 m.
- .10 Enclosure frames interconnected by ground bus with ground lug for connection to ground.

## 2.7 RECTIFIER

- .1 Input power supply from:
  - .1 AC mains.
- .2 Input disconnect: bolt-on moulded case single/double/three pole air circuit breaker, quick make, quick break type for manual or automatic operation, temperature compensated for 40 degrees C ambient, magnetic instantaneous trip element.
- .3 Isolating transformer: connected between AC input and rectifier input.
- .4 Surge suppressor: to protect equipment from supply voltage switching transients.
- .5 Rectifier:
  - .1 Silicon controlled rectifier assembly or sealed silicon diodes.
- .6 Filter: for rectifier DC output.
- .7 Fuse: to protect DC output.
- .8 Meters:
  - .1 DC voltmeter, switchboard type, accuracy +/-2% of full scale, to measure rectifier output voltage.
  - .2 DC ammeter, switchboard type, accuracy +/-2% of full scale, to measure rectifier output current.
- .9 Adjustments and controls:
  - .1 Line voltage adjusting taps to allow for +/-10% variation from nominal.
  - .2 Manual adjustment of float voltage with range of +/-5%.

- .3 Manual adjustment of equalizing voltage.
- .4 Automatic current limiting on rectifier adjustable between 80 and 120% of normal rating.
- .5 Provision to disconnect rectifier from inverter and battery if rectifier dc output exceeds safe voltage limits of battery.
- .10 Metres, adjustments and controls to be grouped on front panel.
- .11 Performance of rectifier:
  - .1 Automatically maintain battery in fully charged state while mains power available, and maintain DC float voltage within +/-1% of setting, no load to full load, during mains voltage variations up to +/-10%.
  - .2 Battery charging rate such that after battery has provided full load power output for specified duration, charger returns battery to 95% of fully charged state in 4 hours.
  - .3 Automatic equalize charging circuit to initiate equalize charging of battery for 24 hours after discharge of 5% of ampere hour battery rating.
  - .4 Manually initiated equalize charging feature with automatic timer adjustable from 0 to 24 hours to return unit to float charge.

## 2.8 INVERTER

- .1 Input power supply from:
  - .1 Rectifier DC output.
  - .2 Battery DC output.
- .2 Input disconnect: bolt-on moulded case, single pole, circuit breaker, quick make, quick break type, for manual or automatic operation, temperature compensated for 40 degrees C ambient, magnetic instantaneous trip element.
- .3 Input filter: with separately fused computer grade capacitor banks and indicator lights, to eliminate inverter source noise and restrictions on input cable length.
- .4 Power stage: high frequency switching type, dual cooled disc type silicon controlled rectifier (SCR). Components, solid state devices capable of satisfactory operation under ambient conditions of -35 degrees C to +55 degrees C.
- .5 Logic module:
  - .1 Integrated circuit logic.
  - .2 Silicon semiconductors.

- .3 Plug-in modules.
- .4 Plug-in connector.
- .5 Front accessible field adjustments for voltage and frequency.
- .6 Front accessible test points: suitably protected coded pin jacks.
- .7 Frequency reference module.
- .8 Current limiting module, automatic high speed by controlled reduction of output voltage.
- .9 Voltage regulator.
- .6 Output filter: output of high frequency switching stage contains elements of carrier frequency which are filtered to low harmonic sine wave.
- .7 Meters:
  - .1 AC voltmeter: switchboard type, accuracy +/-2% of full scale, to measure inverter output voltage with 7 position selector switch to select phase to neutral, phase to phase, off.
  - .2 AC ammeter: switchboard type, accuracy +/-2% of full scale, to measure inverter output current with 4 position selector switch to select each phase and off.
  - .3 Wattmeter: switchboard type, accuracy +/-2% of full scale to measure inverter load.
  - .4 Frequency meter: switchboard type, scale 58 to 62 Hz, pointer type, to measure inverter output frequency.
  - .5 Synchroscope: with switch to check inverter output potential against supply mains potential.
- .8 Output disconnect: bolt-on, moulded case, [single] [two] [three] pole circuit breaker, quick make, quick break type, for manual or automatic operation, temperature compensated for 40 degrees C ambient, magnetic instantaneous trip element.
- .9 Meters and controls: grouped on front panel.

## 2.9 BATTERY

- .1 The UPS battery shall be of modular construction. Each battery module shall be monitored for voltage and temperature for use by the UPS battery diagnostic, and temperature compensated charger circuitry.
- .2 The battery within each removable battery module shall be of the Li-Ion type.

- .3 The UPS shall incorporate a battery management system to continuously monitor the health of each removable battery module. This system shall notify the Owner in the event that a failed or weak battery module is found.

#### 2.10 STATIC BYPASS SWITCH

- .1 Two solid state closed circuit automatic transfer switches.
- .2 Logic unit with three normal source voltage sensors, which monitor overvoltage under-voltage and loss of voltage.
- .3 High speed automatic transfer from normal voltage to alternate source when:
  - .1 Normal source voltage lost: transfer time and sensing 1/4 cycle;
  - .2 Normal source: under-voltage at 90% of nominal value; adjustable.
  - .3 Normal source: over voltage at 110% of nominal value.
  - .4 Loss of normal source static switch continuity.
  - .5 Short circuit on normal trips normal source breaker.
- .4 Return to normal source:
  - .1 When normal source remains within return voltage limits of 95% to 110% of nominal value (adjustable) for approximately 1 s timing interval, circuit checks voltage balance and phase synchronization, then initiates return with zero switching time.
- .5 Switch position lights and contacts.
- .6 Synchronizing verification light.
- .7 Manual reset pushbutton.
- .8 Transfer test switch.
- .9 Alternate power source monitor light.
- .10 All the indication lights to be LED, Push-to-Test type.
- .11 Accessories:
  - .1 Manual bypass switch for maintenance and testing without load disturbance.
  - .2 Continuity monitor: automatic transfer to alternate source in event of static switch discontinuity.
  - .3 Alternate power source loss alarm contacts.



## 2.11 MAINTENANCE BYPASS

- .1 The maintenance bypass shall provide power to the critical load from the bypass source, during times where maintenance or service of the UPS is required. The maintenance bypass shall provide a mechanical means of complete isolation of the UPS from the critical output distribution.
- .2 As a minimum, the maintenance bypass shall contain the following features and accessories:
  - .1 Appropriately rated switches to fully isolate the UPS during times where maintenance is required. As a part of this design there shall be a UPS input switch designated as Q1, a UPS output fused switch designated as Q2, and a wrap-around maintenance bypass switch designated as Q3. Minimum 1A/1B auxiliary contacts for the purpose of relaying status information of each switch actuator to the UPS shall be provided, along with a means of locking out the switches to inhibit operation of the bypass transfer pair. The bypass shall be available for a 208 volt input.
  - .2 The bypass shall have a full length hinged front door, with locking mechanism; to allow access to the switches.
  - .3 The bypass shall bear a full mimic diagram inside the hinged front door. Also associated with the mimic panel shall be indicating lights, capable of depicting proper operation of maintenance bypass circuit breaker and UPS output circuit breaker.

.4 XXXX

## 2.12 SOFTWARE AND CONNECTIVITY

- .1 Network adaptor: The Network Management Card shall allow one or more network management systems (NMS) to monitor and manage the UPS in TCP/IP network environments. The management information base (MIB) shall be provided in DOS and UNIX "tar" formats. The SNMP interface adaptor shall be connected to the UPS via Ethernet Port.
- .2 Unattended shutdown: The UPS, in conjunction with a network interface card, shall be capable of gracefully shutting down one or more operating systems.

## 2.13 REMOTE SYSTEM MONITORING

- .1 The following three methods of remote UPS monitoring shall be available:
  - .1 Web monitoring: Remote monitoring shall be available via a web browser such as Internet Explorer.
  - .2 RS-232 monitoring: Remote UPS monitoring shall be possible via either RS-232 or contact closure signals from the UPS.

- .3 Simple Network Management Protocol (SNMP): Remote UPS monitoring shall be possible through a standard MIB II compliant platform.
- .2 Provide UPS input power monitoring for process control for each UPS
  - .1 Dry contact module (Relay Card) in UPS for process control
  - .2 Conduits and cables as required
  - .3 Programming to have "UPS Power Failure" dry contact output to existing process control system (Filter Valve Control)
- .3 Provide SCADA remote monitoring for each UPS
  - .1 Dry contact module (Relay Card) in UPS for SCADA system
  - .2 Conduits and cables as required
  - .3 Programming to have 5 monitoring points into existing plant SCADA system RPU/PLC

Example of UPS SCADA monitoring c/w location and tag info

EXAMPLE:

<i>FHO-Plant-Wide UPS Status - Other</i>					
UPS Location	UPS IN ALARM	UPS OK	UPS ON BATTERY	UPS ON BYPASS	UPS LOW BATTERY
Plant UPS FHO-ELS-UPS-0001					

- 1. UPS IN ALARM
- 2. UPS OK
- 3. UPS ON BATTERY
- 4. UPS ON BYPASS
- 5. UPS LOW BATTERY

## 2.14 FABRICATION

- .1 Shop assemble:
  - .1 Rectifier & Inverter unit.
  - .2 Bypass switch and transformer unit.
  - .3 Battery rack and battery.
- .2 Interconnect units, and add remote alarms and controls to produce complete uninterruptible power system before Consultant to witness factory tests.

## 2.15 FINISHES

- .1 Apply finishes in accordance with Section 16010 General Electrical requirements.

## 2.16 EQUIPMENT IDENTIFICATION

- .1 Identify equipment in accordance with Section 13040 Toronto Water tagging standard.
- .2 For major components such as AC input breaker, inverter breakers, bypass switch: size 5 nameplates.
- .3 For mode lights, alarms, meters: size 3 nameplates.

## 2.17 SOURCE QUALITY CONTROL

- .1 Complete system including rectifier, inverter, bypass switch, controls and battery factory tested in presence of Consultant and/or owner representative.
- .2 Notify the Consultant:
  - .1 Three weeks in advance of date of factory test.
  - .2 That system has had preliminary testing and has met design requirements satisfactorily.
- .3 Test procedures:
  - .1 Prepare blank forms and check sheet with spaces for recording data.
  - .2 Mark check sheet and record test data on forms in duplicate as test proceeds. Attach meter recordings.
  - .3 Collect Consultant's signature on form to indicate concurrence in results reported.
  - .4 Deliver duplicate of test results Consultant at end of test.
  - .5 Include information from original test as part of Operations and Maintenance Manual.
- .4 Test equipment:
  - .1 Instruments used during test, including indicating meters installed as part of system to have recent calibration certificate.
  - .2 Dummy load for testing, adjustable to 150% of system rated output at [0.8] power factor lagging. Load on each phase adjustable from zero to 100% so that unbalanced output maybe tested for 3 phase systems.
- .5 Tests:
  - .1 Visual inspection to determine:
    - a. Materials, workmanship, and assembly conform with design requirements.

- b. Parts are new and free of defects.
- c. Battery and components are not damaged.
- d. Battery cells are of identical construction.
- e. Electrolyte in each cell is at manufacturer's recommended full level.
- f. Each battery cell polarity and polarity of connections to inverter are correct.
- g. Proper size fuses are installed.
- h. Metres have suitable range.
- i. Accessories are present.
- j. Portable metres for acceptance tests are suitable and instrument transformers connected correctly.

.2 Demonstrate:

- a. System start-up and shut down.
- b. Operation during mains power failure, recording output during failure and return of mains power, using oscilloscope and camera attachment. Repeat several times.
- c. Adjustable settings.
- d. Record values measured at test points using oscilloscope, digital millimetre, visicorder and camera attachment.
- e. Protective devices and indications function as designed. Record actual settings, and note operation of remote indications and transfer to bypass. Tests to include:
- f. Annunciator lights correct indication.
- g. Overcurrent on inverter output.
- h. Over voltage and under voltage of inverter output.
- i. DC input voltage to inverter too low. Gradually reduce DC input voltage to inverter while delivering full load output and load to transfer automatically to bypass and inverter shut down. Record input and output values.
- j. Simulate over temperature by applying heat to sensor with hot air blower.
- k. Simulate fuse blowing to test indication response.

- l. Simulate fan failure.
  - m. Bypass switch automatic operations. Record with camera/oscilloscope absence of load disturbance during automatic bypass switching.
  - n. Over voltage of rectifier DC output.
- .3 Harmonic test:
  - a. With system fully loaded, one-half loaded, and at no load, determine total harmonic content with harmonic distortion meter at output terminals.
  - b. Determine each harmonic magnitude with harmonic wave analyzer.
  - c. Measure phase to neutral at 0.8 lagging power factor.
- .4 Transients:
  - a. With normal power input, apply full load to system.
  - b. Remove one half load from each phase.
  - c. Reapply one half load instantly.
  - d. Record voltages and currents using camera/oscilloscopes/ visicorder.
- .5 Steady load:
  - a. Switch system onto AC mains, start inverter and connect dummy 0.8 power factor load.
  - b. Operate system, each module at full rated load for 24 hours and at 125% load for 10 minutes in ambient temperature of 40 degrees C.
  - c. Record data at start of test and at half hour intervals thereafter; including:
    - (a) Input frequency.
    - (b) Input voltage each phase.
    - (c) Input current each phase.
    - (d) Input kW.
    - (e) Output voltage phase to phase, phase to neutral.
    - (f) Output current each phase.
    - (g) Output kW.
    - (h) Temperature of ventilating air-in.

- (i) Temperature of ventilating air-out.
  - (j) Temperature at critical zones.
  - (k) DC voltage to inverter.
  - (l) DC current to inverter.
  - (m) Rectifier DC current.
- .6 Varying loads:
  - a. Take one set of readings as above of no load, 25% load, 50% load, 75% load and 125% load.
  - b. Calculate efficiencies of rectifier, inverter, and complete system.
- .7 Unbalanced loads:
  - a. Adjust loads on inverter to full load on two phases, 80% load on third phase.
  - b. Adjust loads on inverter to zero load on two phases, 20% load on third phase.
  - c. For both cases, record phase and line voltages and currents with phase angles to prove that phase relation remains unchanged with unbalanced loads.
- .8 Battery:
  - a. Charge battery to ensure cells fully charged. When voltage reaches steady value at end of charge, record:
    - (a) Ambient temperature.
    - (b) Temperature of each cell.
    - (c) Voltage of each cell.
    - (d) Voltage of battery.
    - (e) Charging current.
  - b. Discharge battery by operating uninterruptible power system with AC mains open, at full rated output for duration quoted in design requirements. Record, at 5 minutes intervals:
    - (a) Voltage of battery.
    - (b) Current.

- (c) Voltage of 10% random cells.
  - (d) Ambient temperature.
  - (e) Battery temperature.
- c. Recharge battery automatically by closing AC mains supply to system for 4 hours period, with dummy load connected. Record at 15 minutes intervals.
  - (a) Battery voltage.
  - (b) Charging current.
  - (c) At start and finish of charge record ambient and battery temperatures.
  - (d) Repeat discharge test and readings to prove battery was at least 95% recharged in 4 hours charge period.
  - (e) Recharge battery.
- .9 Operating sound level:
  - a. Operator to take reading by placing meter in front of him with microphone pointed at right angles to path of travel of generated sound, positioned at height of 1.5 m and distance of 1 m from equipment to be tested.
  - b. Measure sound level during low ambient sound level.

### **PART 3 EXECUTION**

#### **3.1 EXAMINATION**

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for uninterruptible power systems static (UPS) installation in accordance with manufacturer's written instructions.
  - .1 Visually inspect substrate in presence of Consultant.
  - .2 Inform Consultant of unacceptable conditions immediately upon discovery.
  - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from the Consultant.

#### **3.2 INSTALLATION**

- .1 Locate UPS cubicles, battery rack and battery as indicated on the contract drawings. Secure equipment to the floor or base channels with anchor bolts of sufficient size and number adequate for the seismic conditions.

- .2 Assemble and interconnect components to provide complete UPS as specified.
- .3 Connect AC mains to main input terminal.
- .4 Connect UPS output to load.
- .5 Start-up UPS and make preliminary tests to ensure satisfactory performance.

### 3.3 TESTING

- .1 Perform tests in accordance with Division 1 and Division 16 testing requirements.
- .2 Provide:
  - .1 Competent field personnel of the manufacturer to perform test, adjustments and instruction on UPS equipment.
  - .2 Dummy load adjustable to 150% of system rated output.
- .3 Notify Consultant 15 working days in advance of test date.
- .4 Tests:
  - .1 Inspection of cubicles, battery rack and battery.
  - .2 Inspection of electrical connections.
  - .3 Inspection of installation/connection of UPS alarms to PLC of the plant/facility.
  - .4 Demonstration of system start-up and shut-down.
  - .5 Run UPS for minimum period of 4 hours at full rated load to demonstrate proper operation with AC mains input.
  - .6 Discharge battery by operating UPS with AC mains open for specified duration of full load. Record readings of temperature of each cell.
  - .7 Recharge battery automatically with full rated load on UPS for 4 hours and record readings of voltage of each cell.

### 3.4 START-UP AND TRAINING

- .1 Provide training in accordance with Division 1-Training requirements.
- .2 Provide a minimum of two (2) training sessions, each of 4 hours not necessarily on the same day, at the job site determined by the owner.
- .3 Provide factory service engineer:
  - .1 For inspection of the installation and start-up of UPS system, checking, adjusting and testing on site.



- .2 For instruction/training of ten (10) owner's personnel on theory, construction, installation, operation and maintenance of the UPS system:
  - a. After installation and during site testing.
  - b. At factory during shop testing.
- .4 Advise on:
  - .1 Expected failure rate of equipment.
  - .2 Type of expected failures.
  - .3 Estimated time between major overhauls based on 20 year equipment life.
  - .4 Estimated cost of major overhaul based on current costs and excluding travelling expenses.
  - .5 Type and cost of test equipment needed for fault isolating and performing preventive maintenance.

### 3.5 PROTECTION

- .1 Protect installed products and components from damage during construction.
- .2 Repair damage to adjacent materials caused by UPS installation.

### 3.6 CLEANING

- .1 Progress Cleaning: clean in accordance with Division – 1 requirements.
  - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Division – 1 requirements.
- .3 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

### END OF SECTION