

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Inspections, calibrations, and acceptance tests for all equipment/systems shall be performed. The inspections and testing activities shall be divided among the following groups as specified in this section:
1. The ETC (Electrical Testing Contractor) services shall be engaged by the electrical Contractor. The ETC shall be a recognized firm specializing in performing inspections, calibrations and acceptance tests specified in this section. The ETC shall provide all material, equipment, labor and technical supervision to perform the inspection, calibration and testing.
 - a. The ETC shall test and provide written certification on company letterhead 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-2003.
 - b. The following testing shall be performed by the ETC:
 - 1) Ground Fault Protection Systems Test & Calibration
 - 2) Transformers Dry Type
 - 3) Switchboards
 - 4) Molded-Case Circuit Breakers
 - 5) Metering Test & Calibration
 - 6) Medium Voltage Switchgear
 2. The original equipment manufacturer's authorized service representative shall provide special equipment, labor, and technical supervision, when required, in addition to what is supplied by the ETC.
 3. Inspections, calibrations, and acceptance tests for equipment and systems not requiring the services of the ETC and manufacturer's representative shall be performed by the Electrical Contractor.
- B. In cases where equipment and systems requires the involvement of two or all of the parties, the parties mentioned above shall coordinate and perform all inspection and testing requirements. The Contractor shall be responsible for coordination of the work and ensuring that the requirements of this section are met.

1.2 QUALIFICATIONS

- A. The Contractor shall retain the services of a third party ETC that is qualified to test electrical equipment, and is an approved testing company by the State of Washington Department of Labor and Industries. The ETC shall not be associated with the manufacture of equipment or systems under test.
- B. The ETC shall have the inspections, calibration, and acceptance tests performed by or under the supervision, review and approval of a professional Electrical Engineer holding a current license from the State of Washington.
- C. The Electrical Engineer shall be an employee of the testing company with at least 5 years of field experience testing electrical apparatus.

- D. The testing company's site lead engineer shall be a degreed electrical engineer, who is a full time employee of the testing company, with at least 5 years of experience testing electrical equipment, troubleshooting and identifying power system and equipment deficiencies.

1.3 RELATED SECTIONS

- A. Section 26 05 73, Power System Studies
- B. Section 26 08 00 Commissioning Support for Contractor requirements in support of the commissioning process.

1.4 REFERENCES

- A. Applicable codes, standards, and references:
 - 1. All inspections and tests shall be in accordance with the following applicable codes and standards except as provided otherwise in this section.
 - a. International Electrical Testing Association – NETA
 - b. National Electrical Manufacturer's Association – NEMA
 - c. American Society for Testing and Materials – ASTM
 - d. Institute of Electrical and Electronic Engineers – IEEE
 - e. American National Standards Institute – ANSI
 - f. National Electrical Safety Code - C2
 - g. State and local codes and ordinances
 - h. Insulated Power Cable Engineers Association – IPCEA
 - i. Association of Edison Illuminating Companies – AEIC
 - j. Occupational Safety and Health Administration - OSHA 29CFR Part 1910.269
 - k. National Electrical Code – NEC
 - l. National Fire Protection Association – NFPA
 - m. ANSI/NFPA 70: National Electrical Code
 - n. ANSI/NFPA 70B: Electrical Equipment Maintenance
 - o. NFPA 70E: Electrical Safety Requirements for Employee Workplaces
 - p. ANSI/NFPA 78: Lightning Protection Code
 - q. ANSI/NFPA 101: Life Safety Code
 - r. NFPA 99: Health Care Facilities
- B. All inspections and tests shall utilize the following references:
 - 1. Project design drawings and specifications
 - 2. Shop drawings and submittals
 - 3. Manufacturer's instruction manuals applicable to each particular apparatus
 - 4. Applicable NETA acceptance testing work scope sections per NETA ATS 1999.

1.5 COORDINATION

- A. Coordinate the Acceptance Testing with the Owner and Owner Representative.
- B. Coordinate ETC and factory field-testing and assistance per the requirements of this section.

1.6 EQUIPMENT AND DEVICE TESTS

- A. Perform all equipment and device testing after installation and prior to substantial completion or owner occupancy, allowing enough time for corrective action of all deficiencies.
- B. Review manufacturer's installation instruction and confirm that equipment is installed in accordance with manufacturer's instructions.
- C. Prior to performing tests confirm that the equipment is clean and free of construction debris and dust.
- 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. Test the open/close or energize/deenergize operation of each switch, circuit breaker, contactor and other item of electrical control with the systems fully energized and operating. Each shall be tested three times. Test report shall include a list of equipment tested and the signed initials of the electricians performing the test on a device by device basis.

1.7 SUBMITTALS

- A. Submittal Information
 - 1. Provide submittal information in accordance with Division 1 - General Requirements, Section 26 05 00 - Common Work Results For Electrical and requirements described in this section.
 - 2. Submit the ETC qualifications according to this section for approval.
 - 3. Submit the coordinated test schedule for approval.
 - 4. Submit detailed test procedures corresponding to the requirements in this section for approval. The test 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 set points and acceptable results for each condition tested.
- B. Test Report
 - 1. The testing firm shall maintain a written record of all tests and shall assemble and certify a final test report indicating all equipment tested and the results found for each. Any system, material, or workmanship which is found to have abnormal operation, shall be specifically identified.
 - 2. Submit a preliminary copy of the hand-written field test results to the Project Engineer and Owner's Representative no longer than one week after the test is completed.
- C. Quality Assurance
 - 1. The testing firm shall submit proof of company qualifications and personnel qualifications. Include resumes of recent experience (within the last three years) for the firm, engineers and technicians that will be assigned to the project. Include references with current phone numbers in the resume.
 - 2. Test Equipment: Provide a complete list of test equipment utilized in all of the testing. Include manufacturer, model number, current calibration date, next calibration date and age of equipment.

3. Prior to energization of equipment submit a letter certifying that the electrical installation being energized complies with contract documents, code and proper system operation.
4. The test reports shall be compiled and submitted in formal form with a summary. The report shall be reviewed and stamped by the Professional Electrical Engineer.

D. Closeout

1. Operational and Maintenance Manuals
 - a. All approved submittal information
 - b. Full test report in the O&M Manual
 - c. Completed form for each item of equipment tested
2. One electronic version of the test report on CD and in the latest version of Microsoft Word.
3. Schedule of recommended testing frequency for all equipment tested under this contract
4. Testing company test stamps or stickers on all tested equipment. Indicate testing company name, testing date and expiration date.

1.8 OPERATIONS AND MAINTENANCE (O&M) MANUALS

- A. Operations and Maintenance Manuals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.

1.9 SCHEDULING

- A. Perform all testing after installation and before energizing. All systems shall pass tests prior to being put into service.
- B. The Contractor in coordination with the ETC Engineer and the equipment manufacturer's representatives 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.
- C. Confirm the test schedule with the Owner's Representative one week prior to the test. The ETC Engineer shall coordinate the test schedule so that the University's Campus Engineering and/or Physical Plant, at their discretion, can witness the testing.
- D. The ETC Engineer shall deliver the test results to the University within 7 working days of test. The Owner shall have the tests results for a two-week review prior to equipment energization.
- E. Testing and calibration of electrical equipment shall be completed prior to the start of commissioning activities. Refer to the commissioning specification to determine which systems are to be commissioned. When required during commissioning, the ETC Engineer shall retest and recalibrate equipment to support the commissioning activities.

1.10 SAFETY AND PRECAUTIONS

- A. Safety practices shall include, but are not limited to, the following requirements:
1. Occupational Safety and Health Act of 1970 – OSHA
 2. Applicable state and local safety operating procedures

3. National Fire Protection Association - NFPA 70E

- B. Tests shall be performed with apparatus de-energized unless otherwise specified (e.g. rotation, phasing).
- C. Power circuits shall have conductors shorted to ground by a hotline grounded device approved for the purpose.
- D. In all cases, work shall not proceed until the Contractor's safety representative has determined that it is safe to do so.
- E. The ETC shall have available, sufficient protective barriers and warning signs, where necessary, to conduct specified tests safely.
- F. The Owner's safety procedures shall be reviewed and understood by the ETC.

1.11 RECEPTACLES

- A. Receptacle Polarity Test: 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 statement of completed testing signed by the electrician that performed the test.
- B. Receptacle Retention (Pull-out) Test: Test every receptacle in patient care areas for retention (pull-out) test of Ground Blade per NFPA 99. Replace receptacles that fail test.
- C. Ground-Fault Receptacle Circuit Interrupter Tests: 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 7/1000 of an ampere within 1/40th of a second and retest.

1.12 WIRING - 600 VOLTS AND UNDER

- A. Scope: Test all circuits that are installed or reconnected under this contract.
- 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 meg-ohm meter test between the conductor and ground of every feeder and all circuits rated over 100 amperes. 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.

1.13 WIRING - OVER 600 VOLTS

- A. Perform tests required by the Washington Administrative Code 296-46B-250.

1.14 GROUND FAULT PROTECTION SYSTEMS

- 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. The relay pickup current shall be determined by current injection at the sensor and the circuit interrupting device operated.
 - 2. 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.
 - 3. System operation shall be tested at fifty-seven percent (57%) rated voltage.
 - 4. Zone interlock systems shall be tested by simultaneous sensor current injection and monitoring zone blocking function.
- D. Test Parameters
 - 1. Relay pickup current shall be within ten percent (10%) of device dial of fixed setting.
 - 2. Relay timing shall be in accordance with manufacturer's published time-current characteristic curves.

1.15 TRANSFORMERS DRY TYPE

- A. Test transformers dry type rated 75 kVA and over provided by this contract.
- B. Visual and Mechanical Inspection. Test dry type transformers per the following procedures:
 - 1. Inspect for physical damage, proper installation, anchorage and grounding.
 - 2. Verify transformer is supplied and connected in accordance with contract documents.
 - 3. Verify that the transformer secondaries have a clockwise phase rotation sequence.
 - 4. Adjust the transformer taps to the nominal system voltages per ANSI C84.1-1989.
- C. Electrical Tests. Perform insulation resistance tests winding-to-winding and winding-to-ground.

1.16 MOTOR CONTROLLERS

- A. Visual and Mechanical Inspection
 - 1. Inspect for physical damage and code violation.
 - 2. Inspect for anchorage and grounding.
 - 3. Compare overload ratings or settings with motor full load current, confirm correct application.
 - 4. Compare starter size with motor horsepower.
- B. Electrical Tests
 - 1. For each motor larger than 5 HP, measure overload time delay by primary current injection at three (3) times motor full load current.
 - 2. Perform operational tests on each starter.
 - 3. Confirm operational interface with Fire Alarm and Division 23 control signals.

1.17 CIRCUIT BREAKERS

- A. Scope. Test all new circuit breakers 100 amps and over within new switchboards and panelboards. Bench test new circuit breakers 100 amps and over that are installed in existing switchboards and panelboards.
- 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.
- 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.

1.18 PANELBOARDS

- A. Inspect for physical damage, proper installation, supports and grounding.
- B. Verify that neutrals are grounded only at the main service.

1.19 SWITCHBOARDS

- A. Scope. Test all new 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 megohmmeter. Record values and report deficiencies.
- E. Inspect for proper identification of protective devices.
- F. Surge Arrestors. Test surge arresters per the following procedures:
 - 1. Visual and Mechanical Inspection
 - a. Inspect for physical damage, such as chipped or fractured porcelain.
 - b. Inspect ground and discharge counter connections for integrity.
 - 2. Electrical Tests
 - a. Perform ground continuity test to ground grid system.

1.20 METERING

- A. Scope: Test all new meters provided by this contract.
- B. Instrument Transformers
 - 1. Verify correct taps and proper connection to meter, instrumentation or transducer.
 - 2. Test transformer polarity electrically
 - 3. Verify connection at secondary CT leads by driving a low current through the leads and checking for this amount at applicable devices
 - 4. Confirm transformer ratio by primary current injection
 - 5. Measure insulation resistance primary-to-ground, secondary-to-ground and primary-to-secondary.
 - 6. Overpotential test primary insulation
 - 7. Measure potential transformer ratio.
- C. Metering and Instrumentation
 - 1. Calibrate all meters at midscale

2. Calibrate watt-hour meter to one-half percent
3. Verify all instrument multipliers

1.21 POWER SYSTEM TESTS

- A. Scope. Inspect and test entire electrical systems provided by this contract to verify equipment and controls are correctly operating. Power system tests shall be performed 4 to 8 weeks after substantial completion, and at such time that the maximum possible load is connected (usually highest available occupancy at mid day.)
- 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. Check shall consist of clamp on ampere readings on each phase for a period of 15 minutes, of each panelboard. Include phase realignment of 1% of the project's 3 pole circuit breakers in bid.
- C. Motor Tests: Check all motors 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. Transformer Taps: Connect all transformers at "Normal" tap. Measure secondary voltages at all new and existing transformers. Forward a list to engineer including service switchboard voltmeter reading at the time of the test for evaluation. Reconnect taps as subsequently directed.
- E. 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

1.22 ISOLATED POWER SYSTEM

- A. After the installation of the isolated power system and equipotential grounding system has been completed, an independent testing agency with assistance from the Contractor shall perform the following tests in accordance with NFPA 56A.
 1. Measure the impedance (capacitive and resistive) to ground of all conductors with the connection between the line isolation monitor and reference grounding point open. Replace wiring that measures less than 500,000 ohms.
 - a. Measure the potential difference and resistances between the isolated power panel ground bus and the grounding pole of each receptacle and the patient grounding point.
 - b. Also measure the potential between the grounding pole of each one of the receptacles and each of the other receptacles. The potential difference shall not exceed 10 millivolts with the system both energized and not energized.
 2. Measure system voltage.
 3. Measure readings of ungrounded system components, including isolation transformer and line isolation monitor.
 4. Measure system leakage with line isolation monitor connected in circuit.
 5. Measure system leakage with surgery track light and film viewers energized.

1.23 EQUIPOTENTIAL GROUNDING SYSTEM

1. After the equipotential grounding system has been installed and prior to the walls being enclosed, the Contractor shall perform the following tests:
 - a. Measure the potential difference between the grounding wire to the patient ground jack and any of the bonded exposed conductive surfaces. Correct bonding of any items with a reading over 100 millivolts.
 - b. Measure the resistance between the grounding wire to the patient ground jack and any of the bonded exposed conductive surfaces. Correct bonding of any items with a reading over 0.1 ohms.
2. After the rooms are finished and all devices are installed, the equipment manufacturer with assistance from the Contractor shall perform the same tests described above, including any items that were not installed prior to the previous tests.
3. Record all test values and include them in the maintenance manual information. The tests shall be witnessed by the Electrical Engineer and the University's Representative. Schedule tests with Owner and Engineer at least one month prior to test date.

PART 2 - PRODUCTS

2.1 TESTING COMPANY

- A. Retain the services of an independent testing company that is qualified to test electrical equipment, and is an approved testing company by the Washington State Department of Labor and Industries.
- B. Pre-approved, subject to the qualifications, third party requirements and association restrictions stated in this section:
 1. Siemens (Westinghouse) Technical Services
 2. ASET Power Systems Services (Division of Sigma Six Inc.)
 3. Electrical Reliability Services (Emerson - ERS; formerly Electrotest, Inc.)
 4. Power Testing and Energization
- C. Testing company shall prepare test reports on the systems they test.
- D. Testing company shall be an independent company, separate from the contractor, sub contractors, suppliers and others involved with the project.

2.2 TEST EQUIPMENT

- A. The Contractor shall provide all apparatus and material required for testing. The Contractor shall use installation tools and test equipment which are designed for the specific task and shall use this equipment per the manufacturer's instructions. All test equipment shall have current calibration certification by a third party calibration laboratory, and shall have a signed and dated calibration sticker affixed to the device. Calibration shall be traceable to the National Bureau of Standards and be less than 6 months since last calibration. Defective test equipment and installation tools shall not be used. Installation tools such as torque wrenches shall be calibration certified.
- B. Use of torque wrenches

1. Use calibrated torque wrenches for all bolted connections on buses and power cable terminations. Mark the head of the bolt with a colored marker pen after its being torqued to manufacturer's recommended value.

PART 3 - EXECUTION

3.1 PROJECT DOCUMENTS

- A. Deliver applicable project documents to testing company two weeks prior to testing. As a minimum include:
 - Division 26 Specification
 - Electrical Floor Plans showing equipment to be tested.
 - Electrical One Line Diagrams
 - Submittals of Manufacturers Data and Shop Drawings including engineers review letter of all systems to be tested.
 - Coordination Study

3.2 SCHEDULE

- A. Perform all testing after installation and before energizing. All primary systems shall pass tests prior to placing in service. Notify Architect 10 working days prior to performance of any test.

3.3 TEST REPORTS

- A. The Contractor 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. ETC shall prepare test reports on the systems tested.
 1. The ETC shall prepare test reports including the following:
 - a. Summary of project
 - b. Description of equipment tested
 - c. Description of test
 - d. Test results including retesting results
 - e. Test dates
 - f. Tester's name
 - g. Witnesses (when required)
 - h. Corrective work
 - i. Acceptance criteria
 - j. Conclusions and recommendations
 - k. Appendix, including appropriate test forms
- 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.

3.4 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 at Contractor's expense until no fault appears.

3.5 LABELS

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

3.6 OBSERVATIONS BY ENGINEER

- A. Contractor shall remove and replace covers of electrical equipment, open manholes and remove/replace ceiling tiles to permit engineer to observe equipment and wiring provided. Furnish ladder and flashlight.

3.7 TROUBLESHOOTING

- A. If a system or device provided under this contract does not operate per manufacturers specifications contractor shall provide qualified men with tools and test equipment to find and repair problem at contractor's expense.

END OF SECTION