METROLINX

Uninterruptible Power Supply Specification

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Amendment Record Sheet

Amendment in Clause No.	Date of Amendment	Description of Changes
Cover Page	March 2023	Removed 'Capital Projects Group' to reflect organizational changes
1.2.3, 1.3.4	March 2023	Added: 'the latest version of' and Updated numbering on Electrical Identification and Nomenclature Specification
1.9.4	March 2023	Added and updated shop drawings package requirements
1.10.4, 2.6.11	March 2023	Updated factory testing requirements and enclosure requirements.
2.11.4, 2.11.5	March 2023	Added output protection requirements
2.13, 2.18, 3.1, 3.2	March 2023	Updated communication requirements, identification requirements, installation requirements and field quality, control and commissioning requirements

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1. GENERAL

1.1. SCOPE OF WORK

1.1.1. Design, labor, products, equipment, tools, supervision, and services necessary for Uninterruptible Power Supply (UPS) Work in accordance with the Contract Documents.

1.2. DESIGN REQUIREMENTS

1.2.1. The equipment furnished and the equipment installation, wiring methods and materials used shall conform to the latest edition of the Ontario Electrical Safety Code, Electrical Safety Authority (ESA) Bulletins and Supplements issued by the Electrical Safety Authority, and the applicable Metrolinx Standards. In case of any conflicts, the more stringent requirement shall apply.

1.2.2. Design equipment and systems to all applicable standards of CSA, ULC, IEEE, ESA.

1.2.3. Design equipment and systems to the latest version of GO DRM.

1.2.4. Design equipment and systems to standards and codes of the latest editions adopted by and enforced by local authorities having jurisdiction (AHJ).

1.2.5. All UPS units shall be designed and manufactured in accordance with CSA C22.2 NO. 107.3 and shall be UL listed.

1.2.6. The UPS shall be designed to consist of a central unit located in the main electrical room which will supply continuous, uninterrupted regulated AC power to critical loads and life safety loads under normal and abnormal conditions, including loss of utility AC power. The system must maintain operations for a minimum of 30 minutes with generator backup or 90 minutes for locations without a generator. The same criteria for systems partial designs for requiring only an inverter or rectifier are to meet the requirements of reliability, monitoring, and control noise and electrical interference.

1.2.7. Appropriate and effective emergency lighting systems and vital emergency egress and computerized life safety systems. UPS shall meet requirements called for by the latest versions of the Ontario electrical safety code, Ontario Building Code. The UPS shall be accordingly certified.

1.2.8. Backup batteries of UPS shall be rated at least 90 minutes without a generator backup power system or 30 minutes with a generator backup power system and as per GO DRM and local AHJ requirements. Connect battery set to DC input of UPS module through its own battery circuit breaker.

1.2.9. UPS power supply shall be provided by generator backup panel if applicable.

1.2.10. The UPS system will be connected to the Building Automation System (BAS) for monitoring and control of critical signals. Refer to BAS specification 25 05 10 for detailed information.

1.2.11. Double Conversion true online UPS configuration shall be provided. Supply AC power to critical loads. Rectifier/charger converting normal AC input power into DC for inverter and for float charging battery.

1.2.12. The UPS shall have an active power factor-corrected IGBT converter/rectifier, capable of maintaining input power factor and input current total harmonic distortion (THDi) within specifications without an additional input filter.

1.2.13. The UPS shall be designed with the modes of operation described in Section 2.3 of this specification.

1.2.14. The UPS shall comply with FCC Rules and Regulations, Part 15, Subclass B, Class A. This compliance is legally required to prevent interference with adjacent equipment. The UPS shall have a label stating FCC compliance. The manufacturer shall provide evidence and test data of compliance upon request.

1.2.15. UPS or battery/flywheel backup system are acceptable if they can meet the design requirements of guaranteed, low maintenance supply of emergency power to a load for the period state above. A UPS differs from an auxiliary or emergency power system or standby generator in that it will provide near-instantaneous protection from input power interruptions, by supplying energy stored in batteries, supercapacitors, or flywheels.

1.3. RELATED WORKS

1.3.1. Section 25 05 10 - Building Automation Systems

1.3.2. Section 26 05 00 - Electrical General Requirements

1.3.3. Section 26 05 21 - Electrical Conductors and Cables

1.3.4. Section 26 05 53 – Electrical Identification and Nomenclature

1.3.5. Section 26 12 16 - Dry Type Transformer

1.3.6. Section 26 28 00 - Circuit Breakers and Fuses

1.3.7. Section 26 28 23 - Disconnect Switches

1.3.8. Section 26 33 33 – Inverter, Rectifier, and Charger Specification

1.4. REFERENCE STANDARDS

1.4.1. Ontario Electrical Safety Code (OESC).

1.4.2. Ontario Building Code (OBC).

1.4.3. Metrolinx Standards, Drawings and Specifications.

1.4.4. GO Design Requirements Manual (DRM).

1.4.5. Metrolinx Electrical Safety Document.

1.4.6. CSA Z462, Workplace Electrical Safety.

1.4.7. CSA C22.2 NO. 107.3 - Uninterruptible Power Systems.

1.4.8. CSA C22.2 No. 107.1, Power Conversion Equipment.

1.4.9. CSA C22.2 No. 107.2, Battery Chargers.

1.4.10. UL Standard 1778, Uninterruptible Power Systems.

1.4.11. IEEE Std 946, Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations.

1.4.12. IEEE Std 446, Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications.

1.4.13. IEEE Std 485, Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications.

1.4.14. IEEE Std 1115, Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications.

1.4.15. IEEE Std 1189, Guide for Selection of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.

1.4.16. IEEE Std 1184, Guide for Batteries for Uninterruptible Power Supply Systems.

1.4.17. IEEE Std 1375, Guide for the Protection of Stationary Battery Systems.

1.4.18. IEEE, C62.41, IEEE recommended Practice on Surge Voltages in Low Voltage AC Power Circuits

1.4.19. IEEE Standard 446-1995, IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications.

1.4.20. NEMA PE-1, Uninterruptible Power Systems (UPS) – Specification and Performance Verification.

1.4.21. NEMA PE 5, Utility Type Battery Chargers.

1.4.22. NEMA PE 7, Communications Type Battery Chargers.

1.4.23. EN 62040-1:2008 Uninterruptible power systems (UPS) – Part 1: General and safety requirements for UPS.

1.4.24. EN 62040-2:2006 Uninterruptible power systems (UPS) – Part 2: Electromagnetic compatibility (EMC) requirements.

1.4.25. EN 62040-3:2011 Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements.

1.4.26. EN 62040-4:2013 Uninterruptible power systems (UPS) - Part 4: Environmental aspects - Requirements and reporting.

1.5. SPARE PARTS

1.5.1. Manufacture to provide stock list of recommended spare parts and quantity of each item.

1.6. TRAINING

1.6.1. Operation Training

a) Allow for minimum of 2 hours of total on-site time to train in all aspects of equipment and system(s) operation(s), per group to be trained.

b) Maximum duration of each training session: 8 hours.

c) Provide training for Metrolinx maintenance personnel to a depth that troubleshooting and maintenance can be carried out by Metrolinx.

1.6.2. Training is to be specific to equipment, model number, and version installed. Provide material for each participant and include record drawings and comprehensive operating and maintenance manual for equipment installed.

1.6.3. Maintenance Training

a) The training course shall cover theory, location of subassemblies, safety, battery considerations and operational procedures. The course shall include AC to DC conversion and DC to AC inversion techniques as well as control, metering, and feedback circuits to the Printed Circuit Board (PCB) level. Troubleshooting and fault isolation using alarm information and internal self-diagnostics should be stressed.

b) Train Metrolinx personnel, including training on UPS system components, operations, safety, and troubleshooting

1.7. WARRANTY

1.7.1. The contractor shall provide a manufacturer warranty for the work of this section with a minimum warranty period of two years after acceptance by Metrolinx. Warranty shall include the following:

a) Twenty-four hours per day, seven days per week emergency service coverage, all parts and labor included. Service response time of four hours onto site shall be required; and

b) Minimum two preventative service visits each year of the warranty period.

1.7.2. The contractor shall provide a manufacturer battery warranty for the work of this section with a minimum warranty period of three year full and seven year pro-rated under full float operation (totaling ten years). In the case of Lithium-Ion batteries, a full ten year warranty under full float operation shall be provided without pro-rating.

1.8. DELIVERY, STORAGE AND HANDLING

1.8.1. Contractor to protect equipment from damage, weather and moisture in accordance with manufacturer's instructions.

1.9. SUBMITTALS

1.9.1. Submittals shall include:

a) System configuration with single-line diagrams;

b) Functional relationship of equipment including weights, dimensions, required clearances for heat dissipation;

c) Descriptions of equipment to be furnished, including deviations from these Specifications;

d) Size and weight of shipping units to be handled by installing Contractor;

e) Detailed layouts of customer power and control connections; and

f) Detailed installation drawings including all terminal locations.

1.9.2. UPS Delivery Submittals

a) Submittals upon UPS delivery shall include a complete set of submittal drawings and one (1) set of instruction manuals that shall include a functional description of the equipment with block diagrams, safety precautions, instructions, step-by-step operating procedures and routine maintenance guidelines, including illustrations.

1.9.3. Product Data Package

a) Submit manufacturer's Product data indicating:

1) Technical data, supplemented by bulletins, component illustrations, detailed views, technical descriptions of items, and parts lists;

2) Performance criteria, compliance with appropriate reference standards, characteristics, limitations, and troubleshooting protocol;

3) Product transportation, storage, handling, and installation requirements;

4) Functional relationship of equipment including weights, dimensions, and heat dissipation;

5) Descriptions of equipment to be furnished, including deviations from these Specifications;

6) Computer link capabilities of system;

7) Centralized management and control configuration schematic and specifications;

8) Remote alarm panel annunciator or monitor screen; and

9) One instruction manual to include functional description of equipment with block diagrams, safety precautions, instructions, step-by-step operating procedures and routine maintenance guidelines, including illustrations.

1.9.4. Shop Drawings Package

a) Submit manufacturer’s Shop Drawings indicating:

1) Single-line diagrams including instrument transformers, meters and other devices;

2) General arrangement drawings. Indicate dimensions, weight, loads, required clearances, components and size of each field connection;

3) Detailed schematic diagrams;

4) Detailed layouts of customer power and control connections;

5) Detailed installation drawings including all terminal locations;

6) Plans, elevations, sections and mounting attachment details; and

7) Show access, workspace and clearance requirements. Show details of control panels and battery arrangement.

1.9.5. Commissioning Package

a) Submit the following:

1) Commissioning Plan;

2) Commissioning Procedures; and

3) Certificate of Readiness.

1.9.6. Closeout Submittals Package

a) Submit the following for incorporation into the Operation and Maintenance Manuals:

1) Complete set of reviewed Shop Drawings of equipment. Submit 6 hard copies and 1 soft copy in AutoCAD (.dwg, .dxf, .dwf formats) of As Built Drawings;

2) Complete bills of materials and spare parts showing manufacturer's names, addresses, local replacement sources and telephone numbers;

3) Stock list of recommended spare parts and quantity of each item;

4) Manufacturer's warranties;

5) Manufacturer's certified reports;

6) Installation instructions;

7) Appropriate servicing, trouble shooting and preventative maintenance schedule and instructions for equipment and systems. Equipment and components performance curves;

8) Field testing and commissioning reports;

9) Factory test reports;

10) Details of design elements, construction features, component function and maintenance requirements, to permit effective start-up, operation, maintenance, repair, modification, extension and expansion of portion or feature of installation; and

11) Final ESA and/or local Hydro Certificates.

1.10. QUALITY ASSURANCE

1.10.1. Coordination

a) Submit start-up testing report for Metrolinx review before scheduling commissioning testing.

1.10.2. Regulatory requirements

a) All electrical items shall be approved by CSA and/or ULC

1.10.3. Manufacturer Qualifications

a) A minimum of twenty years' experience in the design, manufacture, and testing of solid-state UPS systems is required. The manufacturer shall be ISO 9001 certified.

1.10.4. Factory Testing

a) Before shipment, the contractor shall ensure that the manufacturer shall fully and completely test the system to assure compliance with the Specification upon leaving the factory.

b) A load test shall be performed on each UPS supplied. This test shall be conducted at full rated load without failure, for minimum of 4 hours. After the 4-hour period, retest UPS system to verify compliance with UPS system design performance requirements.

c) Battery discharge and recharge tests shall be performed to ensure guaranteed rated performance.

d) Metrolinx or its designated representative(s)) shall witness factory acceptance testing, Manufacturer to provide all testing details to Metrolinx prior to testing and certified testing results after the tests have been completed.

e) Metrolinx or its designated representative(s) shall witness site acceptance testing as part of on-site commissioning. Contractor, commissioning agent and Manufacturer to provide all testing details to Metrolinx prior to testing for approval. Certified commissioning reports and testing results shall be provided after the tests have been completed. A certified copy of the test results shall be available for each system as indicated on the order.

2. PRODUCTS

2.1. ENVIRONMENTAL

2.1.1. The UPS shall be able to withstand the following environmental conditions without damage or degradation of operating characteristics:

a) Altitude: 1000 m (AMSL);

b) Relative humidity: 0 to 95% non-condensing; and

c) Operating Ambient Temperature:

1) UPS: 0°C to 40°C; and

2) Battery: 25°C ±3°C.

2.1.2. The UPS shall be able to withstand the following environmental conditions during storage or transport without damage or degradation of operating characteristics:

a) Altitude: 15,000 m (AMSL); and

b) Ambient Temperature: -20°C to 70°C.

2.2. RATINGS AND PERFORMANCE REQUIREMENTS

2.2.1. Table 2-1 lists the UPS minimum parameters that shall be met.

Table 2-1: UPS Performance Parameters

Parameter	Minimum Requirement	Notes
Battery Backup Duration	30 minutes with generator backup or 90 minutes for sites without generator backup	Time shall be met under full rated load condition.
Battery Recharge Time	To 95% capacity within ten (10) times discharge time.	
Battery Design Life	Minimum 10 years	Battery performance must be met at the end of the battery design life.
UPS Dimension Constraints	(Update Per Project)	
Output Capacity	UPSs shall be sized for the known loads plus an additional 50% spare capacity for future.	Values shall be measured in power units (W) at unity load power factor.

Parameter	Minimum Requirement	Notes
Short Circuit Withstand Rating (SCWR)	65,000 A (Update Per Project)	The withstand rating shall be independently verified by a nationally recognized, third-party lab.
Load Power Factor	Full output for 0.5 lagging to 1.0. Derated output for 0.5 leading to 1.0	
Nominal Input Voltage	600 V (three-phase three-wire plus ground) or 208 V (three-phase four-wire plus ground) or 120 V single phase (grounded)	Same value applies to both UPS input and External Bypass input.
Input Voltage Range	+10% to -15%	
Nominal Output Voltage	600 V or 208 V (three-phase four-wire plus ground) or 120V single phase (grounded)	Same value applies to both UPS output and External Bypass output.
Output Voltage Regulation	±1% RMS average for a balanced, three-phase load ±2% RMS average for 100% unbalanced load for line-to-line imbalances	
Output Voltage Transients (average of all three phases)	±3% of nominal for 100% step load changes. ±1% of nominal for loss or return of AC input power. ±1% of nominal for manual transfer at full load.	
Output Voltage Recovery	Return to 1% of nominal within 16.7 ms	
Output Voltage Distortion	Maximum 2% THD for 100% non-linear load.	

Parameter	Minimum Requirement	Notes
Output Voltage Adjustment Range	±5%	For line drop compensation adjustable manually at UPS.
Nominal Input Frequency	60 Hz	
Input Frequency Range	45 to 65 Hz	
Nominal Output Frequency	60 Hz	
Output Frequency Regulation	Synchronized to bypass with ±0.1 Hz	
Output Frequency slew rate.	0.1 Hz to 1 Hz/second, selectable in 0.1 Hz increments	
Total harmonic distribution on input current (THDi)	<5%	Using double-conversion mode.
UPS efficiency	>93% at 25-100% load without use of static bypass mode.	Defined as output kW/input kW Using double-conversion mode at rated lagging load power factor.
Input Power Factor	0.9 lagging minimum	At nominal input voltage and rated load.
Input current Ramp up	Feld selectable, 5 to 20 seconds to ramp from zero load to full load after input voltage applied.	
Input current limit	125% of nominal full load current.	
Maximum Input Current Inrush	150% of nominal full load current	
Reliability MTBF	>150,000	Mean-Time-Between-Failure (MTBF) for UPS including bypass switches
Audible noise	<65 dB A at 1m from UPS cabinet	
Output Phase shift regulation:	±1% for balanced loads. ±2% for 100% unbalanced loads.	

Parameter	Minimum Requirement	Notes
UPS Overload	125% of full load for 1 minutes 150% of full load for 5 seconds >150% of full load for 200 ms	At full output voltage with ±1% voltage regulation Beyond 200 ms the static bypass shall be utilised.

2.3. MODES OF OPERATION

2.3.1. The UPS shall operate in the following modes:

a) Normal: The critical AC load shall be continuously powered by the UPS inverter. The rectifier/charger shall derive power from the utility AC source and supply DC power to the DC-DC converter, which in turn shall supply the inverter while simultaneously float charging the battery;

b) Battery: Upon failure of utility AC power, the critical load shall be powered by the inverter, which, without any switching, shall obtain its power from the battery plant. There shall be no interruption in power to the critical load upon failure or restoration of the utility AC source;

c) Recharge: Upon restoration of the utility AC source, the rectifier shall supply power to the output inverter and to the DC-DC converter, which shall simultaneously recharge the batteries. This shall be an automatic function and shall cause no interruption to the critical load;

d) Static Bypass: If static bypass switch senses overload or inverter fault, it automatically transfers critical loads to bypass AC source. The transfer process shall cause no interruption in power to the critical load;

e) External Maintenance Bypass: If the UPS must be taken out of service, the external maintenance bypass switch shall transfer the load to the external bypass source. The transfer process shall cause no interruption in power to the critical load; and

f) Off-Battery: If the battery only is taken out of service, it shall be disconnected using the battery circuit breaker. The UPS shall continue to function and meet all the specified steady-state performance criteria, except for the power outage backup time capability. If multiple battery strings are used, each string shall be capable of being electrically isolated for safety during maintenance.

2.4. GROUNDING

2.4.1. UPS chassis to have equipment ground bar for connection to external panels (source/load).

2.4.2. The AC output neutral shall be electrically isolated from UPS chassis/ground.

2.5. MATERIALS

2.5.1. All materials of the UPS of current manufacture, high grade and shall not have been in prior service except as required during factory testing. All active electronic devices shall be solid-state. All power semiconductors shall be sealed. Control logic and fuses shall be physically isolated from power train components to ensure operator safety and protection from heat.

2.6. ENCLOSURE/S

2.6.1. The UPS shall be in NEMA Type 1 enclosure/s for indoor use.

2.6.2. The enclosure/s shall be freestanding and floor mounted.

2.6.3. The enclosure/s shall be accessed from the front through hinged doors for servicing, adjustments and connections. Access doors shall require a special tool (supplied) to open.

2.6.4. The enclosure/s shall be sprinkler-proof for use in rooms protected by water sprinkler fire protection systems.

2.6.5. The enclosure/s shall be structurally adequate and have provisions for hoisting, jacking and forklift handling.

2.6.6. The enclosure/s height shall not exceed be 2.0 m. Mounting height for user controls or other interfaces shall not be greater than 1.6 m above floor level.

2.6.7. The enclosure/s shall be cleaned, primed, and painted with manufacturer's standard color and paint method.

2.6.8. The enclosure/s shall include casters and levelling feet.

2.6.9. The enclosure/s shall be split into sections 1.625 m long maximum to facilitate shipping and handling.

2.6.10. The enclosure/s shall include physically isolated compartments for components:

a) Input isolation transformer;

b) Static transfer switch;

c) External bypass switch;

d) Rectifier/charger;

e) Inverter;

f) Battery;

g) UPS Controller; and

h) External cable/wiring terminations.

2.6.11. UPS shall be constructed of replaceable subassemblies with replacement parts available from a supplier located within a 4-hour driving radius of the location of the UPS unit.

2.6.12. The enclosure/s shall be suitable for both top and bottom cable entry.

2.6.13. The enclosure/s shall include air inlets equipped with standard type filters, changeable without the need of shutdown.

2.6.14. No service clearance or ventilation shall be required at rear of UPS.

2.7. BYPASS SWITCHES

2.7.1. Two bypass switches shall be provided:

a) The static bypass switch (internal bypass) provides the functionality of transferring the UPS load from the inverter to the static bypass without interruption; and

b) The external maintenance bypass switch provides the functionality of completely bypassing the UPS for replacement and maintenance purposes. Load transfer shall not require interruption.

2.7.2. The static bypass switch shall include an overcurrent protection device to protect the static bypass switch from the bypass utility source.

2.7.3. The static bypass switch shall be rated for continuous duty operation at full rated load for highest reliability without the use of mechanical devices as used with a momentary rated device.

2.7.4. The static bypass switch shall be rated to continuously carry 125% of UPS rated output current for 10 minutes, 150% for one minute and 6000% for minimum of one cycle (0.016 sec.).

2.7.5. In the event of a load current inrush or branch load circuit fault in excess of the inverter rating, the bypass static switch shall engage, connecting the alternate AC source to the load. This shall allow up to 1000% of the nominal rated current to flow for up to 600 ms. Output voltage shall be sustained to the extent the alternate AC source capacity permits. If the overload condition is removed before the end of the 600 ms period, the bypass static switch shall turn off and the load shall remain on inverter power. If the overload remains beyond 600 ms, then a transfer to the alternate AC source is to be completed.

2.7.6. As required by CSA and UL1778 static transfer switch shall not back-feed UPS power to the bypass distribution system while the UPS is operating on battery during a bypass power outage. The purpose of this requirement is to prevent the risk of electrical shock on the distribution system when the normal source of power is disconnected or has failed. If a shorted SCR is detected, the static transfer switch shall be isolated by an internal automatic circuit breaker and an alarm message shall be annunciated at the UPS control panel. The load shall remain on conditioned and protected power after detection of a shorted SCR and isolation of the bypass static switch.

2.7.7. The external maintenance bypass switch shall be connected to a separate AC power supply.

2.7.8. The external maintenance bypass switch shall be in a separate enclosure.

2.7.9. The external maintenance bypass switch shall completely isolate the UPS using interlocked circuit breakers to permit the entire UPS system to be electrically isolated from the alternate AC power supply.

2.8. WIRING

2.8.1. Wiring practices, materials and coding in accordance with requirements of the OESC.

2.8.2. All bolted connections of bus bars, lugs, and cables in accordance with requirements of the OESC and other applicable standards.

2.8.3. All electrical power connections shall be torqued to required value and marked with visual indicator.

2.8.4. UPS assemblies shall be of modular plug-in construction or bolted/screwed lug construction to facilitate assembly replacement without requiring soldering iron or special tools.

2.8.5. The UPS shall utilize high-reliability wiring and connectors.

2.8.6. Neutral output to be sized for 200% of rated current.

2.8.7. Field wiring/cable connections shall be made in dedicated termination compartments and shall provide for wiring gutter and wire bend radius as defined by the OESC.

2.8.8. All field wiring power connections shall be to tin-plated copper busbars for connection integrity. Busbars shall have adequate space to allow two-hole, long-barrel, compression type lugs forming a permanent connection between field wiring and field-installed lugs.

2.8.9. Battery cells mounted on slide-out trays with Anderson connectors for ease of maintenance.

2.9. COOLING

2.9.1. Adequate forced-air cooling shall be provided to ensure that all components are operated well within temperature ratings.

2.9.2. UPS shall include a redundant forced air fan cooling system to prevent failure of one fan from exceeding temperature limits of UPS.

2.9.3. Cooling fans shall be low velocity type to minimize audible noise output.

2.9.4. Cooling fans shall be powered by the UPS output.

2.9.5. Temperature sensors shall be provided to monitor the UPS internal temperatures. Temperature sensors shall co-ordinate with the UPS protective devices to take active to reduce temperatures before excessive component or internal cabinet temperatures occur.

2.10. SURGE PROTECTION

2.10.1. The UPS shall have built-in protection against surges, sags and overcurrent from the AC source. The protection shall meet the requirements of IEEE C62.41 A3 and B3 including:

a) 6kV, 100kHZ ring wave, line-to-line, line-to-neutral, line-to-ground and neutral-to-ground; and

b) 6kV, combined wave, line-to-line, line-to-neutral, line-to-ground and neutral-to-ground.

2.11. OUTPUT PROTECTION

2.11.1. The UPS shall be protected against sudden changes in output load and short circuits at the output terminals.

2.11.2. The UPS shall have built-in protection against permanent damage to itself and the connected load for all predictable types of malfunctions. Fast-acting, current-limiting devices shall be used to protect against cascading failure of solid-state devices.

2.11.3. Internal UPS malfunctions shall cause the module to trip off-line with minimum damage to the module and provide maximum information to maintenance personnel regarding the reason for tripping off-line. The load shall be automatically transferred to the bypass line uninterrupted for an internal UPS malfunction.

2.11.4. Malfunctions shall be alarmed and logged by the Building Automation System (BAS). Refer to BAS Metrolinx Specification 25 05 10 for further details.

2.11.5. The status of protective devices shall be indicated by the BAS and on a graphic display screen on the front of the unit.

2.12. CONTROL PANEL

2.12.1. The UPS shall be provided with a microprocessor-based control panel for operator interface to configure and monitor the UPS. The control panel shall be located on the front of the unit where it can be operated without opening the hinged front door. No mechanical push buttons shall be used for the control panel. A physical key shall be required to turn on the control panel. A backlit, menu-driven, full-graphics, color touch screen liquid crystal display shall be used to:

a) show system information and UPS status;

b) show metering information;

c) display UPS one-line diagram;

d) show active events;

e) show event history;

f) reset faults;

g) acknowledge alarms; and

h) enter parameter values.

2.12.2. UPS system logic and control programming shall reside in a microprocessor-based control system with non-volatile flash memory.

2.12.3. Metered values shall be displayed on the control panel in real time. All three phases of three-phase parameters shall be displayed simultaneously. All voltage and current parameters shall be monitored using true RMS measurements for accuracy to ±3% of voltage, ±5% AC current. Metered values shall include:

a) Input voltage, line-to-line;

b) Input current per phase;

c) Input frequency;

d) Input apparent power (kVA);

e) Battery voltage;

f) Battery charging/discharging current;

g) Output voltage, line-to-line;

h) Output frequency;

i) Bypass input voltage, line-to-line;

j) Bypass input frequency;

k) Load current;

l) Load real power (kW), total and percentage;

m) Load apparent power (kVA), total and percentage;

n) Load percentage of capacity;

o) Load power factor;

p) Battery temperature, each battery string;

q) Battery state of charge;

r) Inlet air temperature; and

s) Component temperatures.

2.12.4. Power Flow shall be displayed on the control panel in real time. A UPS one-line diagram shall graphically depict whether the load is being supplied from the inverter, bypass or battery and shall provide, on the same screen, the status of the main switching components (breakers, fuses and disconnect switches).

2.12.5. Event History. This menu item shall display the list of events that have occurred recently while the UPS was in operation. The Event history shall store up to 2048 events, with the oldest events being overwritten first if the log's capacity is reached.

2.12.6. The system information shall include a battery summary screen which shall display DC alarm conditions, temperature, battery state of charge, the present battery voltage, total discharge time, status of last battery test and battery time remaining during discharge.

2.12.7. The following UPS status items shall be displayed:

a) Rectifier (Off / Soft Start / Main Input On / Battery Input On);

b) Input Supply (Normal Mode / Battery Mode / All Off);

c) Battery Self-Test (True / False);

d) Input Disconnect (Open / Closed);

e) Charger (On / Off);

f) Output Disconnect (Open / Closed);

g) Maintenance Disconnect (Open / Closed);

h) Bypass Disconnect (Open / Closed);

i) Inverter (Off / Soft Start / On);

j) Bypass synchronization (Normal / Unable to Trace / Abnormal);

k) Output Supply (All Off / Bypass Mode / Inverter Mode / Output Disable); and

l) Inverter (On / Off).

2.12.8. The UPS shall provide the operator with controls to perform the following functions:

a) Start Inverter (and transfer to inverter);

b) Stop Inverter (after transferring to bypass);

c) Startup Screen;

d) System Settings (Time, Date, Language, LCD Brightness, Password, Audio Level);

e) Alarm Silence Command;

f) Fault Reset Command;

g) Configure and manage manual battery test;

h) Modify test duration and minimum voltage;

i) Start battery test;

j) Monitor test status and progression; and

k) Stop battery test.

2.12.9. The following alarm messages shall be displayed. The UPS shall provide a clearly visual and audible alarms to draw attention to the alarm. The alarms shall also be available via the communications interface and BAS.

a) Mains Voltage Abnormal;

b) Mains Undervoltage;

c) Mains Freq. Abnormal;

d) Charger Fault;

e) Battery Reversed;

f) No Battery;

g) Parallel Comm. Fail;

h) Bypass Unable-to-Track;

i) Bypass Abnormal;

j) Inverter Asynchronous;

k) Fan Fault;

l) Control Power Fail;

m) Unit Over Load;

n) System Over Load;

o) Bypass Phase Reversed;

p) Transfer Time-Out;

q) Load Sharing Fault;

r) Bypass Over Current; and

s) Component over-temperature.

2.13. COMMUNICATIONS

2.13.1. Communication shall be achieved by dry contacts and by digital communications.

2.13.2. The UPS shall be equipped with a digital communication card providing Web-based UPS monitoring and management capabilities and at least two of the following third-party open protocols:

a) SNMP protocols (v1, v2, v3);

b) Modbus RTU or Modbus TCP; or

c) BACnet MSTP or BACnet IP.

2.13.3. Web-based software shall be provided by the Manufacturer.

2.13.4. The UPS will be connected to the Building Automation System (BAS) via the communication card and shall provide status, monitoring and control to the BAS.

2.13.5. Dry contact outputs shall be provided for the following items. Contacts shall be 2-pole normally open and normally closed per item and suitable for connection to the CHUBB security system.

a) Summary Alarm (General alarm);

b) Bypass Active;

c) Low Battery; and

d) AC Input Failure.

2.13.6. External contacts shall be isolated from the UPS control system by relays or optical isolation.

2.13.7. The UPS shall have four discrete input contacts available for the input and display of customer-provided alarms or to initiate a pre-assigned UPS operation. Each input can be signaled by an isolated, external, normally open contact. The alarms and pre-assigned UPS operations include:

a) On Generator. Provides selectable choices to enable or disable battery charging and enable or disable ECO Mode operation while on generator;

b) Transfer to Bypass. Manual command to transfer from inverter operation to static bypass operation;

c) Fast Power Off. Emergency Module Off (EPO) command to stop UPS operation completely without requiring any other additional steps;

d) Acknowledge Fault. Acknowledge a UPS alarm condition and present faults will be reset;

e) Bypass/Inverter Off. Emergency Power Off (EPO) command to stop UPS operation completely without requiring any other additional steps; and

f) External Maintenance Bypass Breaker (MBB) status (open or closed).

2.14. BATTERY

2.14.1. The battery power pack shall consist of batteries and a properly rated disconnect circuit breaker for isolating the battery pack from the UPS. The batteries and disconnect circuit breaker shall be installed and housed in a separate NEMA-1 enclosure, matching the UPS enclosure style and design.

2.14.2. Battery to be lead-calcium, sealed, valve-regulated type, or Lithium-ion type, or Nickel-Cadmium type.

2.14.3. Provide UPS with controls to trip DC battery breaker(s) from control panel

2.14.4. Battery cells shall be mounted on slide-out trays with Anderson connectors for ease of maintenance. The battery design shall be such that disconnection of the battery cell shall not put equipment or personnel safety at risk of damage or injury.

2.14.5. Battery disconnect circuit breaker with undervoltage release (UVR) to be included for isolation of battery pack from UPS module.

2.14.6. Provide casters and leveling feet with battery power pack cabinet for ease of installation.

2.15. FLYWHEEL ENERGY STORAGE SUBSYSTEM

2.15.1. Ride-through energy for the UPS System shall be supplied by a flywheel energy storage (FES) module in the Multi Module Unit that stores energy in the inertia of a rotating mass. The energy shall be immediately accessible to support the critical load without interruption.

2.15.2. The FES shall be a fully integrated device in which the motor, generator, and flywheel energy storage functions are performed by one brushless rotating machine composed of a single rotor and a single stator. The rotor shall be forged from a single piece of 4340 steel and shall have no coils or permanent magnets.

2.15.3. The rotor and stator shall be contained in a single evacuated housing and shall have a vertical shaft orientation.

2.15.4. When in normal operation, at least 75 percent of the FES rotor weight shall be supported by magnetic suspension provided by field coils mounted inside the FES housing.

2.15.5. The field coils and stator windings shall be cast coil type using vacuum impregnation techniques for encapsulation.

2.15.6. The flywheel rotor shall have a plastic yield strength of at least 2.5 times the peak Mises stress resulting from the rated operating speed. Each rotor shall undergo ultrasonic and magnetic particle inspection. The complete FES shall be type-tested to withstand the following fault conditions and copies of the test results shall be available:

a) Sudden loss of vacuum;

b) AC short-circuits;

c) DC short-circuits;

d) Catastrophic bearing failure; and

e) Over speed testing to 120% of rated speed.

2.15.7. Bi-Directional Converters

a) The FES shall be charged and discharged using an AC-to-AC Bi-Directional Convertors (BDC). The BDC shall be composed of two Pulse Width Modulated (PWM) AC-to-DC, and four quadrant converters configured in a back-to-back arrangement.

b) Each AC-DC converter shall use three-phase full wave PWM conversion techniques utilizing three insulated-gate bipolar transistor (IGBT) converter stages. All stages in each AC-DC converter shall be identical and interchangeable and shall have built-in short-circuit and overload protection.

c) Failure or over temperature of the converters shall be monitored and alarmed. A sudden failure of a converter shall not cause the UPS to transfer to bypass if the remaining multi-module power units (MMU) have capacity at least equal to the connected load. If the load exceeds the capacity of the remaining MMUs, the system shall transfer to bypass as required by this Section.

2.16. RECTIFIER

2.16.1. The term rectifier shall denote the solid-state equipment and controls necessary to convert alternating current to regulated direct current to supply the inverter and charge the batteries.

2.16.2. The DC output of the rectifier shall meet the input power demands of the inverter without the battery being connected.

2.16.3. The rectifier shall be designed to meet the requirements of the battery it is to charge.

2.16.4. The rectifier is to be designed to provide the maximum life possible for the battery it is to charge.

2.16.5. The rectifier shall maintain batteries at full charge and also recharge discharged battery to 95% of full capacity within 10 times discharge time of battery. The AC ripple voltage of the rectifier DC shall not exceed 1% RMS of the float voltage.

2.16.6. The rectifier shall Include a pre-selected, elevated-voltage battery recharge after return from failure of normal input AC power.

2.16.7. The rectifier shall actively control and reduce input current harmonic distortion over the full operating range of the UPS without the need for an additional passive input filter.

2.16.8. The rectifier, in conjunction with the other UPS controls and circuitry, shall adjust the current demanded for battery charging as a function of UPS output wattage load and input voltage level.

2.16.9. Battery Equalize Charge. A manually initiated equalize charge feature shall be provided to apply an equalize voltage to the battery. The duration of equalize charge time shall be adjustable from 8 to 30 hours. A method shall be available to deactivate this feature for valve regulated battery systems.

2.16.10. Stop Battery Charging Function. Battery charging may be stopped by a shunt trip of the battery cabinet breaker when overtemperature is sensed in the battery cabinet, on generator or when environmental contact is closed.

2.16.11. Overvoltage Protection. There shall be DC overvoltage protection so that if the DC voltage rises to the pre-set limit, the UPS shall shut down automatically and initiate an uninterrupted load transfer to bypass or shall disconnect the battery via the DC breaker.

2.16.12. Temperature-Compensated Charging. The UPS shall adjust the battery charging voltage based on the battery temperature reported from battery temperature sensors. When multiple sensors are used, the voltage shall be based on the average temperature measured. Excessive difference in the temperature measurements shall be reported and the charging voltage adjusted to protect the batteries from excessive current.

2.16.13. Battery Load Testing. The UPS shall be capable of performing battery load testing under operator supervision. To accomplish this, the rectifier shall reduce charging voltage to force the batteries to carry the load for a brief time. If the curve of battery voltage drop indicates diminished battery capacity, the UPS shall display an alarm message. If the voltage drop indicates battery failure, the UPS shall terminate the test immediately and annunciate the appropriate alarms.

2.17. INVERTER

2.17.1. The term inverter shall denote the equipment and controls to convert direct current from the rectifier or battery to precise alternating current to power the load. The inverter shall be solid-state, capable of providing rated output power and, for increased performance, the inverter shall be a pulse-width-modulated design and shall utilize insulated gate bipolar transistors (IGBTs). To further enhance reliable performance and efficiency, the inverter shall not require an inverter output series static switch/isolator for the purposes of overload or fault isolation or transfers to bypass.

2.17.2. The inverter shall be able to sustain an overload across its output terminals while supplying full rated voltage as shown above in Table 2-1.

2.17.3. The inverter shall be capable of at least 200% current for short-circuit conditions including phase-to-phase, phase-to-ground and three-phase faults. After the fault is removed, the UPS shall return to normal operation without damage. If the short circuit is sustained, the load shall be transferred to the bypass source and the inverter shall disconnect automatically from the critical load bus.

2.17.4. 100% step loads to only use rectifier/charger to supply power to the inverter. Batteries not to be cycled at any time.

2.17.5. The inverter shall track the bypass continuously, providing the bypass source maintains a frequency of 60Hz ±1% (0.6 Hz).

2.17.6. The UPS shall be provided with a means to detect a malfunctioning inverter and isolate it from the critical load bus to prevent disturbance of the critical load voltage beyond the specified limits.

2.17.7. The inverter shall be provided with monitoring and control circuits to protect the battery system from damage due to excessive discharge. Inverter shutdown shall be initiated when the battery voltage has reached the end of discharge voltage. The battery end-of-discharge voltage shall be calculated and automatically adjusted for partial load conditions to allow extended operation without damaging the battery. Automatic shutdown based on discharge time shall not be acceptable.

2.18. IDENTIFICATION

2.18.1. Furnish colour coding in accordance with Metrolinx Electrical Identification and Nomenclature Specification 26 05 53.

2.18.2. Provide identification for equipment and the sub-components in accordance with Metrolinx Electrical Identification and Nomenclature Specification 26 05 53.

2.18.3. Provide nameplates, warning signs and labels as required by the AHJ.

3. EXECUTION

3.1. INSTALLATION

3.1.1. Contractor to provide site service during installation and commissioning of UPS.

3.1.2. Install UPS on a concrete base with minimum 103 mm height.

3.1.3. Maintain minimum clearances and workspace at equipment according to manufacturer's recommendations and Ontario Electrical Safety Code.

3.1.4. Contractor to install UPS as per manufacturer recommendations and requirements.

3.1.5. Contractor to retorque battery cabling and intercell connectors after completion of battery discharge testing as per manufacturer's instruction.

3.1.6. Contractor to supply and install all inter-cabinet wiring as required to form a complete UPS in accordance with this Specification.

3.2. FIELD QUALITY CONTROL AND COMMISSIONING

3.2.1. Contractor to arrange factory trained field service representative from UPS system equipment manufacturer to:

a) Inspect UPS system equipment supplied, and mechanical and electrical connections for integrity and accuracy;

b) Perform start-up site testing of UPS system;

c) Provide manufacturer's service representative to perform testing at no additional cost to Owner;

d) Perform commissioning tests such as full load power test, battery discharge at full load, transfers and retransfers without interruptions and related items in the presence of Owner to verify compliance with UPS system design performance requirements; and

e) Complete on-Site test procedure to check controls and indicators after installation of system equipment.

3.2.2. The following inspections and test procedures shall be performed by factory-trained field service personnel during the UPS start-up.

a) Visual Inspection:

1) Inspect equipment for signs of damage;

2) Verify installation per drawings;

3) Inspect cabinets for foreign objects;

4) Verify neutral and ground conductors are properly sized and configured;

5) Inspect battery cases;

6) Inspect battery for proper polarity; and

7) Verify all printed circuit boards are configured properly.

b) Mechanical Inspection:

1) Check all control wiring connections for tightness;

2) Check all power wiring connections for tightness by calibrated torque-wrench method according to manufacturer's published data or the latest version of NETA ATS; and

3) Check all terminal screws, nuts, and/or spade lugs for tightness.

c) Electrical Inspection:

1) Check all fuses for continuity;

2) Confirm input voltage and phase rotation is correct;

3) Verify control transformer connections are correct for voltages being used; and

4) Assure connection and voltage of the battery string(s).

d) Site testing:

1) Step load testing, 0-50 %, 50-100%;

2) Full load test using load bank, transfer to bypass and retransfer back to inverter;

3) Battery discharge and re-charge; and

4) Confirm operation of all software features located on human machine interface screen.

3.2.3. Site testing

a) Perform 0%, 50% and 100% load test recording input voltage, input current, input current THD, output voltage, output current, output %kW, output %kVA, output frequency.

b) Perform a battery discharge test recording DC voltage and current every minute.

c) Perform 125% overload test and validate transfer to bypass.

d) Validate that system options are functioning.

e) Electrical contractor to supply temporary load bank as required for the duration of testing.

f) Test and demonstrate all functions, controls, indicators, sensors and protective devices. Provide calibrated tools such as meters, wrench, etc. as required. All the features shall conform with the human machine interface and BAS.

g) Perform Emergency power off (EPO) test.

h) Perform thermographic survey according to NETA ATS.

END OF SECTION