PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes
   1. System start-up and commissioning services.
   2. Battery charging.
   3. Load bank testing.
   4. Battery load testing.
   5. Integral system testing.

B. All equipment, including load banks, measuring instruments, cables, connectors, etc. required for the site testing of the complete UPS system installation shall be provided by the UPS manufacturer’s factory authorized firm. The electrical contractor shall assist and coordinate with the UPS manufacturer’s factory authorized firm in the administration and performance of the site testing.

1.2 SUBMITTALS

A. Factory test reports.

B. Field test reports and other documentation including a description of the test procedures and inspections with results listed for each test performed in a type-written format. Include results of tests, inspections and retests.

C. Battery test results including resistance measurements, voltage and temperature readings, specific gravity readings, load values and discharge times and other tests and inspections required in this specification.

D. Infrared scanning reports with pictures printed in a final report with any deficiencies and actions taken to rectify.

1.3 QUALITY ASSURANCE

A. Provide a list of testing equipment with make and model numbers. Test Equipment shall have current calibration validation.

1.4 REFERENCES

A. Section 019100 Commissioning Requirements
PART 2 – PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 START-UP, COMMISSIONING AND INTEGRATED SYSTEM TESTING

A. Commissioning and testing of the UPS system shall be provided by the Owner’s Commissioning Agent. After installation, the UPS supplier shall provide one or more qualified, experienced representatives to assist and supervise start-up commissioning. The Owner shall advise the UPS supplier at least 5 days in advance of the date when such supervisors will be required. Such supervisors shall meet with the Owner and the Owner’s Commissioning Agent prior to system start-up to establish a mutually agreeable schedule for start-up and testing activities. The supervisors shall be assigned to work continuously until successful start-up completion. The Electrical Contractor shall assist and coordinate with the Owner’s Commissioning Agent and the UPS system supplier’s on-site support personnel in the administration and performance of the site testing and commissioning.

B. Commissioning: The UPS supplier shall provide on-site support for the duration of equipment commissioning. A minimum of [fifteen (15)] <number of days> man days for each system shall be included in the Bid. Support shall be dedicated to this project and assigned to work continuously until successful commissioning completion. A man day shall be no more than but up to 12 hours each day, Monday through Friday.

C. Integrated System Testing: The UPS supplier shall provide on-site support for the duration of equipment integrated system testing. A minimum of [fifteen (15)] <number of days> man days for each system shall be included in the Bid. Support shall be dedicated to this project and assigned to work continuously until successful completion of integrated system testing. A man day shall be no more than but up to 12 hours each day, Monday through Friday.

D. System Start-Up:
   1. After completion of the UPS system installation and battery system certification, the following inspections and test procedures, as a minimum, shall be performed by the UPS manufacturer’s Field Engineers.
         1) Compare equipment nameplate data with drawings and specifications.
         2) Inspect equipment for signs of damage incurred during delivery.
         3) Inspect anchorage, alignment, grounding and required clearances.
         4) Verify installation per drawings, including proper termination of all cables.
         5) Inspect cabinets for foreign objects and remove any if present.
         6) Verify phase, neutral and ground conductors are properly sized and configured.
7) Verify date code on batteries to insure batteries have been manufactured within the past 12 months. Return batteries to manufacturer with a date code indicating batteries are older than 12 months.
8) Verify battery racks and cabinets are seismically rated for the geographical location and installed as specified. Verify mounting, anchorage and alignment of battery racks and cabinets.
9) Verify battery support rack and cabinet grounding and clearances.
10) Verify battery systems are clean.
11) Verify and inspect battery spill containment installation.
12) Verify application of oxide inhibitor on battery terminal connections.

b. Mechanical Inspection.
1) Check all control wiring connections for tightness.
2) Check all power wiring connections for tightness.
3) Check all terminal screws, nuts, and/or spade lugs for tightness.
4) Verify filters are in place and vents are clear.
5) Verify battery area ventilation is operable.
6) Verify existence of eyewash equipment as required by drawings.

c. Electrical Inspection.
1) Check all fuses for continuity.
2) Confirm input and bypass voltage and phase rotation is correct.
3) Verify control transformer connections are correct for voltages being used.
4) Assure connection and voltage of the battery string(s).
5) Verify battery electrolyte levels and measure electrolyte specific gravity and temperature where applicable.
6) Verify all alarm indicating lamps and audible devices are operating properly. Record all trip points either by simulation or actual fault condition. Indicate on documented procedure, which faults, were conducted by which means.

3.2 SITE TESTING

A. In general, the UPS system supplier shall be responsible for the performance of all site tests on the UPS system, including batteries, switchgears and disconnecting devices, as required to certify the proper operation of the system as a whole. A recommended site test procedure shall be provided by the UPS system supplier and approved by the Owner or Commissioning Agent. The UPS supplier shall inspect the installation location of the UPS system for the purpose of choosing locations for portable load bank installation. This testing shall be coordinated with the Owner and may occur during normal working hours, overtime or premium time hours.

B. As a minimum, the following site tests are required:
1. Verify that all operating controls, alarms, meters and mimic lights are functioning properly.
2. Verify that all alarms function properly. Record all trip points either by simulation or actual fault condition. Indicate on documented procedure, which faults, were conducted by which means.

3. Verify all switchgear functions including all transfer capabilities.

4. [Conduct tests on air power circuit breakers in accordance with applicable ANSI/IEEE Standards, including but not limited to the following:]
   a. Insulation resistance tests pole-to-pole, pole-to-ground, across open poles and all major insulation components.
   b. Insulation resistance test on control wiring. For units with solid-state components or control devices, that cannot tolerate the applied voltages, follow the manufacturer's recommendations.
   c. Primary current injection tests for breakers outside the UPS equipment. Verify components located in the UPS equipment have been factory tested and provide field testing of breakers as recommended by the manufacturer.
   d. Contact resistance test using a Digital Low Resistance Ohmmeter.
   e. Alignment test with master call to verify interfaces and interchangeability.
   f. Mechanical and electrical operational tests.
   g. Coil check test.

5. Voltage regulation. Record L-L voltage for each module for the system.
   a. Record each module and system output voltage at no load.
   b. Record each module and system output voltage at half rated load.
   c. Record each module and system output voltage at full rate load.
   d. Calculate the voltage regulation as follows:
      e. (NL-L)/NL)x100= % Voltage regulation
      f. NL=No load volts
      g. L = 1/2 of full rated load volts
      h. Verify multi-module systems are sharing the load evenly across all modules per manufacturer's specifications.

6. Transient Tests
   a. A disturbance analyzer capable of capturing subcycle impulses shall be utilized with sufficient channels to monitor three-phase voltage output, single-phase current output, single-phase current input and single-phase voltage input.
   b. Record all system level voltages, current, kW and PF for both, input and output of steady state load steps prior to conducting test.
   c. Example: Step load from 25% to 75%. Record the 25% load setting and the 75% load setting before performing the transient test.
   d. Each transient test listed below shall be recorded and shall meet the following criteria, except when noted otherwise:
      1) Plus 8% or minus 8% with a recovery of 16 milliseconds to within plus or minus one percent of the initial steady state value. These criteria shall be met by each individual transient, measured line-to-line.
      2) The method of measuring a transient is as follows. The steady state voltage envelope prior to the transient measure in millimeters is subtracted from the peak-to-peak transient measure in millimeters. This absolute difference is divided by the steady state voltage envelope and multiplied by 100 to arrive at the percent transient.
e. Module Level Transient Response Tests: (Record operation times)
   1) 0% to 50% to 0% of the full module load.
   2) 25% to 75% to 25% of the full module load.
   3) 50% to 100% to 50% of the full module load.
   4) 75% to 110% to 75% of the full module load.
   5) 0% to 100% to 0% of the full module load.

f. System Level Transient Response Tests: (Record operation times)
   1) 0% to 50% to 0% of the redundant load.
   2) 25% to 75% to 25% of the redundant load.
   3) 50% to 100% to 50% of the redundant load.
   4) 75% to 110% to 75% of the redundant load.
   5) 0% to 100% to 0% of the redundant load.

1. Repeat for the system operating in non-redundant mode.

h. UPS to Bypass Transfer Transients
   1) With the entire system operating at full load, transfer the load from the UPS to the bypass and back to the UPS. Mark operation time.
   2) Repeat the test with the system operating in non-redundant mode.

i. Isolation Transients: With the entire system operating at full redundant load, simulate a blown fuse in one module. Observe the module removing itself from the output bus without affecting the load or the other UPS modules. Verify with disturbance analyzers there was no loss of load. Verify remaining modules share the load. Record transfer times. Simulate a blown fuse in the second module; verify that the system transfers to bypass.

j. Input Fail Transient: This test is to be conducted with a fully charged battery, with all modules on-line and at full rate load. The system output voltage shall be monitored by the light beam recorder.

k. Note that the transients do not exceed the Specification or that the output modulation of each module does not exceed 1% as defined by the formula below:

\[ VM\% = \frac{(Ep_{MAX} - Ep_{MIN}) \times 100}{Ep_{MAX}} \]

EpMAX = Maximum phase voltage (peak-to-peak)

EpMIN = Minimum phase voltage (peak-to-peak)

l. Remove the input power for one minute and then re-energize.

m. Repeat this test a total of three times to demonstrate consistency in performance.

n. Loss of Bypass: Remove the bypass line from the system input for 3 minutes. Reconnect the bypass and record the time until the UPS system synchronizes to the bypass.

7. Heat Run:

   a. Operate the entire system continuously for 8 hours at full reactive load. Load banks and cabling shall be provided by the installing Contractor. For the first four hours operate with all modules on line. Immediately
thereafter, operate the system with each module off sequentially for three hours. Complete the heat run with all modules on line again. Perform step load transfers after heat run.

b. Record the system output voltage, current and frequency on each phase at one-hour time intervals to verify stability of the UPS output. Also monitor and record the room temperature throughout the heat run. Perform an infrared scan of each mechanical connection in the critical path 15 minutes after full load has been reached and every 30 minutes during the testing period. Record pictures of the initial scan and put into a report for future reference.

8. System Battery Tests: The objective of this test is to verify the compatibility of the batteries with the associated UPS system and to verify the full load operation of each module for the reserve time and cutoff voltage specified.

a. Prior to the start of the test, the battery shall be floated at the required voltage for the time specified by the battery UPS supplier. Measure and record the resistance of all inter-cell and inter-tier connections using a Digital Low Resistance Ohmmeter. Measure and record the internal-cell resistance of all cells.

b. Each module shall be tested with a [675kW] <specify load> load that shall be maintained for a minimum of 15 minutes and to a DCUV (DC Under Voltage) trip at the cutoff voltage of 1.67 volts/cell. Test shall be monitored with a battery monitoring system at the cell level. The module output voltage shall be recorded to verify compliance with the steady-state voltage regulation specified.

c. After all modules have been successfully load tested, recharge batteries of system for minimum of 3 hours (to 100% capacity), after which time perform system tests as specified.

d. The test shall be conducted with each UPS module at the specified load. Remove the AC input and record the time and measure and record voltage drop across each battery connection under full load. At thirty second intervals, record the DC voltage and current. Record the time in which the battery discharge related alarm occurs and conduct an infrared scan of the battery installation. Using the waveform recorder running at highest resolution, record the critical load voltage and one phase input current prior to and during the entire input fail. Continue to record without interruption for a minimum of five minutes to demonstrate the input walk-in current and the input current limit. These manual readings are required as well as automated data recording.

e. After successful completion of individual module testing, perform the following system tests at full load using a disturbance analyzer connected across system output.

1) Open utility input breaker, record output voltage and current during input failure when inverter input transfers from rectifier to battery.

2) Close utility input breaker, record output voltage and current during time when inverter input transfer from battery to rectifier.

3) Fail UPS system, critical load transfers to UPS static by-pass utility input, record voltage and current during time, load transfers between inverter output and utility.
4) Re-establish UPS system output, critical load transfers from UPS static bypass to UPS output, record voltage and current during time, load transfers between static switch and inverter output.

f. In order to test the Redundant/Non-redundant system feature, perform following tests with systems of [5 x 750KVA/675 kW operating module systems]] <specify system configuration and edit below>, using a disturbance analyzer connected across system output, record output voltage and current:

1) With a load of [2700 kW], disable one module and [four (4)] remaining modules should power load without going to static bypass.
2) With a load of more than [2700 kW], disable one module, [four (4)] remaining modules cannot support load and load shall transfer to static bypass.
3) With a load of [1350 kW, disable three (3) modules, remaining two (2)] modules should power load without going to static bypass.
4) With a load of [2700 kW], system operates in 'redundant' fashion.

g. The batteries shall be recharged to 95% of full charge within 12 times the discharge time. Record every thirty (30) minutes the input and output voltage, current, kW, pf, frequency and the DC voltage and current until the recharge requirement is met.

h. Upon successful completion of the battery tests and after the batteries have a chance to reach their normal charge and temperature, take a full set of cell voltage readings, specific gravity and cell temperature readings.

i. After completion of discharge testing, re-torque connections varying by more than ±10% of average voltage.

j. After completion of installation and acceptance of system by the Owner, UPS supplier shall certify that installation is complete and in accordance with all of UPS suppliers requirements and the UPS supplier warrantee is in effect.

9. Synchronizing Circuit: The operation of the synchronizing circuits shall be demonstrated during the site acceptance-testing test.

10. Switchgear: UPS parallel output switchgear including all circuit breakers shall be tested as described herein prior to being connected to the UPS System:

a. Inspect for physical damage.

b. Compare equipment nameplate information with latest single line diagram and report discrepancies.

c. Inspect for proper alignment, anchorage and grounding.

d. Check tightness of accessible bolted bus joints by calibrated torque wrench method. Refer to manufacturer’s instructions for proper foot-pound levels.

e. Interlock systems shall be physically tested to ensure proper functions.

1) Closure attempt shall be made on locked open devices. Opening attempt shall be made on locked closed devices.

2) Key exchange shall be made with devices operated in off-normal positions.

f. All doors, panels and sections shall be inspected for paint, dents, scratches and fit.

g. Insulation Resistance Test:
1) Measure insulation resistance of each bus section phase-to-phase and phase-to-ground for one (1) minute.

h. Test Valves:
   1) Insulation resistance test to be performed in accordance with the following:

<table>
<thead>
<tr>
<th>Voltage Rating</th>
<th>Test Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>150-600V</td>
<td>1000V</td>
</tr>
<tr>
<td>601-5000V</td>
<td>2500V</td>
</tr>
<tr>
<td>5001 and above</td>
<td>5000V</td>
</tr>
</tbody>
</table>

2) Values of insulation resistance less than manufacturer’s minimum or 100 megohms should be investigated. Overpotential tests should not proceed until insulation resistance levels are raised to said minimum.

i. Circuit breaker draw-out mechanisms shall be inspected and adjusted as required for proper reliable operation. Each circuit breaker shall be racked in and out at least 5 times. All auxiliary switches shall be tested for proper and reliable operation. Circuit breakers shall be exchanged between cubicle without readjustment to assure a uniform standard of fit and adjustment.

j. Installed circuit breaker options shall be verified against those required by the shop drawings with a report given to the Owner of any deviations.

k. All circuit breakers shall be tested and calibrated by means of primary injection and secondary injection.

l. Circuit breakers shall be exercised at least 10 times to assure consistent mechanical and electrical operation of all functions.

m. Conduct visual and mechanical inspections and electrical testing of switchgear assemblies in accordance with current NET ATS specifications.

C. An integral power system test designed to demonstrate the operation of the UPS system in conjunction with the emergency generators shall also be conducted by the Contractor with the assistance of the UPS supplier. The test shall extend for at least four (4) hours and shall prove the following:
   1. Compatibility between the UPS system and the generators, i.e. harmonics shall not influence voltage regulation and the UPS input filter shall not affect the generators.
   2. Ability of the UPS system to synchronize the generator output.
   3. Ability of the UPS system to transfer the load from UPS system to maintenance bypass and back while on generator power.
   4. Ability of the UPS to limit battery recharge current while on generator power.
   5. Infrared scanning of critical path mechanical connections shall be performed during integral power systems test.

3.3 DEMONSTRATION

A. The UPS supplier shall provide qualified field service personnel as required to supervise the site tests. The UPS supplier’s field service technicians shall provide all special instrumentations, including line disturbance analyzers, oscilloscopes and event recorders, required to perform the tests.
B. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate and maintain the UPS System

END OF SECTION