

# Electrical - Standard Specifications

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## INSPECTION, CALIBRATION AND TESTING

### STANDARD SPECIFICATIONS

This standard specification is intended to be integrated into the project specifications. The Consultant shall write the specifications to meet the project needs in consultation with the Owner.

#### **PART 1 - GENERAL**

##### 1.01 DESCRIPTION

###### A. Purpose

1. The purpose of this section is to assure that all electrical equipment, both Contractor and Owner- supplied, is operational, within industry manufacturer's tolerances, calibrated per the Power System Studies, complies with all applicable codes, installed in accordance with design specifications, and functioning in the system in the manner designed by the engineer. This effort should minimize damage and limit outages caused by electrical failures, assure proper personnel protection, and will determine suitability for reliable operation.

###### B. General

1. 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:
  - a. 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.
  - b. 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.
  - c. 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.

2. 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.

## 1.02 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 licensed professional 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.
- E. Pre-approved, subject to the qualifications, third party requirements and association restrictions stated in this section:
  1. Siemens Technical Services
  2. Sigma Six Inc.
  3. Electrotest, Inc.

## 1.03 RELATED SECTIONS

- A. The work under this section is subject to requirements of the Contract Documents including the GENERAL CONDITIONS, SUPPLEMENTAL CONDITIONS, and sections under Division 1 GENERAL REQUIREMENTS.
- B. Power System Protective Device Studies
- C. Refer to Commissioning section for Contractor requirements in support of the commissioning process.

## 1.04 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

## 1.05 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.

## 1.06 SUBMITTALS

A. General

- 1. Submittals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.
- 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 setpoints and acceptable results for each condition tested.
- 5. 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.
- 6. Prior to energization of equipment submit a letter certifying that the electrical installation being energized complies with contract documents, code and proper system operation.
- 7. 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.

### 1.07 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.

### 1.08 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 Engineering Services 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.

### 1.09 MEETINGS

- A. Pre-installation conference: The Contractor shall request a pre-testing conference with the University's Engineering Services. For projects with medium/high voltage testing, the group shall include the University's Campus Operations High Voltage Shop.

### 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.

## **PART 2 - PRODUCTS**

### 2.01 TEST EQUIPMENT

- A. All test equipment shall be furnished by and remain the property of the Contractor.
- B. Test instrument calibration
  - 1. The electrical testing Contractor shall have a calibration program, which maintains all applicable test instrumentation within rated accuracy.
  - 2. The accuracy shall be traceable to the National Bureau of Standards in an unbroken chain.
  - 3. Up-to-date calibration labels shall be visible on all test equipment.
- C. 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**

### 3.01 REQUIREMENTS

- A. Perform acceptance tests in accordance with manufacturer's recommendations, NFPA 70B and International Electrical Testing Association (NETA) testing specifications NETA ATS-1999.
- B. Voltage adjustments shall be in accordance with SCL Standard E1-4.1.
- C. The test plan, procedures, test results and reports shall be reviewed, under the supervision of and approved by the ETCs site engineer who is a licensed professional Electrical Engineers.
- D. Division of responsibility:
  - 1. The Electrical Contractor shall torque down all accessible bolts, perform routine insulation resistance and continuity tests on branch and feeder circuits and rotational tests for all distribution and utilization equipment, prior to and in addition to tests performed by the ETC specified in this section.
  - 2. The Electrical Contractor shall supply a suitable and stable source of test power to the ETC at each test site. The ETC shall specify these requirements.
  - 3. The Electrical Contractor shall notify the ETC Company when equipment becomes available for electrical tests. Work shall be coordinated to expedite project scheduling.
  - 4. The Electrical Contractor shall clean all the electrical equipment prior to testing by the ETC.
  - 5. The ETC Company shall be responsible for implementing all final settings and adjustments on protective devices and electrical equipment in accordance with the Power System Protective Device Studies.

- E. Any questions or concerns identified shall be promptly addressed to the Owner's Representative.
- F. Any system, material, or workmanship which is found defective on the basis of electrical inspections and tests shall be reported directly to the Owner's Representative.
- G. If a test reveals a fault or problem, the entire test will be repeated until the problem is corrected. Submit additional written test reports.
- H. Maintain a written record of all tests, and upon completion of the project, assemble and certify a final test report. The field test reports shall be compiled, "stamped", and signed by the site lead engineer.
- I. Power systems protective device calibration
  - 1. Adjustments, settings and modifications
    - a. The ETC shall calibrate necessary field settings, adjustments and minor modifications to conform to 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.)
      - i. Adjust protective devices to the values provided in the coordination study.
      - ii. Test the minimum pickup and delay, ground fault pickup and delay.
      - iii. The trip characteristics, when adjusted to setting parameters, shall fall within the manufacturer's published time-current characteristic tolerance.
    - 2. The ETC shall verify that the protective devices have been adjusted and set in accordance with the approved protective device study.
- J. Acceptance criteria
  - 1. Each function and test shall be performed under conditions which simulate actual operating conditions as closely as possible.
    - a. To that end the Contractor shall provide all necessary materials and equipment and temporary system voltages and currents to simulate fault conditions on the system being tested in order to prove and verify proper operation.
    - b. At satisfactory completion of all verified tests, the building electrical system being tested shall be returned to the condition required by the contract documents as a complete and operational system.
  - 2. The ETC shall perform general inspections at the job site and shall also review the following:
    - a. Assembly of the accessory equipment, and the interconnecting wiring for control circuits and fire alarm interface
    - b. General Inspection of the following: 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; verify that shop drawings and instructions have been shipped with all equipment and are available.

- c. Support of electrical equipment: Inspect and check all electrical equipment for support and seismic bracing.
  - d. Spare fuses: The ETC Engineer shall inspect and verify spare fuse inventory as specified by Division 26 00 00.
3. Testing requirements and procedures
- a. The following equipment and systems shall be inspected and tested by the ETC per NETA, manufacturer's instructions, and additional requirements noted.
    - i. Transformers
      - (a) All dry type greater than 600 Volt
      - (b) Dry type 600 Volt and below
        - (1) All transformers greater than or equal to 167 KVA single-phase and 225 KVA 3-phase
      - (c) All liquid-filled transformers.
      - (d) Tests
        - (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.
    - ii. Instrument transformers
    - iii. Medium voltage vacuum and air circuit breakers
    - iv. Cables
      - (a) Medium voltage cable (greater than 600V)
        - (1) Apply grounds for a time period adequate to drain all insulation-stored charge - minimum of 24 hours.
        - (2) Field test D.C. voltages (kilovolts):

<b>Insulation Voltage Class</b>	<b>Acceptance Voltage</b>	<b>Maintenance Voltage</b>
	<b><i>New Cable</i></b>	<b><i>Cable age &gt; 10 years</i></b>
15kV AC	35kV DC	16kV DC
5kV AC	15kV DC	2.5kV DC, Megger for 10 minutes

\*Prior to splicing new cable into existing, test existing cable at maintenance value. If acceptable, perform splicing, then test old and new together at the maintenance value.

- v. AC and DC motors 10 hp and larger
- vi. DC battery systems
- vii. Surge arrestors
- viii. Reactors
- ix. Other utilization equipment
- x. Switches (air and oil)
  - (a) Verify correct wire bending radii at terminations per wire manufacturer's recommendations and NEC.
- xi. Circuit breakers
  - (a) Low voltage power circuit breakers (all) and insulated case/molded case circuit breakers 400a and larger and all with adjustable instantaneous trip adjustments.
    - (1) Calibrate and set all breaker settings per the Protective Device Coordination Study.
- xii. Protective relays and devices
  - (a) Modify NETA tests according to manufacturer's recommended testing procedures.
  - (b) Calibrate and set all relay settings according to the Protective Device Coordination Study.
- xiii. Ground fault systems
  - (a) Calibrate and set all ground fault settings according to the Protective Device Coordination Study.
- xiv. Metering
  - (a) Modify NETA tests according to manufacturer's recommended testing procedures.
  - (b) Calibrate and set all meter configuration settings.
    - (1) Settings:
      - Set Vars to + to the load.
      - Remote programming enabled
      - Request the device address from the University and set it accordingly.
      - Setup PT and CT ratios, system voltage and all other programmable parameters to make the meter and its features fully functional.
- xv. Emergency off switches



- (a) Test all emergency off switches and verify shut down and reset of equipment.
- xvi. Motor control
  - (a) Motor starters - medium and low voltage
- xvii. Motor control centers
  - (a) Verify correct overload heaters are installed.
- xviii. Variable frequency drives
  - (a) Electrical tests and inspections to be performed by the manufacturer
  - (b) Measure and document harmonics at main switchgear or a designated point of common coupling. Confirm measurements meet Division 15 requirements.
- xix. Capacitors
  - (a) Verify that 97% power factor correction has been reached at full equipment load.
- b. The following equipment shall be inspected and test by the manufacturer's authorized service representative in coordination with the ETC and the Contractor. Inspect and test according to NETA, the manufacturer's recommended procedures and the operational testing procedures described herein.
  - i. Spot or distributed network substations:

Special functional testing requirements are detailed below for power substations that are configured as spot or distributed networks. These procedures are based on the typical "Network Control" and "Network Control Power" schematic drawings shown in the Switchboard section. Modify procedures as needed to suit the actual network protector system provided. Items a through c shall be completed before scheduling the testing procedure with the University detailed in Items d through dd.

    - (a) Complete the entire installation for the unit substation including the bus tie to the other two unit substations so the entire substation is functional.
    - (b) Set all breaker trip unit functions per the coordination study. Remember to configure the spot network relay.
    - (c) The testing agency shall complete all the required testing and calibration for the entire substation and associated equipment/devices. This includes breakers, relays, and other devices set according to the Short Circuit and Coordination study.
    - (d) Arrange for the following testing with the UW High Voltage Shop, Engineering Services and the UW Construction Manager/Coordinator. The network relay and/or switchgear manufacturer representative should be present to assist in the commissioning process. Only the original equipment manufacturer's authorized service representative shall perform

- all testing associated with network protector relays. No exceptions to this requirement shall be permitted.
- (e) The UW High Voltage Shop shall inspect the primary switch and unit substation for proper connection and verify phasing.
  - (f) Place the network Auto/Off/Manual selector switch into the off position.
  - (g) With the main and tie breaker open and racked out, close the primary switch to energize the transformer.
  - (h) The High Voltage Shop shall verify phasing, rotation and voltage at both the transformer and across the open tie breaker.
  - (i) Verify control voltage is present.
  - (j) Rack in the main breaker.
  - (k) Place the network Auto/Off/Manual selector switch into the manual mode. The main breaker should charge but not close.
  - (l) Make sure the 86 lock-out relay is reset.
  - (m) Close the main breaker with the breaker control switch. Check the bus and control voltage.
  - (n) Trip the main breaker with the breaker control switch. The main breaker should open and the breaker should recharge.
  - (o) Open the primary switch and discharge the main breaker spring.
  - (p) Place the network Auto/Off/Manual selector switch into the off position.
  - (q) Rack in and close the network tie breaker. Check the bus and control voltage.
  - (r) Place the network Auto/Off/Manual selector switch into the manual position. The main breaker should charge but not close.
  - (s) Attempt to close the main breaker with the breaker control switch. The breaker should not close since the primary switch is open.
  - (t) Place the network Auto/Off/Manual selector switch into the Auto position. The main breaker should not close since the primary switch is open.
  - (u) Close the primary switch. The main breaker should automatically reclose.
  - (v) Place the network protector Auto/Off/Manual selector switch into the manual mode.
  - (w) Trip the main breaker with the breaker control switch.
  - (x) With the main breaker NAC contact on the breaker control switch tripped (green flag), place the network Auto/Off/Manual selector switch into the auto mode. The main breaker should not reclose.
  - (y) Close the main breaker with the breaker control switch, resetting the NAC switch (red flag). The main breaker should automatically reclose.
  - (z) Trip the 86 lockout relay which should open the main breaker and lock it out.
  - (aa) Reset the 86 lockout relay. The main breaker should automatically reclose.
  - (bb) Open the primary switch. The main breaker should trip and recharge.
  - (cc) Close the primary switch. The main breaker should reclose.
  - (dd) Repeat the last two steps with the tie breaker open and also the network Auto/Off/Manual selector switch in the off and manual modes.

- ii. Emergency systems
  - (a) Emergency generator systems
    - (1) Inspect and test per NETA and manufacturer's recommended start-up and testing procedures.
    - (2) Perform resistive and reactive load testing at .8 pf (lagging).
    - (3) Test phase rotation to determine compatibility with load requirements.
  - (b) Automatic transfer switches
    - (1) Coordinate with Automatic Transfer Switches Section.
    - (2) Verify clockwise phase rotation and in-phase transfer between the two sources of power.
    - (3) Adjust all timers and other parameters as recommended by the manufacture and the Engineer. A set-up sheet of final parameter settings, which includes spare columns for future modifications, shall be provided inside the enclosure.
    - (4) Test all the standard and optional features specified for the transfer switches.
    - (5) Test load management contacts, both block transfer and load shed. Simulate a load-shed signal from the CMCS (Central Monitoring and Control System) for this purpose.
  - (c) Uninterruptible power supplies
- c. The following equipment shall be inspected and tested by the Contractor. Coordinate activities with the manufacturer's authorized service representatives and the ETC.
  - i. General power system tests
    - (a) Load balance tests: Check all panelboards for proper load balance between phase conductors, and make adjustments as necessary to bring unbalanced phases to within 15% of average load.
    - (b) Motor tests: Check all motors for proper rotation and measure actual load current. Submit tabulation of motor currents for all motors 10 HP and larger after the HVAC system has been balanced.
    - (c) 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.
  - ii. Metal enclosed ducts
    - (a) Inspect bus for physical damage and proper connection. Clean interior and insulators where applicable.
    - (b) Inspect for proper bracing, suspension, alignment and enclosure grounding.

- (c) Measure insulation resistance of each bus phase-to-phase and phase-to-ground (1 minute minimum).
    - (d) Inspect all accessible bus joints and cable connections by infrared scanner to detect loose or high-resistance connections and other circuit anomalies.
  - iii. Low voltage feeder and branch circuit conductors 4/0 and larger (600V and below)
    - (a) Test for continuity of each circuit.
    - (b) Test for grounds in each circuit; test 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.
    - (c) 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 2500 feet and over, nor less than 8 megohms for those circuits (115V-600V) with single conductor length of less than 2500 feet. If conductor fails test, replace wiring or correct defect and retest.
    - (d) Perform torque test for every conductor tested and terminated in an overcurrent device or bolted type connection; torque all connections per manufacturer's recommendations and tabulate the results on a tabular form.
  - iv. Panelboards
    - (a) Inspect for physical damage, proper installation, supports and grounding.
    - (b) Verify that neutrals are grounded only at the main service.
    - (c) 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.
  - v. Grounding systems
    - (a) Perform fall-of-potential test on main grounding electrode system per IEEE Standard No. 81. Maximum resistance to ground shall be less than 5 Ohms for commercial or industrial systems and less than 1 ohm for generating or transmission station grounds. If this resistance cannot be obtained with the ground system, notify UW Project Coordinator for further instruction.
    - (b) Verify that neutrals are grounded only at the main service by removing the service neutral grounding conductor and meggering the neutral bus.
    - (c) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system-neutral, and/or derived neutral points. Investigate resistance values, which exceed .5 ohm. If this resistance cannot be obtained with the ground system, notify UW Project Coordinator for further instruction.
  - vi. Convenience receptacles

- (a) Receptacle polarity test: Randomly test one receptacle in each room or hallway installed or re-connected by this project. Test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot on neutral and hot open. For Hospital areas add retention (pull out) test of Ground Blade per NFPA99. Rewire receptacles as required.
  - (b) Ground-fault receptacle circuit interrupter tests: The Test Engineer shall test each receptacle or branch circuit breaker having ground-fault circuit protection to ensure 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.
- vii. Special systems
- (a) Service column for operating rooms
  - (b) Test each electrical and communication device to insure proper connections. If device does not work, find the problem and correct it. This work shall include correcting wiring inside the patient service column. Demonstrate correct polarity and show that neutral to "hot" does not exceed 68 volts AC.
- viii. Isolated power system for operating rooms
- (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.
    - (2) 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.
    - (3) 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.
  - (b) Measure system voltage.
  - (c) Measure readings of ungrounded system components, including isolation transformer and line isolation monitor.
  - (d) Measure system leakage with line isolation monitor connected in circuit.
  - (e) Measure system leakage with surgery track light and film viewers energized.
- ix. Equipotential grounding system for operating rooms

- (a) After the equipotential grounding system has been installed and prior to the walls being enclosed, the Contractor shall perform the following tests:
  - (1) 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.
  - (2) 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.
- (b) 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.
- (c) 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.

K. Labels

1. Upon completion of the inspection, calibration and testing, attach a label to all devices tested. These labels shall indicate the date tested, the ETC company name and tester's initials.

L. Retesting

1. 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.

### 3.02 REPORTS

- A. ETC shall prepare test reports on the systems tested. Include a copy of each test report in the Operation and Maintenance Manuals.

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