SECTION 26 08 11
COMMISSIONING: ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide commissioning and testing of the electrical systems.

B. Test and provide written certification that the entire electrical installation complies with contract documents, code and proper system operation. Perform acceptance tests in accordance with manufacturer's recommendations, NFPA 70B and International Electrical Testing Association (NETA) testing specifications NETA ATS-1991. It is the intent of the acceptance tests to assure that all electrical equipment, both Contractor and Owner supplied, is operational and within industry manufacturer's tolerances, complies with all applicable codes, and is installed in accordance with design specifications.

C. Electrical Testing Company. The following testing shall be performed by a third party ETC (Electrical Testing Company):
   1. Service Grounding Test
   2. Ground Fault Protection Systems Test
   3. Automatic Transfer Switch Test & Calibration
   4. Switchboards, Switchgear
   5. Molded-Case Circuit Breakers
   6. Metering Test & Calibration
   7. Variable Frequency Drives
   8. Infrared Thermographic Scanning

1.2 RELATED WORK

1. Refer to other sections of this specification for contractor responsibilities relative to the commissioning process.

1.3 TEST PERFORMANCE RESPONSIBILITY

1. The Test Engineer shall be responsible for the performance of all specified installation and commissioning tests.
2. The Test Engineer shall hire the services of a third party, ETC (Electrical Testing Company) to inspect and test all electrical equipment systems as specified in 1.1.C above and other specialized equipment as specified in this section.
3. Any questions and concerns identified by the ETC shall be promptly addressed to the Owner’s Representative.

PART 2 - PRODUCTS

2.1 ELECTRICAL TESTING COMPANY

A. Retain the services of Third Party ETC (Electrical Testing Company) that is qualified to test electrical equipment, and is an approved testing company by the Washington State Department of Labor and Industries. The ETC shall not be associated with the manufacturer of equipment or systems under test. Approved companies: Electro-Test, Westinghouse Engineering Service (for equipment not manufactured by Westinghouse), Asset.

B. ETC shall prepare test reports on the systems they test.

2.2 TEST EQUIPMENT

A. All shall be furnished by and remain property of the contractor. The following test equipment shall

be provided and shall include as a minimum:

1. Amprobe
2. Voltmeter
3. Circuit Tracer
4. Power Factor Meter
5. Dranetz 901 or equal
6. Insulation resistance tester
7. Earth ground resistance tester
8. Circuit breaker tester
9. Thermovision infrared scanning equipment
10. Receptacle testers
11. 2 way radios

B. Test Instrument Traceability: The ETC shall have a calibration program which maintains all applicable test instrumentation within rated accuracy. The accuracy shall be traceable to the National Institute of Standards and Technology (NIST) in an unbroken chain. Instruments shall be calibrated in accordance with the following frequency schedule and dated calibration labels shall be visible on all test equipment:

1. Field instruments: 6 months maximum
2. Laboratory instruments: 12 months
3. Leased specialty equipment: 12 months (where accuracy is guaranteed by lessor)

PART 3 - EXECUTION

3.1 CONSTRUCTION OBSERVATION BY TEST ENGINEER

A. Obtain and review design documents for overall design intent and the overall required systems configurations.

B. Obtain and review shop drawings and submittals for installation criteria and the required construction details, as they support and further define the systems features.

C. The Test Engineer shall make general inspections at the job site and shall review the following for configuration, quality of construction, adherence to design requirements, and conformance with shop drawings and submittal information.

1. Service entrance switchboard
2. Main distribution switchgear, substations
3. Sub-distribution panels
4. Branch circuit panelboards
5. Ground systems
6. Variable frequency drives

D. The Test Engineer shall make general inspections at the job site and shall also review the following:

1. Assembly of the accessory equipment, and the interconnecting wiring for control circuits and fire alarm interface.
2. General Inspection of: Appearance, finish, alignment of doors, covers and similar parts; quality of workmanship; possible shipping and other damage; missing, broken or incorrectly applied devices; loose, or missing accessories, bushings, or hardware; loose or broken wires; proper installation of all equipment; equipment to verify that shop drawings and instructions have been shipped with all equipment and are available.

E. Electrical Nameplates: Review submittals for correct nameplates. Inspect and check all electrical equipment and devices above and below ceiling spaces for the correct nameplate. Prepare and submit checklist that identifies each electrical device with a sign off column for Test Engineer’s initials.

F. Fire Stopping. Inspect all raceways for proper installation of fire stopping after installation of voice,

data, video, audio, and security cables.

G. Support of Electrical Equipment: Inspect and check all electrical equipment for support and seismic bracing. Inspect and check light fixture seismic wires.

H. Emergency Off Switches: Test all emergency off switches and verify shut down and reset of equipment.

I. Spare Fuses: The Test Engineer shall inspect and verify spare fuse inventory as specified by Section 26 28 13.

J. Lighting. Verify operation of all lamps one week prior to substantial completion.

3.2 ELECTRICAL TESTING COMPANY

A. The Test Engineer shall deliver the following project documents to the ETC eight weeks prior to testing:
   1. Division 16 Specifications
   2. Electrical Floor Plans showing equipment to be tested.
   3. Electrical one Line Diagrams
   4. Submittals of Manufacturers Data and Shop Drawings including engineers review letter of all systems to be tested.
   5. Coordination Study
   6. Fault Current Study

B. The ETC shall prepare test reports including description of project, description of equipment tested, description of test, test results, conclusions and recommendations, retesting results and list of test equipment used and calibration date. Calibration shall be traceable to the National Bureau of Standards and shall not be more than 6 months since last calibration.

C. One copy of each test report shall be delivered directly to the electrical engineer and Owner within 7 calendar days of the test.

D. Insert a copy of each test report in the operation and maintenance manuals.

3.3 ACCEPTANCE CRITERIA

A. The primary purpose of this section is to witness and verify operation of electrical equipment and systems as shown on electrical drawings and as specified in Division 16 of the contract documents.

B. Each function and test shall be performed under conditions which simulate as close to an actual operating condition as possible. To that end the contractor shall provide all necessary materials and temporary system voltages, currents to simulate fault conditions on the system being tested in order to prove and verify proper operation. At satisfactory completion of all verified tests, the building electrical systems being tested shall be returned to the condition required by the contract documents as a complete and operational system.

C. Demonstrate to the Owner’s Representative successful execution of the following FPT’s (functional performance tests) in accordance with approved FPT procedures as described in Test Procedures.

3.4 RECEPTACLE AND DEVICE TEST

A. Receptacle Polarity Test: The Test Engineer shall test every receptacle installed or reconnected under this contract with a receptacle circuit tester. Tester shall test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot or neutral and hot open. Rewire receptacles with faults and retest. Submit test report signed by Test Engineer that performed the test.

B. Ground-Fault Receptacle Circuit Interrupter Tests: The Test Engineer shall test each receptacle or branch circuit breaker having ground-fault circuit protection to assure that the ground-fault circuit

interrupter will not operate when subjected to a ground-fault current of less than 4 milliamperes and will operate when subjected to a ground-fault current exceeding 6 milliamperes. Perform testing using an instrument specifically designed and manufactured for testing ground-fault circuit interrupters. Apply the test to the receptacle. "TEST" button operation will not be acceptable as a substitute for this test. Replace receptacles that do not shutoff power with 5/1000 of an ampere within 1/40th of a second and retest. Submit test report signed by Test Engineer who performed this test.

C. Operational Tests: Demonstrate the operation of each switch, circuit breaker and other item of electrical control with the systems fully energized and operating. Each shall be demonstrated three times.

3.5 600 VOLT WIRING

A. Scope: The Contractor shall test all electrical feeders and exterior branch circuits whose operating voltage is 600 volts or less that are installed under this contract and exterior branch circuits. The Test Engineer shall verify tests and submit a test report.

B. Test for continuity of each circuit.

C. Test for grounds in each circuit which shall consist of the physical examination of the installation to ensure that all required ground jumpers, devices, and appurtenances do exist and are mechanically firm.

D. Perform a 500 volt megohm meter test on each circuit between the conductor and ground. The insulation resistance shall not be less than 2 megohms for circuits under 115V, 6 megohms between conductor and ground on those circuits (115V-600V) with total single conductor length of 2,500 feet and over, nor less than 8 megohms for those circuits (115V-600V) with single conductor length of less than 2,500 feet. If conductor fails test replace wiring or correct defect and retest.

E. Perform torque test for every conductor tested and terminated in an overcurrent device or bolted type connection; torque all connections per manufacturers recommendations and tabulate the results on a tabular form.

3.6 POWER SYSTEM TESTS

A. Scope. The Test Engineer shall inspect and test entire electrical systems provided by this contract to verify equipment and controls are correctly operating.

B. Load Balance Tests: Checks all panelboards for proper load balance between phase conductors and make adjustments as necessary to bring unbalanced phases to within 15% of average load.

C. Motor Tests: Check all motors for proper rotation and measure actual load current. Submit tabulation of motor currents for all motors 1 HP or more after the HVAC system has been balanced.

D. Phase Relationship Tests: Check connections to all new and existing equipment for proper phase relationship. During such check, disconnect all devices which could be damaged by the application of voltage or reversed phase sequence.

E. Transformer Taps: Connect all transformers at “Normal” tap. After facility is occupied for two weeks, measure the following voltages for each transformer:
   1. Primary and secondary voltages at transformer.
   2. Receptacle voltages at 2 receptacles or 2 light fixtures that are the longest distance (greatest branch circuits length) from the panelboard.
   3. Forward list of reading by transformer to Engineer for evaluation.
   4. Reconnect all taps as directed.

3.7 SERVICE GROUNDING TEST

A. Perform three point fall-of-potential tests on main grounding electrode system per IEEE Standard No. 81, Section 9.04. Maximum resistance to ground shall be less than 5 ohms. If this resistance cannot be obtained with the ground system shown, notify the Architect immediately for further instruction.

B. Perform the two-point method test per IEEE Standard 81, Section 9.03 to determine the ground resistance between the main ground system and all major electrical equipment frames, system neutral, and/or derived neutral points. Resistance shall be no greater than 5 ohms.

C. Confirm that the neutral is grounded only at the service equipment by removing the service neutral grounding conductor and meggering the neutral bus.

D. Take ground readings as follows:
   1. Phase I. Prior to connection of exterior ground system to building equipment or lightning protection down conductors.
   2. Phase I. Prior to building occupancy, after connection to building ground system.
   3. Retest exterior ground system after Phase II exterior ground system is intertied to Phase I system.
   4. Phase II. Prior to building occupancy after connection to building ground system.
   5. Phase III. Prior to building occupancy after ground system is complete.

3.8 GROUND FAULT PROTECTION SYSTEMS TESTS

A. Scope. Test all ground fault systems provided by this contract.

B. Prior to test:
   1. Inspect neutral main bonding connection to assure:
      a. Zero sequence system is grounded upstream of sensor.
      b. Ground connection is made ahead of neutral disconnect link.
      c. Ground strap systems are grounded through sensing device.
      d. Verify ground electrode conductor(s) for proper size and connection.
   2. Inspect control power transformer to insure adequate capacity for system.
   3. Monitor panels (if present) shall be manually operated for:
      a. Trip test.
      b. No trip test.
      c. Non-automatic reset.
      d. Proper operation and test sequence shall be recorded.
   4. Zero sequence systems shall be inspected for symmetrical alignment of core balance transformers about all current carrying conductors.
   5. Ground fault system integral to the circuit breaker will have its current sensors and neutral sensor inspected for proper polarity.
   6. Ground fault device circuit nameplate identification shall be verified by device operation.
   7. Pickup and time delay settings shall be set in accordance with engineer's instructions or as shown.

C. Electrical Test
   1. System neutral insulation resistance shall be measured to insure no shunt ground paths exist, neutral-ground disconnect link shall be removed, neutral insulation resistance measured and link replaced.
   2. The relay pickup current shall be determined by current injection at the sensor and the circuit interrupting device operated.
   3. The relay timing shall be tested by injecting one hundred fifty percent (150%) and three hundred percent (300%) of pickup current into sensor. Total trip time shall be electrically monitored.
   4. System operation shall be tested at fifty-seven percent (57%) rated voltage.
   5. Zone interlock systems shall be tested by simultaneous sensor current injection and

monitoring zone blocking function.

D. Test Parameters
   1. System neutral insulation resistance shall be two (2) megohm or greater.
   2. Relay pickup current shall be within ten percent (10%) of device dial of fixed setting.
   3. Relay timing shall be in accordance with manufacturer's published time-current characteristic curves.

3.9 MOLDED-CASE CIRCUIT BREAKERS

A. Scope. Test all circuit breakers 100 amps and over.

B. Inspect each breaker, operate manually, and electrically. Test shunt trips and alarm devices manually and electrically.

C. Adjust breaker trips to settings furnished by the coordination study and verify settings of the manufacturer's rating by passing controlled current through the trip devices. Record values and report deficiencies. The trip characteristics when adjusted to setting parameters shall fall within the manufacturer’s published time - current characteristics tolerance band.

D. Circuit Breaker Electrical Tests
   1. Contact resistance shall be measured.
   2. Time-current characteristic tests shall be performed by passing three hundred percent (300%) rated current through each pole separately. Trip time shall be determined.
   3. Instantaneous pickup current shall be determined by run-up or pulse method. Clearing times should be within four (4) cycles or less.
   4. Insulation resistance shall be determined pole to pole, across pole and pole to ground and across open contacts. Test voltage shall be 1000 volts D.C.
   5. Check trip unit reset operation.

3.10 SWITCHBOARDS

A. Scope. Test all switchboards.

B. Inspect equipment and each breaker, fused switch and report installation or shipping damage, loose material, shipping blocks, contamination or unfavorable environmental conditions that must be corrected. Check equipment for operation of doors, security of mounting. Report deficiencies.

C. Check the equipment ground and record the number and size of ground bus and straps. Report deficiencies.

D. Inspect the bus assembly for deficiencies and torque test all bolted connections. Test insulation of each bus phase-to-phase and phase-to-ground and all control circuits to ground with a suitable megohmeter. Record values and report deficiencies.

E. Inspect for proper identification of protective devices.

F. Surge Arrestors
   1. Test surge arrestors per the following procedures:
      a. Visual and Mechanical Inspection
         1) Inspect for physical damage, such as chipped or fractured porcelain.
         2) Inspect ground and discharge counter connections for integrity.
   2. Electrical Tests
      a. Perform ground continuity test to ground grid system.

3.11 AUTOMATIC TRANSFER SWITCHES

A. Scope. Test Automatic Transfer Switches.

B. Visual and Mechanical Inspection

1. Inspect for physical damage, anchorage and grounding.
2. Perform manual transfer operation.
3. Clean and lubricate transfer mechanism as required. Check alignment and operation in accordance with manufacturer's instructions.
4. Verify proper operation of all interlocks.
5. Perform bypass and isolation functions.

C. Electrical Tests
1. Monitor and verify correct operation and timing of the following applicable items:
   a. Normal voltage sensing relays.
   b. Emergency voltage sensing relays.
   c. Test switch.
   d. In-phase monitor.
   e. Time delay upon transfer.
   f. Alternate voltage sensing relay.
   g. Interlocks and limit switch function.
   h. Timing delay and re-transfer upon normal power restoration.
   i. Contact resistance shall be measured across main contacts.

D. Perform insulation resistance tests phase-to-phase and phase-to-ground with switch in both source positions.

E. Set and calibrate in accordance with specifications:
1. Voltage sensing relay.
2. Frequency sensing relay.
3. Transfer time delay relay.

3.12 METERING TEST & CALIBRATION FOR METERS

A. Scope: Test all analog and digital meters provided by this contract.

B. Visual and Mechanical Inspection
1. Examine all devices for broken parts, shipping damage, and tightness of connections.
2. Verify that meter types digital scales, and connections are in accordance with manufacture’s drawings and specifications.

C. Instrument Transformers
1. Test transformer polarity electrically
2. Verify connection at secondary CT leads by driving a low current through the leads and checking for this amount at applicable devices
3. Confirm transformer ratio by primary current injection
4. Measure insulation resistance primary-to-ground, secondary-to-ground and primary-to-secondary.
5. Overpotential test primary insulation
6. Measure potential transformer ratio.

D. Metering and Instrumentation
1. Calibrate all analog meters at midscale
2. Calibrate watt-hour meter to one-half percent
3. Verify all instrument multipliers
4. Verify operation of each installed function (volt amps, etc.) on digital meters.
5. Determine accuracy at 50/75/100% of full scale for digital meters for each function.
6. Verify operation of alarm contacts if installed.

E. Verify and test operation of electronic metering communication links.

3.13 **METAL ENCLOSED BUS DUCT**

A. Scope: Test metal enclosed bus duct provided by this contract per the following procedures:

B. Visual and Mechanical Inspection
   1. Inspect bus for physical damage and proper connection. Clean interior and insulators where applicable.
   2. Inspect for proper bracing, suspension, alignment and enclosure grounding.
   3. Check tightness of bolted joints by calibrated torque wrench.

C. Electrical Tests
   1. Measure insulation resistance of each bus phase-to-phase and phase-to-ground for one (1) minute.
   2. Inspect all accessible bus joints and cable connections by infrared scanner with maximum load to detect loose of high-resistance connections and other circuit anomalies.

3.14 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES 1200A OR GREATER

A. Perform complete inspection for assembly, fit, anchoring and grounding. Inspect the bus assembly for deficiencies and torque test all bolted connections.

B. Perform insulation resistance test on each bus section, phase-to-phase, and phase-to-ground, and on control wiring. minimum test voltage and insulation resistance shall be as follows:

Voltage Rating	Minimum Test Voltage	Minimum Insulation
0 - 250 V	500 V DC	25
250 - 600 V	1,000 V DC	100
601 - 5,000 V	2,500 V DC	1,000
5,001 - 15,000 V	2,500 V DC	5,000

C. Existing EEB Substation PCM-E00-No. 1. The existing substation will be relocated. Inspect and perform preventative maintenance on substation. Test all protective devices. Inspect the bus assembly for deficiencies and torque test all bolted connections. Verify bonding and grounding connections. Prepare testing report and note deficiencies.

3.15 POWER SYSTEMS PROTECTIVE DEVICE AND CALIBRATION

A. Scope: It is the intent of these tests to assure all protective devices are operational, correctly applied, within industry and manufacturer's tolerances, and installed in accordance with the specifications. This effort should minimize the damage caused by any electrical failure. The ETC shall verify and certify that the electrical system and electrical equipment configuration matches the contract documents, electrical equipment shop drawings, and the electrical system coordination study recommended settings.

B. Adjustments, Settings and Modifications: The ETC shall calibrate necessary field settings, adjustments and minor modifications to conform with the coordination study without additional cost. (Examples of minor modifications are trip sizes within the same frame, the time curve characteristics of induction relays, ranges etc.) Adjust protective devices to the values provided in the coordination study. Test the minimum pickup and delay, ground fault pickup and delay. Demonstrate the zone interlock feature. The trip characteristics, when adjusted to setting parameters, shall fall within the manufacturer’s published time-current characteristic tolerance.

C. Certifications: Two weeks prior to final inspection, the ETC shall deliver four copies of the following certifications to the Owner's representative:
   1. That the protective devices have been adjusted and set in accordance with the approved protective device study.
   2. That tests and settings have been witnessed by the Test Engineer.

3.16 VARIABLE FREQUENCY DRIVES

A. Scope: Test variable frequency drives.

B. Mechanical and Visual Inspection
   1. Visually inspect for obvious indications of physically damaged or overheated components.
   2. Verify all static switch and jumper settings are applicable to the input and load.
   3. Inspect for loose terminations.
   4. Verify stop and safety circuits are properly terminated.
   5. Verify the motor terminations are consistent with the drive output.

C. Electrical Tests
   1. Test and record the line volts and amps. Observe for balance within 10%.
   2. Inspect for proper jumper or switch settings for given drive parameters if so equipped.
   3. If possible, start and run the drive while observing the test metering or fault indicators if so equipped.
   4. Test and record output volts and amps while the drive the drive is at 25%, 50%, and 100% speed and attached load. Observe for balance and within manufacturers' specifications.
   5. Set adjustable parameters to match the settings provided.
   6. Activate the various safety devices when possible to ensure proper operation.
   7. Record harmonic distortion at two levels of common coupling, each level is to be at the next upstream feed.
   8. After completion of air balancing, record final drive settings of the vfd's.

3.17 INFRARED THERMOGRAPH SCANNING:

A. In general, the scan shall be made when the equipment is energized and is operating at its normal capacity. It is intended that the scan be made after the equipment has been in full operation as follows:
   1. Phase I: One year after occupancy
   2. Phase II: One month after occupancy

B. Test equipment, miscellaneous tools, and materials shall be transported properly, moved, and set up by trained personnel. Equipment used in testing shall be capable to perform all recommended procedures required by the apparatus and related equipment. All test equipment shall have certification of calibration and be in working order.

C. All hot spots shall be marked, identified and an infrared thermographic scanning report prepared and furnished to the Test Engineer.

D. The report shall contain infrared photos of trouble spots with temperature readings.

E. All sources of heating problems shall be promptly reported to the owner for corrective action by the Division 16 contractor.

F. Infrared scanning equipment shall be an AGA (or approved equal) thermovision set capable of viewing an entire bus or equipment assembly at one time and have a sensitivity of 0.2° C. with a liquid nitrogen reference.

3.18 TEST PROCEDURES

A. Submit for approval detailed FPT procedures corresponding to the FPT criteria in Acceptance Criteria in this Section. FPT procedures shall be detailed test instructions, written with sufficient step-by-step information to allow a test to be repeated under identical conditions. List the value for all setpoints and electrical values and acceptable results for each condition tested. Provide a unique alpha-numeric identification for each FPT procedure.

B. Submit for approval test procedure check-off sheets. Number each test procedure check-off item with the same number as the corresponding FPT procedure.

C. Demonstrate successful execution of FPT's listed under Acceptance Criteria in this Section. Sign-off each successful test and obtain the sign-off of the Commissioning Agent or other Owner-designated witness.

3.19 SCHEDULE

A. Perform all testing after installation and before energizing. All systems shall pass tests prior to placing in service.

B. The Test Engineer shall submit to the Owner's Representative a schedule of all tests to be performed one month prior to the scheduled performance of the first test. Items to include summary of project, description of test, conclusions and recommendations, appendix including sample test forms.

C. Confirm test schedule with owner's representative one week prior to test. The Test Engineer shall coordinate the test schedule so that the Owner's Representative can witness all testing.

D. The Test Engineer shall deliver to the construction coordinator, owner's representative, and the engineer, within 5 working days of test the test results. The owner shall have the tests for a two week review prior to energization.

3.20 TEST REPORTS

A. The ETC shall prepare test reports including description of project, description of equipment tested, description of test, test results, conclusions and recommendations, retesting results and list of test equipment used and calibration date.

B. Insert a copy of each test report in the operation and maintenance manuals.

3.21 RETESTING

A. Any fault in material or in any part of the installation revealed by these tests shall be investigated, replaced or repaired by the Contractor and the same test repeated by the ETC at Contractor's expense until no fault appears.

3.22 LABELS

A. Upon completion of the tests a label shall be attached to all tested devices. These labels shall indicate date serviced and the ETC.

END OF SECTION