PART 1 – GENERAL

1.1 DEFINITIONS

1.1.1 Validate: for tests and demonstrations: to witness and validate successful performance demonstration or record deficiencies; to validate after correction successful demonstration; these validations of the tests become references for the Consultant's certification.

1.1.2 Certify: for documents including as-built drawings: Review for accuracy and completeness or record deficiencies.

1.1.3 Witness: the Commissioning Authority will observe as required and record summary of test results.

1.2 REFERENCES

1.2.1 Section 01 91 13 - Facility Commissioning - General

1.2.2 CAN/ULC-S524-06 - Installation of Fire Alarm Systems

1.2.3 CAN/ULC-S537-04 - Verification of Fire Alarm Systems

1.2.4 LEED Canada NC v2009- Green Building Rating System Reference Guide

1.2.5 Canadian Electrical Code - 23rd Edition/2015 (CSA)

1.2.6 National Building Code - Latest edition of National Building Code

1.2.7 NECB 2011 - National Energy Code of Canada for Buildings

1.3 DOCUMENTS

1.3.1 In case of discrepancies or conflicts between the documents, the documents will be governed in the order specified in Division 1.

1.4 COMMISSIONING OBJECTIVES

1.4.1 Objectives of the commissioning process are:

1.4.1.1 to support quality management through monitoring and checking of the installation.

1.4.1.2 to verify system performance through testing, verification and Functional performance testing of the completed installation.

1.4.1.3 to transfer the facility from the Contractor to the Owner in such a manner that provision of a quality facility to the Owner has been assured.

1.4.1.4 to enhance operating and maintenance through delivery of comprehensive quality training and instruction to the Owner's operating personnel.

1.4.1.5 to assure provision of accurate and useful historical records, such as, as-builts drawings, test certificates, etc. to the Owner. Such records provide important data for operating and maintaining the systems as well as for future system testing, maintenance or renovations and to trouble shoot and repair the components of the systems.

1.4.1.6 to extend the commissioning activities into operational phase in order to verify performance levels under a range of operating conditions; such as change of seasons. This process will help to avoid unforeseen or hidden operating and maintenance expenses that may develop later on.

1.4.1.7 monitor the operation, performance and maintenance programs; optimize system's performance under normal operating conditions and partial and full occupancy, under the direction and review of the Commissioning Authority. This phase lasts throughout the warranty period. It may, however, involve activities so as to ensure completion of:

1.4.1.7.1 system debugging and optimization.

1.4.1.7.2 completion of training and instruction for the operating and maintenance personnel.

1.4.1.7.3 completion of all commissioning activities on defective, seasonally-sensitive systems, for varying modes and periodic simulated emergency conditions.

1.4.1.8 The commissioning process shall be considered complete when all of the objectives of the commissioning activities, as specified herein, have been achieved.

1.5 COMMISSIONING MEETINGS SCHEDULING AND REPORTING

1.5.1 Contractor shall include the commissioning plan and shall schedule for all tests and equipment start-up in the construction schedule.

1.5.2 Commissioning meetings shall be scheduled as required. The meetings shall address commissioning related responsibilities as well as all specified testing, documentation, O&M manuals, training, and post construction requirements. The testing schedules and results of all tests shall be reviewed at the meetings.

1.5.3 Where construction may be completed in phases, allow for the frequency of meetings to correspond to the varying stages of construction of each phase.

1.5.4 The Contractor shall attend commissioning meetings at regular intervals, as called by the Commissioning Authority

1.5.5 The Contractor shall schedule work to include specified Commissioning activities. Cooperate with the Owner's Commissioning Authority, and coordinate subtrades as required, to successfully demonstrate and verify commissioning activities.

1.5.6 The Contractor shall schedule work to include specified Commissioning activities prior to Owner's demonstration and Owner's training.

1.5.7 Testing forms and reports associated with the electrical systems shall be directed to the Owner, to the Consultant, and to the Commissioning Authority.

1.5.8 Forms and reports to be issued shall include:

1.5.8.1 shop drawings, issued and accepted.

1.5.8.2 equipment testing and verification forms.

1.5.8.3 testing forms.

1.5.8.4 reports resulting from tests.

1.5.8.5 testing schedule.

1.6 WARRANTY

1.6.1 Involvement of Commissioning Authority shall not void any guarantees or warranties nor shall it relieve Contractor of any contractual responsibilities.

1.7 RESPONSIBILITIES OF COMMISSIONING AUTHORITY

1.7.1 Responsibilities of Commissioning Authority are as follows:

1.7.1.1 Design Phase:

1.7.1.1.1 Participate in design team meetings. Obtain Owner's requirements and Consultant's philosophy and intent and expected system performance. This will form the basics of the testing and commissioning activity documents.

1.7.1.1.2 provide input and feedback to the design team with emphasis on testing, verification, functional performance testing, operation and maintenance of the proposed system and equipment.

1.7.1.1.3 provide commissioning documents to form part of the Bid documents.

1.7.1.2 Bid Phase:

1.7.1.2.1 review Bid documents, design Drawings and specifications.

1.7.1.2.2 provide commissioning related reviews for incorporation in Contract Documents to ensure documents have included all required testing and commissioning requirements.

1.7.1.2.3 provide commissioning related comments for incorporation in Contract Documents.

1.7.1.2.4 participate in Bid review meetings to ensure Bidders are aware of the commissioning requirements.

1.7.1.3 Construction Phase:

1.7.1.3.1 review contractor's approved shop drawing submission for commissioning related issues.

1.7.1.3.2 review Contractor's commissioning plan and schedule to ensure proposed tests, sequences and the methods of tests conform to Contract requirements; ensure ample time is schedule for the commissioning activities.

1.7.1.3.3 monitor, check and inspect installation throughout the construction stages.

1.7.1.3.4 supervise the commissioning activities, including scheduling.

1.7.1.3.5 issue deficiencies reports noting any issues that may have an impact on the commissioning of the equipment and system.

1.7.1.3.6 attend construction site meetings as required to discuss commissioning related items and any impact on the project schedule.

1.7.1.3.7 set-up and chair commissioning meetings.

1.7.1.3.8 witness and validate tests; note deficiencies and issue progress reports.

1.7.1.3.9 work with Project team to expeditiously resolve any problems that may arise due to site conditions.

1.7.1.3.10 prepare Systems Operation Manual.

1.7.1.3.11 coordinate with Consultant training and instructions provided by Contractors, manufacturers and Suppliers.

1.7.1.4 Post-Construction Phase:

1.7.1.4.1 prepare final report on commissioning, identifying any deficiencies that may be outstanding.

1.7.1.4.2 recommendation of any additional training and/or instruction of operating and maintenance personnel deemed necessary over and above that already provided.

1.7.1.4.3 complete system checks with the Contractor.

1.8 RESPONSIBILITIES OF OWNER

1.8.1 Responsibilities of Owner are as follows:

1.8.1.1 to provide operating personnel to attend training and instruction regarding specific components, equipment and systems.

1.8.1.2 to retain the services of independent third parties for system verification and certification as required in the document or by applicable codes.

1.8.1.3 to observe on-site installation, start-up and testing equipment and systems.

1.9 RESPONSIBILITIES OF CONSULTANT

1.9.1 Responsibilities of Consultant are as follows:

1.9.1.1 review Contractor's shop drawings submission to verify general conformance with the contract documents;

1.9.1.2 periodically observe the installation throughout the construction stages to determine that the installation generally conforms to the requirements of the contract documents and issue field observation reports;

1.7.1.5 review operating and maintenance manuals; test reports and as-builts for completeness;

1.7.1.6 witness selected tests; note any deficiencies and provide field observation reports;

1.7.1.7 assist Commissioning Authority and Contractors on any design related issues found during the commissioning process.

1.10 RESPONSIBILITIES OF CONTRACTOR

1.10.1 Responsibilities of the Contractor are as follows:

1.10.1.1 Construction Phase:

1.10.1.1.1 to manage and ensure the entire installation comply with the requirements of the Contract Documents.

1.10.1.1.2 submit shop drawings complete with Contractor's Stamp of Review.

1.10.1.1.3 submit working detail (interference or installation) drawings, as required.

1.10.1.1.4 complete data test forms provided by the Commissioning Authority

1.10.1.1.5 complete University FAMIS New Equipment forms and EQU Stickers, tags, and chains placement for equipment supplied. Each piece of equipment supplied will require completion of an information form, application of a Barcode Sticker to the information form and application of a Barcode Sticker to each piece of equipment.

1.10.1.1.6 submit installation method statement. This generally includes:

1.10.1.1.6.1 method of equipment delivery to the installation location on site.

1.10.1.1.6.2 prerequisite preparation for delivery, such as completion of the factory testing and the completion of site work to accept this equipment.

1.10.1.1.6.3 installation method and sequences of installing the equipment and the associated connections to the equipment.

1.10.1.1.7 submit an installation schedule. This schedule includes:

1.10.1.1.7.1 time schedule of each activity, with lead and lag time allowed and indicated.

1.10.1.1.7.2 shop drawings and working detail drawings submission.

1.10.1.1.7.3 major equipment delivery and factory testing dates.

1.10.1.1.7.4 coordinate installation activities and sequences in compliance with the Construction Manager's Project schedule and other trade's installation schedule.

1.10.1.1.7.5 schedule of commissioning activities for the systems and major equipment.

1.10.1.1.8 submit a commissioning schedule. This schedule includes:

1.10.1.1.8.1 time schedule for system and equipment commissioning activities which are in compliance with the timing and sequences of installation schedule stated above. Including but not limited to 'dry running' functional performance testing such that the formal test can be performed in a timely manner without impacting the overall project schedule or cause delay to Project completion.

1.10.1.1.8.2 dates for completion of required factory tests prior to equipment delivery to the site shall be indicated in the schedule.

1.10.1.1.8.3 prepare and submit commissioning activities record or report forms for review and approval.

1.10.1.1.9 attend progress and commissioning meetings.

1.10.1.1.10 promptly rectify or replace reported deficiencies and defects.

1.10.1.1.11 where required by codes and/or specification, retain manufacturers and/or independent third parties to provide service for testing and certification of the systems and training of Owner's personnel.

1.10.1.1.12 provide training and instruction to the Owner's operating personnel.

1.10.1.1.13 pay for and retain the services of Independent Third Party Testing Agent (ITPTA) and manufacturer as required to perform commissioning activities for equipment and systems to satisfaction of Consultant and Commissioning

Authority as stated in approved schedule and method described above. Commissioning activities will be witnessed by the Commissioning Authority as required. Contractor or his retain agents shall also record procedure and finding in approved test and record forms. Submit test and record forms with the signature of the tester for review and approval to the Consultant and Commissioning Authority.

1.10.1.1.14 pay for and be responsible for all inspections required by codes, specification and Authorities having Jurisdiction. Obtain and submit all Certificate of Approval for such inspections and verifications.

1.10.1.1.15 submit for review as-builts drawings including those for location of control devices and wiring and operating and maintenance manuals for each equipment as per the specification requirements.

1.10.1.1.16 provide Operating and Maintenance Manuals for review by the Consultant and Commissioning Authority with all the commissioning activities results and reports incorporated.

1.10.1.1.17 obtain, issue and assign warranties for equipment and systems to the Owner.

1.10.1.1.18 provide all necessary test equipment shall be the responsibility of Contractor. Provide recently validated calibration certificate for all equipment to be used for verification prior to commissioning activities commencement.

1.10.1.2 Post-Construction Phase:

1.10.1.2.1 complete all commissioning procedures and activities and performance verification procedures which were delayed or not concluded during the commissioning phase.

1.10.1.2.2 complete system checks.

1.10.1.2.3 complete rectification of all deficiencies revealed by these checks. Equipment manufacturers involved in commissioning activities shall participate in systems checks.

1.10.1.2.4 revise all “as-built” and operating and maintenance documents to reflect all changes, modifications, revisions and adjustment upon completion of commissioning activities.

1.10.1.2.5 schedule a 4 hour on site question and answer session for the operating and maintenance personnel 3 months after handover of the facility to the Owner.

1.11 COMMISSIONING INVOLVEMENT

1.11.1 Commissioning Authority shall witness and validate as required; and Contractor and/or his Suppliers or retained Independent Third Party Agents shall perform the following:

1.11.1.1 check and ensure installation of the systems and equipment to ensure installations are completed and in a proper and safe state ready for functional performance testing.

1.11.1.2 run and test the systems and equipment through their design parameters to verify their capabilities in performance, sequencing, safety protection and alarms annunciation.

1.11.1.3 ensure deficiencies and defects found are rectified and replaced and the systems and equipment re-tested as required.

1.11.1.4 arrange and provide demonstration and training of Owner's personnel.

1.11.1.5 issue Operating and Maintenance Manuals for systems and equipment.

1.12 SYSTEMS TO BE COMMISSIONED

1.12.1 Electrical systems shall include but not limited to following:

1.12.1.1 Distribution panel boards.

1.12.1.2 Branch panel boards.

1.12.1.3 Transformers, and service entrance board.

1.12.1.4 Central lighting inverters.

1.12.1.5 Emergency power.

1.12.1.6 Uninterruptible power supply

1.12.1.7 Motor control centers, and overcurrent settings

1.12.1.8 Solar Photovoltaic

1.12.1.9 Lighting and Lighting Control System, emergency lighting.

1.12.1.10 Fire alarm system.

1.12.1.11 Duress Alarm system.

1.12.1.12 P.A. system.

1.12.1.13 Security system and Access control.

1.12.1.14 Telecommunications system.

1.12.1.15 Video Surveillance System (CCTV)

1.13 TESTING EQUIPMENT

1.13.1 Contractor and manufacturer shall provide all instrumentation and test equipment necessary to conduct the tests specified during the commissioning process. The Contractor shall submit a list of equipment to be used and copies of latest equipment calibration certificates to the Commissioning Authority and Consultant for approval.

1.14 EXTENT OF FUNCTIONAL PERFORMANCE TESTING

1.14.1 The following outlines, but not limited to, the Functional Performance Testing sampling rates:

1.14.1.1 Major Systems - 100% sample rate:

1.14.1.1.1 Transformers (<750 Volts)

1.14.1.1.2 Fire Alarm

1.14.1.1.3 Emergency Generator

1.14.1.1.4 Emergency lighting

1.14.1.1.5 Exit Lighting

1.14.1.1.6 UPS systems

1.14.1.1.7 Security Panel / Monitoring

1.14.1.1.8 Solar Photovoltaic

1.14.1.2 Minor Systems - 25% sample rate

1.14.1.2.1 Normal Power panels (<750 Volts)

1.14.1.2.2 Lighting and lighting control

1.14.1.2.3 CCTV Cameras

1.14.1.3 Balance of Systems - 10% sample rate:

1.15 DOCUMENTATION

1.15.1 Contractor shall submit test procedures for review prior to functional performance testing. Record test results and procedures on approved record forms and submit the forms together with copies of test certificates to consultant and Commissioning Authority for review and approval.

1.15.2 When results are validated, Commissioning Authority shall incorporate those records in his System Description Manual.

1.16 COMMISSIONING PROCESS

1.16.1 Commissioning Authority: to perform and complete all work as specified in the “GENERAL” Section of this specification “Responsibilities of Commissioning Authority”.

1.16.2 Contractors: To perform and complete all works as specified in the “GENERAL” Section of this specification “Responsibilities of Contractor”. In general, it shall include complete activation of all systems; calibration, test, and verification of performance of all components, equipment and systems; verification of performance of all systems through all specified modes of control and sequence of operation; rectification of deficiencies; recording of test results for submission; demonstration, instruction and training of Owner’s operating and maintenance personnel; follow-up during first year of operation for fine tuning and building service monitoring.

1.16.3 Equipment verification: The Contractor shall complete the equipment verification forms for each piece of equipment. The forms shall be included in the commissioners System Description Manual. The equipment data shall include, but is not limited to:

1.16.3.1 manufacturer’s name, address and telephone number.

1.16.3.2 distributors’ name, address and telephone number.

1.16.3.3 make, model number and serial number, year built.

1.16.3.4 voltage, ampere rating, fault rating, frequency, breaker size, fuse size, overload size.

1.16.3.5 equipment enclosure type.

1.16.3.6 any other special characteristics.

1.16.4 Pre-requisites to Functional Performance Testing (FPT) for a System/Assembly in order of required completion:

1.16.4.1 Prefunctional / FAMIS forms Completed , EQU stickers, tags, and chains are complete.

1.16.4.2 Static Installation Completed.

1.16.4.3 Electrical Contractor Testing and Verification.

1.16.4.4 Electrical Inspection Deficiencies complete.

1.16.4.5 The contractor is to perform a dry run of the Functional Performance Testing prior to the start of FPT by the Commissioning Authority.

1.16.5 Functional Performance Testing by the Commissioning Authority:

1.16.5.1 It is expected that once the contractor has performed a dry run of the Functional Performance Test (FPT) and is satisfied that the system is working properly; the contractor will invite the Commissioning Authority to the Functional Performance Testing.

1.16.5.2 During the Functional Performance Testing; minor issues (that can be resolved in 15 – 30 minutes) will be tolerated to an extent depending on the importance/severity of the issue. Once two minor issues have been encountered; testing may be suspended (and re-scheduled) at the Commissioning Authority's discretion.

1.16.5.3 If the first Functional Performance Test fails, the Owner will pay for a second test. If the test fails thereafter, the cost of re-testing(s) will be the contractor's.

1.16.5.4 Any System/Assembly that is microprocessor based, and includes any customized programming/software is required to pass functional performance testing without any failure. Partial functional performance testing is not acceptable. Should any aspect of the functional performance test fail, defects shall be corrected and the entire test shall be repeated

1.17 TESTING FOR ELECTRICAL SYSTEMS

1.17.1 All systems as specified in the Electrical specification sections.

1.17.2 Test and commission equipment and system as per Electrical Specification, CSA Z318.0-05 and the following requirements.

1.17.3 Contractor to submit test reports for the test procedures, results of all items inspected, checked, measured and tested. Comments and deficiencies should also be noted in the reports.

1.17.4 Low voltage switchboard (below 750V): Manufacturer/ITPTA shall carry out the following pre-service tests.

1.17.4.1 all pre-service checks, inspections and testing as recommended by the manufacturer.

1.17.4.2 check and record nameplate data.

1.17.4.3 check and inspect the switchboard that it is installed in accordance with the manufacturer's recommendations and to the Code requirements.

1.17.4.4 check the installation is complete and is ready and safe to carry out the testing.

1.17.4.5 check and report the switchboard enclosure is suitable for the environment in which it is installed.

1.17.4.6 check and test grounding is completed and satisfactory prior to carrying out any test.

1.17.4.7 check and record the entire switchboard is clean and free of debris before the testing.

1.17.4.8 check the mechanical operation of the switches or breakers.

1.17.4.9 check all connecting bolts are tightened to the correct torque values.

1.17.4.10 megger test

1.17.4.11 set all protective devices to the settings as per the reviewed Coordination Study.

1.17.4.12 check all the indication lights and control switches for correct functions.

1.17.4.13 set up, check and test the proper operations of the TVSS, measuring, indicating and recording meters.

1.17.4.14 after the board is energized, check and test phase sequence, the available voltages and load on the system and each feeder. For multi-section boards with different sources, check the phase sequence, available voltage and the polarity of each source.

1.17.5 Low voltage motor control centres (MCC): Manufacturer shall carry out the following pre-service tests and measurements after the board is energized.

1.17.5.1 all pre-service checks, inspections and testing as recommended by the manufacturer.

1.17.5.2 check and record nameplate data.

1.17.5.3 check and inspect the MCC to ensure they are installed in accordance with the manufacturer’s recommendations and to the Code requirements.

1.17.5.4 check the installation is complete and is ready and safe to carry out the testing.

1.17.5.5 check and report the MCC enclosure is suitable for the environment in which it is installed.

1.17.5.6 check and test grounding is completed and satisfactory prior to carrying out any test.

1.17.5.7 check and record the entire MCC is clean and free of debris before the testing.

1.17.5.8 check the mechanical operation of the switches or breakers.

1.17.5.9 check all connecting bolts are tightened to the correct torque values.

1.17.5.10 megger test

1.17.5.11 set all protective devices to the settings as per the reviewed Coordination Study.

1.17.5.12 check and record the size of all fused switches and fuses.

1.17.5.13 Check, set and record the rating and setting of the overload relays.

1.17.5.14 check all the indication lights and control switches for correct functions.

1.17.5.15 check all control functions for proper functioning and connections.

1.17.5.16 check all interface contacts for control and indications for proper functioning and connections.

1.17.5.17 set up, check and test the proper operations of the TVSS, measuring, indicating and recording meters.

1.17.5.18 after the MCC is energized, check and test phase sequence and the available voltages.

1.17.5.19 check motor running current and for correct rotation.

1.17.6 Low voltage Distribution cables (below 750V): Contractor/Independent Third Party Testing Agent shall carry out the following tests:

1.17.6.1 check cables are properly installed, terminated and tightened to the correct torque values.

1.17.6.2 check and record cable sizes, types and method of installation.

1.17.6.3 check and confirm the installed cable sizes are of adequate rating, taking into consideration of the type of cable, the method of installation, the correction factors and any other requirements.

1.17.6.4 grounding test to ensure the equipment, the conduit and the cable armour/sheath, if applicable, are properly grounded.

1.17.6.5 megger test.

1.17.6.6 check and measure voltage and current under typical building load conditions (once other systems are commissioned and running). For cables in parallel, measure load current on each cable.

1.17.7 Transformers (below 750V): Independent Third Party Testing Agent or manufacturer shall carry out following tests:

1.17.7.1 check and record nameplate data.

1.17.7.2 check and report the transformer enclosure is suitable for the environment in which it is installed.

1.17.7.3 check and record sizes and types of primary and secondary protection devices, conductor sizes and types.

1.17.7.4 check cables are properly installed, terminated and tightened to the correct torque values.

1.17.7.5 megger the primary and secondary windings.

1.17.7.6 measure the primary and secondary winding resistances.

1.17.7.7 grounding test to ensure transformer is properly grounded.

1.17.7.8 polarity and phase sequence tests.

1.17.7.9 sound level test for different points at 1 m (3') away from transformers.

1.17.7.10 check and record transformer primary and secondary voltages and load current under typical load conditions. Check and record transformer on-load temperatures.

1.17.8 Central Lighting Inverters: Manufacturer shall perform tests to the specification, CSA C22.2 No. 141-15 and the following requirements:

1.17.8.1 Prior to carrying out site test, the following items must be completed:

1.17.8.1.1 the complete installation, must be completed, properly set and tested, and report submit. Report to include all settings.

1.17.8.1.2 test procedures submitted and reviewed by the Consultants and the Commissioning Authority.

1.17.8.1.3 factory test report submitted and reviewed by the Consultants and the Commissioning Authority.

1.17.8.2 check and record nameplate data.

1.17.8.3 verify the room conditions, such as temperature and humidity is within the range as recommended by the central lighting inverter manufacturer.

1.17.8.4 check cables are properly installed, terminated and tightened to the correct torque values.

1.17.8.5 check and test grounding system to ensure the unit, switchboard, panels and the associated equipment is properly grounded.

1.17.8.6 test all protective devices for proper shutdown and warning operations.

1.17.8.7 perform 100% full load test on the central lighting inverter for 30 minutes and one hour on the bypass circuit. Record all electrical data and the room temperatures. Measure and record battery voltages before and after the full load test.

1.17.8.8 measure and record input and output voltage, current, harmonic performance for each test.

1.17.8.9 0-100% and 100%-0% step load transient test on normal power available and battery supply only.

1.17.8.10 battery discharge test to verify the specified performance requirements.

1.17.8.11 manufacturer to provide a full site test report recording all the tests carried out, the results, including the results of the operation of the associated electrical and mechanical systems. The records must also include all settings in the Central Lighting Inverter. All deficiencies are also to be noted.

1.17.9 Distribution panel boards and branch panel boards: Contractor/ Independent Third Party Agent shall carry out following tests:

1.17.9.1 check and record nameplate data.

1.17.9.2 check and report the panel enclosure is suitable for the environment in which it is installed.

1.17.9.3 check cables are properly installed, terminated and tightened to the correct torque values.

1.17.9.4 check and test to verify the panel board directory is correct.

1.17.9.5 include the directory in the test records. The directory shall contain size of each breaker, equipment served, cable type and size.

1.17.9.6 check and test the voltage drop is within the specify limit from the service entrance switchboard to the distribution panels and branch panel boards.

1.17.9.7 test branch circuits voltage drop is within the requirements.

1.17.9.8 grounding test to ensure panel boards are properly grounded.

1.17.9.9 megger test.

1.17.9.10 Measure voltage and load current on each phase under typical building load conditions. Submit test reports to Consultant. When required, re-arrange branch circuits as directed by the Consultants for proper load balancing.

1.17.9.11 Provide thermographic scans of all distribution and branch panel boards under typical load conditions. Submit report including thermographic image of each panel. Images to be identified with the panel name, image date, and colour scale.

1.17.10 Coordination study:

1.17.10.1 Independent Third Party Testing Agent shall, in accordance with the reviewed Coordination Study, set up all the protective devices, check and verify the rating and types of fuses and record all such ratings and settings in his reports.

1.17.11 Lighting and Lighting Control systems: Manufacturer and Contractor shall carry out the following tests:

1.17.11.1 prior to carrying out site test, submit a lighting system operation matrix to the Consultant and Commissioning Authority. Matrix to show the zoning layout, how each zone is controlled, and the settings, such as timer and sensor settings for each zone.

1.17.11.2 check and verify all lighting fixtures are connected and switched properly.

1.17.11.3 check and verify all automatic controls are connected and functioning properly. Cooperate with BAS contractor to field verify lighting integration with the BAS.

1.17.11.4 check and verify all operations shown in the matrix.

1.17.11.5 check and verify the emergency lighting system, including battery lighting system, are connected and functioning properly.

1.17.11.6 carry out lighting level tests as required and directed by the Commissioning Authority.

1.17.12 Fire Alarm System: Manufacturer and/or Independent Third Party Testing Agent shall carry out following tests:

1.17.12.1 prior to carrying out site test, submit a fire alarm system operation matrix to the Consultant and Commissioning Authority. This matrix shall include of operation of the fire alarm system and the operations of all systems interfaced with the fire alarm system.

1.17.12.2 check and record nameplate data.

1.17.12.3 check and report the panel enclosure is suitable for the environment in which it is installed.

1.17.12.4 check and verify system is installed to specification, NBC, and S524 requirements.

1.17.12.5 perform system verifications and tests according to CAN/ULC-S537.

1.17.12.6 check and verify all system operations shown in the matrix.

1.17.12.7 perform system integration test to verify proper fire alarm system operation, and the proper operations of all systems interfaced with the fire alarm system.

1.17.12.8 Submit verification reports and system operation verification reports.

1.17.12.9 Upon receiving the required documentation, provide resources to conduct testing as outlined in specification Section 01 91 13 subsection 1.19 Integrated Systems Testing.

1.17.13 CCTV, Security, Access Control and all other Communication Systems: Manufacturer shall carry out following tests:

1.17.13.1 prior to carrying out site test, submit

1.17.13.1.1 system operation matrix to the Consultant and Commissioning Authority. This matrix shall include of operation of the system and the operations of all interfaced systems;

1.17.13.1.2 test procedures to detail what tests and how each test will be carried out. Procedure to include how the system operation will be commissioned.

1.17.13.2 check and record nameplate data.

1.17.13.3 check and report the panel enclosure is suitable for the environment in which it is installed.

1.17.13.4 Check and verify the operation of each device.

1.17.13.5 check and verify all system operations shown in the matrix.

1.17.13.6 perform system integration test to verify proper system operation, and the proper operations of all interfaced systems.

1.17.13.7 Submit report to include the system operation matrix, test procedures, system settings and all the test results, comments and list of deficiencies.

1.17.14 Solar Photo Voltaic testing:

1.17.14.1 all pre-service checks, inspections and testing as recommended by the manufacturer.

1.17.14.2 check and record nameplate data.

1.17.14.3 check and inspect each panel is installed in accordance with the manufacturer's recommendations and to the Code requirements.

1.17.14.4 check the installation is complete and is ready and safe to carry out the testing.

1.17.14.5 check and report each panel enclosure is suitable for the environment in which it is installed.

1.17.14.6 check and test grounding is completed and satisfactory prior to carrying out any test.

1.17.14.7 check and record each panel is clean and free of debris before the testing.

1.17.14.8 check the mechanical operation of panel.

1.17.14.9 check all connecting bolts are tightened to the correct torque values.

1.17.14.10 megger test

1.17.14.11 check all indication lights, control switches, disconnects are connected and have the correct function.

1.18 COMMISSIONING MEETINGS AND REPORTING

1.18.1 Contractor shall include the commissioning plan and schedule for all tests and equipment start-up tests in the construction schedule.

1.18.2 Commissioning meeting as required shall follow the regular construction meetings. The testing schedules and results of all tests shall be reviewed.

1.18.3 Testing forms and reports associated with the electrical systems shall be directed to Consultant, Commissioning Authority and Owner.

1.18.4 Forms and reports to be issued shall include:

1.18.4.1 shop drawings, issued and accepted;

1.18.4.2 equipment testing and verification forms;

1.18.4.3 reports resulting from testing and verification; and

1.18.4.4 testing schedule.

1.19 OPERATING AND MAINTENANCE MANUAL

1.19.1 Contractor shall prepare and submit the Operating and Maintenance Manual to Consultant and Commissioning Authority 6 weeks prior to beginning of training.

1.19.2 The O&M manual to be in searchable PDF format on CD, DVD or USB drive.

1.19.3 Each Electrical Operations and Maintenance manual shall be prepared and organized as per section 01 78 00 Closeout Submittals.

1.19.4 Contractor shall re-submit the manual should the Consultant or Commissioning Authority find deficiencies. Training shall not begin until the manual has been accepted by Consultant.

1.19.5 The operating procedures shall be the recommended manufacturer's operating procedures for the equipment.

1.19.6 The maintenance procedures shall include Scope of Work, frequency of activity, parts required and necessary documentation.

1.19.7 Spare parts list shall be manufacturers' recommended list for maintenance purposes.

1.19.8 Trouble shooting guide shall be manufacturer's recommendations for the equipment.

1.19.9 Equipment list shall include make, model, serial number, voltage, rated current, number of phase and wire and fault rating.

1.19.10 Operating and Maintenance Manual shall be submitted to the Owner in searchable PDF format.

1.19.11 The Systems Operating and Maintenance Manual will be used by the maintenance personnel to assist them in the daily operation of the systems.

1.20 SYSTEMS OPERATION MANUAL

1.20.1 Systems Operation Manual shall be prepared by Commissioning Authority using data collected by Contractor and test results.

1.20.2 The content and format of the SOM to be as per the university's document "Systems Operation Manual Creation Process and Expected Contents".

1.20.3 Commissioning Authority shall provide a copy of the Systems Operation Manual to Owner.

1.21 OPERATOR TRAINING AND INSTRUCTIONS

1.21.1 Contractor and equipment manufacturers shall provide operator training for each system and equipment.

1.21.2 Training and instruction shall be provided by qualified technicians and shall be conducted in a classroom setting at the equipment or system.

1.21.3 Owner Training Pre-requisites:

1.21.3.1 O&M manual(s) been reviewed and approved by the engineers.

1.21.3.2 For the system/assembly that training will occur on:

1.21.3.2.1 Contractor Testing and Verification has been 100% completed, with no remaining deficiencies

1.21.3.2.2 Functional Performance Testing has been 100% completed, with no remaining deficiencies, or items on the Commissioning Issues Log.

1.21.3.3 Two weeks in advance of the scheduled training date, the following to be submitted to the owner for review:

1.21.3.3.1 An Agenda

1.21.3.3.2 A Trainor's bio

1.21.3.3.3 Training materials specific to the Agenda have been provided in electronic form for review and approval.

1.21.3.4 The owner reserves the right to reject the Trainor, or modify the agenda, if either are found to be unacceptable.

1.21.4 Each session shall be structured to cover:

1.21.4.1 Operating and Maintenance Manual.

1.21.4.2 operating procedures.

1.21.4.3 maintenance procedures.

1.21.4.4 trouble-shooting procedures.

1.21.4.5 manufacturer's or service representative's name, address and phone number.

1.21.5 Contractor shall prepare a detailed training and instruction plan. This plan shall include the outline of all sessions and identification of the training presenters.

1.21.6 Provide course documentation for up to 6 people.

1.21.7 The sessions may be videotaped by the owner as required.

1.21.8 Training and instruction shall be provided for following systems wherever applicable:

SYSTEM	MINIMUM TRAINING DURATION
Central Lighting Inverters	4 hours
Fire Alarm System	4 hours
Electrical Systems Overview	6 hours
Lighting Control System	as per section 26 50 05
Security / CCTV / Access Control Systems	2 hours as per sections 28 13 00, 28 16 00 and 28 23 00
Distribution and MCC	16 hours
Solar Photovoltaic	4 hours
High Voltage distribution and Transformers	4 hours

1.21.9 The training and instruction requirement for the electrical system shall include a walk-through of the building by the Contractor. During the walk-through the Contractor shall:

1.21.9.1 identify, describe and explain the function of the equipment.

1.21.9.2 Detail explanation of the operation, including mechanical operation and electrical operation of the equipment; procedures and sequence of operation; procedures of switching, isolation and emergency switching.

1.21.9.3 detail explanation of the maintenance of the equipment including the procedures and items to check for.

1.21.9.4 safety procedures to be implemented before the maintenance.

1.21.9.5 interlock, interface and control with other equipment.

1.21.9.6 fault finding procedures.

1.21.10 When each session has been completed, the Commissioning Authority shall sign to certify completion.

1.22 SYSTEMS DEMONSTRATION AND TURNOVER

1.22.1 System demonstration and turnover to the Owner shall occur when:

1.22.1.1 installation is complete.

1.22.1.2 acceptance test conducted by the Consultant has been successfully completed.

1.22.1.3 Commissioning Authority Functional Performance Testing (FPT) has been successfully complete.

1.22.1.4 training and instruction has been completed.

1.22.1.5 Operating and Maintenance Manual have been accepted.

1.22.1.6 System Operating Manuals have been accepted.

1.22.1.7 shop drawings have been updated.

1.22.1.8 as-built drawings have been completed.

1.22.2 Systems demonstration shall be conducted by Contractor and manufacturers. The demonstration shall cover all operation and maintenance requirements and a physical demonstration of equipment installation and operation.

1.23 TESTING FORMS

1.23.1 Contractor and manufacturers shall fill out the forms listed in this section and any other additional data sheets not included in this specification, but required for the mechanical and electrical systems of this Project.

1.23.2 Independent Testing Agent/Manufacturer to submit test form for the Commissioning Authority's review. The test forms should contain the test procedures, and all the required Functional Performance Testing items.

1.23.3 Commissioning index form shall be maintained by the Commissioning Authority to track the progress of the commissioning activity requirements.

1.23.4 Electrical testing and verification forms to be completed are as follows wherever applicable, but not limited to:

1.23.4.1 system and equipment warranty dates form.

1.23.4.2 switchboard test form.

1.23.4.3 motor control center test form.

1.23.4.4 Central lighting inverter test form.

1.23.4.5 transformer test form.

1.23.4.6 distribution cable test sheet.

1.23.4.7 Distribution and Panel board test form.

1.23.4.8 Solar Photo Voltaic form.

1.23.4.9 loose starter test form.

1.23.4.10 fire alarm testing and verification form.

1.23.4.11 CCTV/Security/Access control test form.

1.24 EQUIPMENT AND SYSTEM WARRANTIES

1.24.1 Equipment and system warranties shall be as defined in Division 1.

1.24.2 Contractor shall fill-out the warranty form listing the equipment and systems and the start and finishing dates for warranty.

1.24.3 Refer to the Division 1 and all Mechanical and Electrical divisions of the specification for the requirements during the warranty period.

1.24.4 Contractor shall re-visit the building during the warranty period with the Consultant, Commissioning Authority and the Owner. During these visits the performance of the system shall be reviewed.

1.24.5 At these meetings Owner, Consultants and the Commissioning Authority shall review the performance of the systems. If performance is satisfactory then no further action need to be taken. If unsatisfactory then Contractor will be instructed to correct deficiencies, at his cost, to the satisfaction of Consultants.

END OF SECTION