SECTION 26 05 53 - TESTS AND IDENTIFICATION

PART 1 - GENERAL

1.01 SECTION INCLUDES
A. Provide all work required to list, procure, fabricate and install all nameplates, labels, tags, and identifiers for power and communications cable and equipment shown on the drawings.

B. Complete all acceptance and start-up tests for power and communications cabling and equipment. For additional requirements refer to Division 27 Section, Voice and Data Communication.

C. The work includes planning, listing of all identifiers, installation, testing of all cable and equipment and documentation.

1.02 SUBMITTALS
A. Test Reports: In accordance with Division 1 requirements.

1.03 DEFINITION
A. Circuit designation: This term is construed to mean panel designation and circuit number, i.e.: LA-13.

1.04 SAFETY AND PRECAUTIONS
A. All parties involved must be cognizant of applicable safety procedures. This document does not include any procedures, including specific safety procedures. It is recognized that an overwhelming majority of the tests and inspections recommended in these specifications are potentially hazardous. Individuals performing these tests shall be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved.

B. Safety practices shall include, but are not limited to, the following requirements:
   1. All applicable provisions of the Occupational Safety and Health Act, particularly OSHA 29CFR 1910.
   3. Applicable state and local safety operating procedures.
   4. Owner’s safety practices.
   5. ANSI/NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces.
C. A safety lead person shall be identified prior to commencement of work.

D. A safety briefing shall be conducted prior to the commencement of work.

E. All tests shall be performed with the apparatus de-energized and grounded except where otherwise specifically required to be ungrounded or energized for certain tests.

F. The testing organization shall have a designated safety representative on the project to supervise operations with respect to safety.

1.05 SYSTEM FUNCTION TESTS

A. It is the purpose of system function tests to prove the correct interaction of all sensing, processing, and action devices.

B. Perform system function tests upon completion of the acceptance tests on specified equipment.

1. Develop test parameters and perform tests for the purpose of evaluating performance of all integral components and their functioning as a complete unit within design requirements and manufacturer's published data.

2. Verify the correct operation of all interlock safety devices for fail-safe functions in addition to design function.

3. Verify the correct operation of all sensing devices, alarms, and indicating devices.

1.06 THERMOGRAPHIC SURVEY

A. Equipment to be inspected shall include all current-carrying devices.

1. Visual and Mechanical Inspection

   a. Perform thermographic survey when load is applied to the system.

   b. Remove all necessary covers prior to thermographic inspection. Use appropriate caution, safety devices, and personal protective equipment.

2. Provide a report which includes the following:

   a. Description of equipment to be tested.

   b. Discrepancies.

   c. Temperature difference between the area of concern and the reference area.

   d. Probable cause of temperature difference.

   e. Areas inspected. Identify inaccessible and/or unobservable areas and/or equipment.
f. Identify load conditions at time of inspection.
g. Provide photographs and/or thermograms of the deficient area.
h. Recommended action.

3. Test Parameters
   a. Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1° C at 30° C.
   b. Equipment shall detect emitted radiation and convert detected radiation to visual signal.
   c. Thermographic surveys should be performed during periods of maximum possible loading. Refer to ANSI/NFPA 70B, Section 20.17.

4. Test Results
   a. Suggested actions based on temperature rise can be found in NETA-ATS Table 100.18.

1.07 TESTS AND ADJUSTMENTS

A. All test equipment shall be in good mechanical and electrical condition.
   1. The testing organization shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy for each test instrument calibrated.
   2. The firm providing calibration service shall maintain up-to-date instrument calibration instructions and procedures for each test instrument calibrated.
   3. The accuracy shall be directly traceable to the National Institute of Standards and Technology (NIST).
   4. Instruments shall be calibrated in accordance with the following frequency schedule:
      a. Field instruments: Analog, 6 months maximum. Digital, 12 months maximum.
      b. Laboratory instruments: 12 months maximum.
      c. Leased specialty equipment: 12 months maximum.
      d. Dated calibration labels shall be visible on all test equipment.
      e. Records, which show date and results of instruments calibrated or tested, must be kept up to date.
   5. Calibrating standard shall be of better accuracy than that of the instrument tested.
B. Field test metering used to check power system meter calibration must be more accurate than the instrument being tested.

C. Accuracy of metering in test equipment shall be appropriate for the test being performed.

D. Waveshape and frequency of test equipment output waveforms shall be appropriate for the test and the tested equipment.

E. Testing and adjustments of equipment shall be made by an Owner-approved independent testing firm. Testing firm shall meet the criteria for full membership of the International Electrical Testing Association (NETA). All equipment acceptance tests for power apparatus shall be made in accordance with the latest version of NETA-ATS, Acceptance Testing Specification. Submit testing firm qualifications to Owner for approval.

F. Prior to energizing, test all systems. Test to ensure systems are:
   1. Free from short circuits and grounds.
   2. Free from mechanical and electrical defects.

G. Adjust all equipment for its intended use and rating as defined in manufacturer’s specifications and test procedures.

H. Adjust distribution transformer taps under full load operating conditions, to provide nominal operating voltages at the loads. (+5% for light loads, nominal at full load).

I. Ground systems:
   1. Visual and mechanical inspection: Verify ground system is in compliance with Drawings and Specifications.
   2. Electrical tests:
      a. Perform fall-of-potential test or alternative in accord with IEEE 81, latest version, on the main grounding electrode or system.
      b. Perform point-to-point tests to determine resistance between main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.
   3. Test values:
      a. The resistance between main grounding electrode and ground shall be no greater than 10 ohms. Additional rods shall be installed and bonded to
grounding system and driven to a depth of 50 ft. or refusal, whichever comes first.

b. Investigate point-to-point resistance values which exceed 0.5 ohm.

c. Record all test values and provide certified copies to Owner.

J. Cable Insulation Resistance Test:

1. Make insulation resistance tests on all power cables using a self-contained instrument such as the direct-indicating ohmmeter of the generator type, or “megger” such as manufactured by J.G. Biddle Company, or Owner-approved equivalent. Insulation resistance values shall be at least 75% of shop test records.

   a. Apply the following test voltages for 1 minute, except where specified otherwise herein, in accord with procedure recommended by manufacturer of test equipment and as specified herein.

<table>
<thead>
<tr>
<th>Rated Circuit Voltage</th>
<th>Megger Voltage (DC)</th>
<th>Minimum Megger Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 volts</td>
<td>500 volts</td>
<td>600 kilohms</td>
</tr>
<tr>
<td>4160 volts</td>
<td>2500 volts</td>
<td>1000 megohms</td>
</tr>
<tr>
<td>15,000 volts</td>
<td>5000 volts</td>
<td>5000 megohms</td>
</tr>
</tbody>
</table>

2. Record all test values and provide certified copies to Owner.

3. Replace cables not meeting specified resistance values.

K. Medium-voltage cables:

1. Visual and mechanical inspection before testing cables:

   a. Compare cable data with Drawings and Specifications.

   b. Inspect exposed sections of cables for physical damage.

   c. Inspect for shield grounding, cable support, and terminations when cables are disconnected from any apparatus. Cables shall be positioned to minimize surface leakage current and corona.

   d. Verify that visible cable bends meet manufacturer’s minimum allowable bending radius.

   e. Inspect for adequate fireproofing in common cable areas.
f. Visually inspect splice jacket and insulation condition.

2. Electrical tests:
   a. Perform a shield-continuity test on each power cable by ohmmeter method.
   b. Perform an insulation-resistance test utilizing a megohmmeter with a voltage output of at least 2500 volts. Individually test each conductor with all other conductors and shields grounded. Test duration shall be 1 minute.
   c. Perform a DC high-potential test on all cables. Adhere to all precautions and limits as specified in the applicable NEMA/ICEA standard for the specific cable. Perform tests in accord with ANSI/IEEE 400. Test procedure shall be as follows, and the results for each cable test shall be recorded as specified herein. Test voltage shall be 50 Kv but shall not exceed 80% of cable manufacturer’s factory test value or the maximum test voltage of 55 kV.
      1) Ensure that the input voltage to the test set is regulated.
      2) Current-sensing circuits in test equipment shall measure only the leakage current associated with the cable under test and shall not include internal leakage of the test equipment.
      3) Record wet- and dry-bulb temperatures or relative humidity and temperature.
      4) Test each section of cable individually.
      5) Individually test each conductor with all other conductors grounded. Ground all shields.
      6) Terminations shall be adequately corona-suppressed by guard ring, field reduction sphere, or other suitable methods as necessary.
      7) Ensure that the maximum test voltage does not exceed the limits for terminators specified in IEEE 48 or manufacturer’s specifications.
      8) Apply a DC high-potential test in at least five equal increments until maximum test voltage is reached. No increment shall exceed the voltage rating of the cable. Record DC leakage current at each step after a constant stabilization time consistent with system charging current.
      9) Raise the conductor to the specified maximum test voltage and hold for 15 minutes on shielded cable. Record readings of leakage current at 30 seconds and 1 minute, and at 1 minute intervals thereafter.
     10) Gradually reduce the conductor test potential to zero and measure residual voltage at discrete intervals.
11) Apply grounds for a time period of at least 60 minutes and adequate to drain all insulation stored charge.

3. Test values:
   a. Shielding shall exhibit continuity. Investigate resistance values in excess of 10 ohms per 1000 ft. of cable.
   b. Investigate any failed high-potential test.
   c. Record all test values and report of repairs made and provide certified copies to Owner.

L. Transformers Dry-Type

1. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with drawings and specifications.
   b. Inspect physical and mechanical condition.
   c. Verify removal of any shipping bracing after final placement.

2. Inspect all bolted electrical connections for high resistance using one of the following methods:
   a. Use of low-resistance ohmmeter in accordance with Section 5 (Electrical Tests).
   b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data.
   c. Perform thermographic survey.

3. Perform specific inspections and mechanical tests as recommended by manufacturer.

4. Verify correct equipment grounding.

5. Electrical Tests:
   a. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable, in accordance with Section 1 (Visual and Mechanical Inspection).
   b. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground.
   c. Calculate polarization index.
   d. Perform turns-ratio tests at all tap positions.
e. Perform winding resistance tests on all tap positions.

6. Test Values:
   a. Compare bolted connection resistance to values of similar connections.
   b. Bolt-torque levels should be as specified by manufacturer.
   c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer’s data is not available, investigate any values which deviate from similar connections by more that 50 percent of the lowest value.
   d. Insulation-resistance test values at one minute should not be less than 5000 megohms.
   e. The polarization index shall be greater than 1.5 and shall be recorded for future reference.
   f. Turns-ratio test results shall not deviate more than one-half percent from either the adjacent coils or the calculated ratio.
   g. Windings-resistance test results, after factoring in temperature correction, should compare within on percent of factory obtained results except in instances of extremely low resistance values.

M. Transformers, Liquid Filled
   1. Visual and Mechanical Inspection
      a. Compare equipment nameplate data with drawings and specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, and grounding.
      d. Verify the presence of PCB content labeling.
      e. Verify removal of any shipping bracing after placement.
      f. Verify the bushings are clean.
      g. Inspect impact recorder prior to unloading, if applicable.
      h. Test dew point of tank gases, if applicable.
      i. Verify that alarm, control, and trip settings on temperature and level indicators are as specified.
      j. Verify that cooling fans and/or pumps operate correctly and that fan and pump motors have correct overcurrent protection, if applicable.
k. Verify operation of alarm, control, and trip circuits from temperature and level indicators, pressure relief device, gas accumulator, and fault pressure relay, if applicable.

l. Inspect bolted electrical connections for high resistance using one of the following methods:
   1) Use of low-resistance ohmmeter.
   2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA-ATS Table 100.12.
   3) Perform thermographic survey.

m. Verify correct liquid level in tanks and bushings.

n. Verify that positive pressure is maintained on gas-blanketed transformers.

o. Perform inspections and mechanical tests as recommended by the manufacturer.

p. Test load tap-changer if applicable.

2. Electrical Tests

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable.

b. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground, with test voltage in accordance with NETA-ATS Table 100.5. Calculate polarization index.

c. Perform turns-ratio tests at all tap positions.

d. Perform excitation-current tests in accordance with test equipment manufacturer's published data.

e. Measure the resistance of each high-voltage winding in each no-load tap-changer position. Measure the resistance of each low-voltage winding in each load tap-changer position, if applicable.

f. Remove a sample of insulating liquid in accordance with ASTM D 923. Sample shall be tested for the following.

   1) Dielectric breakdown voltage: ASTM D 877 and/or ASTM D 1816
   2) Acid neutralization number: ANSI/ASTM D 974
   3) Interfacial tension: ANSI/ASTM D 971 or ANSI/ASTM D 2285
   4) Color: ANSI/ASTM D 1500
5) Visual Condition: ASTM D 1524

6) Remove a sample of insulating liquid in accordance with ASTM D 3613 and perform dissolved-gas analysis (DGA) in accordance with ANSI/IEEE C57.104 or ASTM D3612.

3. Test Values
   a. Compare bolted connection resistances to values of similar connections.
   b. Bolt-torque levels should be in accordance with NETA-ATS Table 100.12 unless otherwise specified by the manufacturer.
   c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer’s published data. If manufacturer’s data is not available, investigate any values which deviate from similar connections by more than 50 percent of the lowest value.
   d. Insulation-resistance test values at one minute should be in accordance with NETA-ATS Table 100.5.
   e. The polarization index shall be greater than 1.0 and shall be recorded for future reference.
   f. Turns-ratio test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio.
   g. Temperature corrected winding-resistance measurements should compare within one percent of factory obtained results.
   h. Core insulation values should not be less than 1.0 megohm at 500 volts dc.
   i. Insulating liquid test results shall be in accordance with NETA-ATS Table 100.4.
   j. Evaluate results of dissolved-gas analysis in accordance with ANSI/IEEE C57.104. Use results as baseline for future tests.
   k. Compare grounding impedance device results to manufacturer’s published data.

N. Switchgear and Switchboard Assemblies
   1. Visual and Mechanical Inspection:
      a. Compare equipment nameplate data with drawings and specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding, and required area clearances.
d. Verify the unit is clean.

e. Verify that fuse and/or circuit breaker sizes and types correspond to drawings and coordination study as well as to the circuit breaker’s address for microprocessor-communication packages.

f. Verify that current and voltage transformer ratios correspond to drawings.

g. Inspect bolted electrical connections for high resistance using one of the following methods:
   (1) Use of low-resistance ohmmeter.
   (2) Verify tightness of accessible bolted electrical connections by calibrated torque-Wrench method in accordance with manufacturer’s published data or NETA-ATS Table 100.12.
   (3) Perform thermographic survey.

h. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
   (1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
   (2) Make key exchange with devices operated in off-normal positions.

i. Lubrication requirements
   (1) Verify appropriate lubrication on moving current-carrying parts.
   (2) Verify appropriate lubrication on moving and sliding surfaces.

j. Inspect insulators for evidence of physical damage or contaminated surfaces.

k. Verify correct barrier and shutter installation and operation.

l. Exercise all active components.

m. Inspect mechanical indicating devices for correct operation.

n. Verify that filters are in place and/or vents are clear.

o. Perform visual and mechanical inspection of instrument transformers.

p. Inspect control power transformers.
   (1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
   (2) Verify that primary and secondary fuse or circuit breakers ratings match drawings.

q. Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests
a. Perform electrical tests on instrument transformers in accordance with Section 7.10.

b. Perform ground-resistance tests in accordance with Section 7.13.

c. Perform resistance measurements through bolted electrical connections with a low-resistance ohmmeter, if applicable, in accordance with Section 7.1.1.

d. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute in accordance with NETA-ATS Table 100.1.

e. Perform an overpotential test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer’s published data. If manufacturer has no recommendation for this test, it shall be in accordance with NETA-ATS Table 100.2. The test voltage shall be applied for one minute.

f. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute. For units with solid-state components or control devices that can not tolerate the applied voltage, follow manufacturer’s recommendation.

g. Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 ampere flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

h. Determine accuracy of all meters and calibrate watthour meters in accordance with Section 7.11. Verify multipliers.

i. Perform phasing check on double-ended or dual-source switchgear to insure correct bus phasing from each source.

j. Control Power Transformers

(1) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with NETA-ATS Table 100.1 unless otherwise specified by manufacturer.

(2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at all devices.

(3) Verify correct secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.

(4) Verify correct function of control transfer relays located in switchgear with
multiple control power sources.

k. Voltage Transformers

(1) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with NETA-ATS Table 100.1 unless otherwise specified by manufacturer.

(2) Perform secondary wiring integrity test. Verify correct potential at all devices.

(3) Verify secondary voltages by energizing primary winding with system voltage.

l. Verify operation of cubicle switchgear/switchboard space heaters.

3. Test Values

a. Compare bus connection resistances to values of similar connections.

b. Bolt-torque levels should be in accordance with NETA-ATS Table 100.12 unless otherwise specified by manufacturer.

c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer’s published data. If manufacturer’s data is not available, investigate any values which deviate from similar bus by more than 50 percent of the lowest value.

d. Insulation-resistance values for bus and control power transformers shall be in accordance with manufacturer’s published data. In the absence of manufacturer’s published data, use NETA-ATS Table 100.1. Values of insulation resistance less than this table or manufacturer’s minimum should be investigated. Overpotential tests should not proceed until insulation-resistance levels are raised above minimum values.

e. Bus insulation shall withstand the overpotential test voltage applied.

f. Insulation-resistance values for control wiring shall be a minimum of 2.0 megohms.

O. Switches, Air, Medium Voltage, Metal-Enclosed

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and required clearances.

d. Verify the unit is clean.
e. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.

f. Verify that fuse sizes and types are in accordance with drawings, short-circuit studies, and coordination study.

g. Verify that expulsion-limiting devices are in place on all holders having expulsion-type elements.

h. Verify that each fuseholder has adequate mechanical support and contact integrity.

i. Inspect bolted electrical connections for high resistance using one of the following methods:
   (1) Use of low-resistance ohmmeter.
   (2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data or NETA-ATS Table 100.12.
   (3) Perform thermographic survey.

j. Verify operation and sequencing of interlocking systems.

k. Verify correct phase barrier installation.

l. Verify correct operation of all indicating and control devices.

m. Lubrication requirements
   (1) Verify appropriate lubrication on moving current-carrying parts.
   (2) Verify appropriate lubrication on moving and sliding surfaces.

2. Electrical Tests

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable.

b. Measure contact resistance across each switchblade and fuseholder.

c. Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground with switch closed and across each open pole for one minute. Test voltage shall be in accordance with manufacturer’s published data or NETA-ATS Table 100.1.

d. Perform an overpotential test on each pole with switch closed. Test each pole-to-ground with all other poles grounded. Test voltage shall be in accordance with manufacturer’s published data or NETA-ATS Table 100.2.

e. Measure fuse resistance.
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f. Verify cubicle space heater operation.

3. Test Values
   a. Compare bolted connection resistances to values of similar connections.
   b. Bolt-torque levels should be in accordance with NETA-ATS Table 100.12 unless otherwise specified by manufacturer.
   c. Microhm or millivolt drop values should not exceed the high levels of the normal range as indicated in the manufacturer’s published data. If manufacturer’s data is not available, investigate any values which deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   d. Insulation resistance values should be in accordance with manufacturer’s published data or NETA-ATS Table 100.1.
   e. The insulation shall withstand the overpotential test voltage applied.
   f. Investigate fuse resistance values that deviate from each other by more than 15 percent.

P. Capacitors
   1. Visual and Mechanical Inspection
      a. Compare equipment nameplate data with drawings and specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, and grounding.
      d. Verify the units are clean.
      e. Verify that capacitors are electrically connected in their specified configuration.
      f. Inspect bolted electrical connections for high resistance using one of the following methods:
         (1) Use of low-resistance ohmmeter.
         (2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data or NETA-ATS Table 100.12.
         (3) Perform thermographic survey.
   2. Electrical Tests
a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable.

b. Perform insulation-resistance tests from phase terminal(s) to case for one minute. Test voltage and minimum resistance shall be in accordance with manufacturer’s published data or NETA-ATS Table 100.1.

c. Measure the capacitance of all terminal combinations.

d. Confirm automatic discharging in accordance with NFPA 70 National Electrical Code Article 460.

3. Test Values

a. Compare bolted connection resistances to values of similar connections.

b. Bolt-torque levels should be in accordance with Table 100.12 unless otherwise specified by manufacturer.

c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer’s published data. If manufacturer’s data is not available, investigate any values which deviate from similar connections by more than 50 percent of the lowest value.

d. Insulation-resistance values should be in accordance with Table 100.1.

e. Investigate capacitance values differing from manufacturer’s published data.

f. In accordance with NFPA 70 National Electrical Code Article 460, residual voltage of a capacitor shall be reduced to 50 volts after being disconnected from the source of supply:

<table>
<thead>
<tr>
<th>Rated Voltage</th>
<th>Discharge Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; or = to 600 volts</td>
<td>1 minute</td>
</tr>
<tr>
<td>&gt; 600 volts</td>
<td>5 minutes</td>
</tr>
</tbody>
</table>

Q. Direct-Current Batteries, Valve-Regulated Lead Acid

1. Visual and Mechanical Inspection

a. Verify ventilation of battery room or enclosure.

b. Compare equipment nameplate data with drawings and specifications.

c. Inspect physical and mechanical condition.
d. Inspect anchorage, alignment, and grounding.

e. Verify adequacy of battery support racks or cabinets, mounting, anchorage, and clearances.

f. Verify the units are clean.

g. Verify the application of an oxide inhibitor on battery terminal connections.

h. Inspect bolted electrical connections for high resistance using one of the following methods:

   (1) Use of low-resistance ohmmeter.

   (2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data or NETA-ATS Table 100.12.

   (3) Perform thermographic survey.

2. Electrical Tests

a. Perform resistance measurements through all bolted connections with a low-resistance ohmmeter, if applicable.

b. Measure negative post temperature.

c. Measure charger float and equalizing voltage levels.

d. Verify all charger functions and alarms.

e. Measure each monoblock/cell voltage and total battery voltage with charger energized and in float mode of operation.

f. Measure intercell connection resistances.

g. Perform internal ohmic measurement tests.

3. Test Values

a. Compare bolted connection resistances to values of similar connections.

b. Bolt-torque levels shall be in accordance with manufacturer’s published data.

c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer’s published data. If manufacturer’s data is not available, investigate any values which deviate from similar connections by more than 50 percent of the lowest value.

d. Charger float and equalize voltage levels shall be in accordance with the battery manufacturer’s published data.
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- Monoblock/cell voltages should be in accordance with manufacturer’s published data.
- Monoblock/cell internal ohmic values (resistance, impedance, or conductance) should not vary by more than 25 percent between identical monoblocks/cells that are in a fully charged state.

R. Direct-Current Systems, Chargers

1. Visual and Mechanical Inspection
   - Compare equipment nameplate data with drawings and specifications.
   - Inspect for physical and mechanical condition.
   - Inspect anchorage, alignment, and grounding.
   - Verify the unit is clean.
   - Inspect all bolted electrical connections for high resistance using one of the following methods:
     (1) Use of low-resistance ohmmeter.
     (2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data or NETA-ATS Table 100.12.
     (3) Perform thermographic survey under load.
   - Inspect filter and tank capacitors.
     (1) Verify operation of cooling fans. Clean filters if provided.

2. Electrical Tests
   - Perform resistance measurements through all bolted connections with a low-resistance ohmmeter, if applicable.
   - Verify float voltage, equalize voltage, and high voltage shutdown settings.
   - Verify current limit.
   - Verify correct load sharing (parallel chargers).
   - Verify calibration of meters.
   - Verify operation of alarms.
   - Measure and record input and output voltage and current.
   - Measure and record AC ripple current and/or voltage imposed on the battery.
3. Test Values
   a. Compare bolted connection resistances to values of similar connections.
   b. Bolt-torque levels shall be in accordance with manufacturer’s published data or NETA-ATS Table 100.12.
   c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer’s published data. If manufacturer’s data is not available, investigate any values which deviate from similar connections by more than 50 percent of the lowest value.
   d. Float and equalize voltage settings shall be in accordance with the battery manufacturer’s published data.
   e. Current limit shall be within manufacturer’s recommended maximum.
   f. Ripple current should not exceed battery manufacturer’s recommendations.
   g. Charger shall be capable of manufacturer’s specified full load at rated voltages.

S. SF6 Switch
   1. Visual and Mechanical Inspection:
      a. Compare equipment nameplate data with drawings and specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding, and required clearances.
      d. Verify the unit is clean.
      e. Inspect and service mechanical operator and SF6 gas insulated system in accordance with the manufacturer’s published data.
      f. Verify correct operation of SF6 gas pressure alarms and limit switches, if applicable, as recommended by the manufacturer.
      g. Measure critical distances as recommended by the manufacturer.
      h. Inspect bolted electrical connections for high resistance using one of the following methods:
         (1) Use of low-resistance ohmmeter,
         (2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data.
         (3) Perform thermographic survey.
i. Verify that each fuse has adequate mechanical support and contact integrity.

j. Verify that fuse sizes and types correspond to drawings.

k. Verify operation and sequencing of interlocking systems.

l. Lubrication requirements
   (1) Verify appropriate contact lubrication on moving current-carrying parts.
   (2) Verify appropriate lubrication on moving and sliding surfaces.

m. Test for SF6 gas leaks in accordance with manufacturer’s published data.

n. Record as-found and as-left operation counter readings, if applicable.

2. Electrical Tests:
   a. Perform resistance measurements through accessible bolted electrical connections with a low-resistance ohmmeter.
   b. Perform a contact/pole-resistance test.
   c. Perform insulation-resistance tests at 5kVDC on each pole, phase-to-phase and phase-to-ground with switch closed and across each open pole for one minute.
   d. Perform overpotential test across each gas bottle with the switch in the open position in accordance with manufacturer’s published data.
   e. Verify open and close operation from control devices, if applicable.

3. Test Values:
   a. Compare bolted connection resistances to values of similar connections.
   b. Bolt-torque levels shall be as specified by the manufacturer.
   c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer’s published data. If the manufacturer’s data is not available, investigate any values which deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   d. Insulation resistance values should be in accordance with manufacturer’s published data.
   e. Critical distances of operating mechanism should be in accordance with manufacturer’s published data.
   f. The gas interrupters shall withstand the overpotential voltage applied.
g. The insulation shall withstand the overpotential test voltage applied.

h. Insulation-resistance values for control wiring shall be a minimum of 2.0 megohms.

T. Circuit Breakers, Air, Insulated-Case/Molded-Case

1. Visual and Mechanical Inspection
   a. Compare equipment nameplate data with drawings and specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage and alignment.
   d. Verify the unit is clean.
   e. Operate the circuit breaker to insure smooth operation.
   f. Inspect bolted electrical connections for high resistance using one of the following methods:
      (1) Use of low-resistance ohmmeter,
      (2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data.
      (3) Perform thermographic survey.
   g. Inspect operating mechanism, contacts, and arc chutes in unsealed units.

2. Electrical Tests
   a. Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole for one minute. Test voltage shall be in accordance with manufacturer’s published data or NETA-ATS Table 100.1.
   b. Perform a contact/pole-resistance test.
   c. Perform adjustments for final setting in accordance with coordination study.
   d. Determine long-time pickup and delay by primary current injection.
   e. Determine short-time pickup and delay by primary current injection.

3. Test Values
   a. Compare bolted connection resistances to values of similar connections.
b. Bolt-torque levels should be in accordance with NETA-ATS Table 100.12 unless otherwise specified by manufacturer.

c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer’s published data. If manufacturer’s data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.

d. Circuit breaker insulation resistance should be in accordance with NETA-ATS Table 100.1.

e. Insulation-resistance values for control wiring shall be a minimum of 2.0 megohms.

f. Trip characteristic of breakers shall not exceed manufacturer’s published time-current characteristic tolerance band, including adjustment factors. If manufacturer’s curves are not available, trip times shall not exceed the value shown in NETA-ATS Table 100.7. Circuit breakers exceeding specified trip time at 300 percent of pickup shall be tagged defective.

g. Instantaneous pickup values of molded-case circuit breakers shall be within the tolerances shown in NETA-ATS Table 100.8.

h. Minimum pickup voltage on shunt trip and close coils should be in accordance with manufacturer’s published data. In the absence of manufacturer’s published data, refer to NETA-ATS Table 100.20.

U. Circuit Breakers, Vacuum, Medium Voltage

1. Visual and Mechanical Inspection

   a. Compare equipment nameplate data with drawings and specifications.

   b. Inspect physical and mechanical condition.

   c. Inspect anchorage, alignment, and grounding.

   d. Verify the unit is clean.

   e. Perform all mechanical operational tests on both the circuit breaker and its operating mechanism.

   f. Measure critical distances such as contact gap as recommended by manufacturer.
Tests and Identification

2. Electrical Tests

a. Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground with circuit breaker closed and across each open pole for one minute. Test voltage shall be in accordance with manufacturer’s published data or NETA-ATS Table 100.1.

b. Perform a contact/pole-resistance test.

c. Perform minimum pickup voltage tests on trip and close coils in accordance with NETA-ATS Table 100.20.

d. Verify trip, close, trip-free, and antipump functions.

e. Trip circuit breaker by operation of each protective device.

f. Perform vacuum bottle integrity (overpotential) test across each vacuum bottle with the breaker in the open position in strict accordance with manufacturer’s published data. Do not exceed maximum voltage stipulated for this test. Provide adequate barriers and protection against x-radiation during this test. Do not perform this test unless the contact displacement of each interrupter is within manufacturer’s tolerance. (Be aware that some dc high-potential test sets are half-wave rectified and may produce peak voltages in excess of the breaker manufacturer’s recommended maximum.)

g. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute. For units with solid-state components, follow manufacturer’s recommendation.

h. Perform an overpotential test in accordance with manufacturer’s published data.
3. Test Values
   a. Bolt-torque levels should be in accordance with NETA-ATS Table 100.12 unless otherwise specified by the manufacturer.
   b. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer’s published data. If the manufacturer’s data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
   c. Circuit breaker insulation resistance should be in accordance with NETA-ATS Table 100.1.
   d. Contact displacement shall be in accordance with factory recorded data marked on the nameplate of each vacuum breaker or bottle.
   e. The interrupter shall withstand the overpotential voltage applied.
   f. Insulation-resistance values for control wiring shall be a minimum of 2.0 megohms.
   g. Power-factor or dissipation-factor test results shall be compared to manufacturer’s published data. In the absence of manufacturer’s published data the comparison shall be made to similar breakers.
   h. Power-factor or dissipation-factor test results and capacitance test results should be within ten percent of nameplate rating for bushings.
   i. The insulation shall withstand the overpotential test voltage applied.

V. Instrument Transformers
   1. Visual and Mechanical Inspection
      a. Compare equipment nameplate data with drawings and specifications.
      b. Inspect physical and mechanical condition.
      c. Verify correct connection of transformers with system requirements.
      d. Verify that adequate clearances exist between primary and secondary circuit wiring.
      e. Verify the unit is clean.
      f. Inspect bolted electrical connections for high resistance using one of the following methods:
(1) Use of low-resistance ohmmeter.
(2) Verify tightness of accessible bolted electrical connections by calibrate torque-wrench method in accordance with manufacturer’s published data or NETA-ATS Table 100.12.
(3) Perform thermographic survey.
g. Verify that all required grounding and shorting connections provide contact.
h. Verify correct operation of transformer withdrawal mechanism and grounding operation.
i. Verify correct primary and secondary fuse sizes for voltage transformers.
j. Lubrication requirements
   (1) Verify appropriate lubrication on moving current-carrying parts.
   (2) Verify appropriate lubrication on moving and sliding surfaces.

2. Electrical Tests - Current Transformers
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable.
   b. Perform insulation-resistance test of each current transformer and wiring-to-ground at 1000 volts dc. For units with solid-state components, follow manufacturer’s recommendations.
   c. Perform a polarity test of each current transformer.
   d. Perform a ratio-verification test using the voltage or current method in accordance with ANSI/IEEE C57.13.1.
   e. Perform an excitation test on transformers used for relaying applications in accordance with ANSI/IEEE C57.13.1.
   f. When applicable, perform insulation-resistance and dielectric withstand tests on the primary winding with the secondary grounded. Test voltages shall be in accordance with NETA-ATS Tables 100.5 and 100.9 respectively.
   g. Verify that current circuits are grounded and have only one grounding point in accordance with ANSI/IEEE C57.13.3.

3. Electrical Tests – Voltage Transformers
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable.
   b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages shall be applied for one minute in accordance with
c. Perform a polarity test on each transformer to verify the polarity marks or H1-X1 relationship as applicable.

d. Perform a turns ratio test on all tap positions, if applicable.

4. Test Values

a. Compare bolted connection resistances to values of similar connections.

b. Bolt-torque levels should be in accordance with NETA-ATS Table 100.12 unless otherwise specified by the manufacturer.

c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer’s published data. If manufacturer’s data is not available, investigate any values which deviate from similar connections by more than 50 percent of the lowest value.

d. Insulation-resistance measurement on any instrument transformer shall be not less than that shown in NETA-ATS Table 100.5.

e. Polarity results shall agree with transformer markings.

f. Compare measured burdens to instrument transformer ratings.

g. Ratio accuracies shall be within 0.5 percent of nameplate or manufacturer’s published data.

h. The insulation shall withstand the overpotential test voltage applied.

i. Capacitance of capacitor sections of coupling-capacitance voltage transformers shall be in accordance with manufacturer’s published data.

j. Power-factor or dissipation-factor shall be in accordance with test equipment manufacturer’s published data.

W. Metering Devices

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.

c. Verify tightness of electrical connections.

d. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case-shorting contacts, as applicable.
e. Verify the unit is clean.

f. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests

a. Verify accuracy of meters at all cardinal points.

b. Calibrate meters in accordance with manufacturer’s published data.

c. Verify that current transformer and voltage transformer secondary circuits are intact.

X. Protective Relays

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect relays and cases for physical damage. Remove shipping restraint material.

c. Tighten case connections. Inspect cover for correct gasket seal. Clean cover glass. Inspect shorting hardware, connection paddles, and/or knife switches. Remove any foreign material from the case. Verify target reset.


2. Electrical Tests

a. Perform insulation-resistance test on each circuit-to-frame. Determine from the manufacturer’s instructions the allowable procedures for this test for solid-state and microprocessor-based relays.

b. Inspect targets and indicators.

   (1) Determine pickup and dropout of electromechanical targets.
   (2) Verify operation of all light-emitting diode indicators.
   (3) Set contrast for liquid-crystal display readouts.

c. Instantaneous Overcurrent Relay

   (1) Determine pickup.
   (2) Determine dropout.
   (3) Determine time delay.
Tests and Identification

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d. Time Overcurrent
   (1) Determine minimum pickup.
   (2) Determine time delays at two points on the time current curve.

e. Control Verification
   Verify that each of the relay contacts performs its intended function in the control scheme including breaker trip tests, close inhibit tests, 86 lockout tests, and alarm functions.

f. System Tests
   After the equipment is initially energized, measure magnitude and phase angle of all inputs and compare to expected values.

g. Test Values
   (1) Use manufacturer’s recommended tolerances when other tolerances are not specified.
   (2) When critical test points are specified, the relay shall be calibrated to those points even though other test points may be out of tolerance.

1.08 TEST REPORT

A. Prepare a test report and submit in accordance with Section 16010.

B. The test report shall include the following:
   1. Summary of project.
   2. Description of equipment tested.
   3. Description of tests.
   4. Test data.
   5. Analysis and recommendations.

C. Test data records shall include the following minimum requirements:
   1. Identification of the testing organization.
   2. Equipment identification.
   3. Humidity, temperature, and other conditions that may affect the results of the tests and/or calibrations.
   4. Date of inspections, tests, maintenance, and/or calibrations.
   5. Identification of the testing technician.
6. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.

7. Indication of expected results when calibrations are to be performed.

8. Indication of “as-found” and “as-left” results, as applicable.

9. Sufficient spaces to allow all results and comments to be indicated.

1.09 LABELING AND IDENTIFICATION

A. Provide engraved plastic nameplates and vinyl identification tagging systems for all communications, data, and electrical site utilities pull and splice boxes, manholes, vaults, equipment, apparatus, and other items installed for this project and as indicated on the project plans, schematics, single-line diagrams.

B. Provide equipment and circuit designation on nameplates with minimum letter and plate sizes as indicated. Electrical distribution system equipment, conduit and wire, pullboxes, manholes, and vaults shall have identification. Equipment number or plan identification shall be unique and as shown on the plans and based on the Campus Numbering Scheme. There shall be no duplication of identification numbers such as “LP-11” shall not be used in an addition if the building already has an “LP-11”. Labels shall be based on the Campus Electrical Equipment Numbering and Identification Scheme included in this Section. Equipment nameplates and tags shall remain visible after completion of construction. The Contractor shall submit an editable Microsoft Excel Spreadsheet listing of all nameplates and tags to be provided and installed for this project for review and approval by the Campus prior to installation of any identification labels or tags.

C. Provide engraved plastic nameplates (color to be determined by the Campus) for all equipment, panels, switchboards, transformers and apparatus with 1/4 in. minimum height letters indicating:

1. Circuit designation at branch overcurrent devices in distribution panelboards, switchboards, and metering switchgear.

2. Circuit designation of panel, equipment controlled or device controlled on disconnect switches and on circuit breakers, starters and controls which are individually enclosed.

3. Designation of pull and splice boxes, control and terminal cabinets as indicated on plans.
4. Equipment and device designation on front of switchboards, distribution and panelboards, and metering switchgear for each section.

D. Secure nameplates with at least two rivets. Use of silicone cement adhesive is acceptable.

E. Data and Communications Cabling:
   1. Reflective vinyl markers such as Tech Products, Inc., black legend with yellow background for copper communication cables and black legend with orange background for data and fiber optic cabling. Letters shall be attached to heavy vinyl sheeting and attached to cable with tie-wrap at four points. Lettering shall be at least ¼ inch high. Mark with black permanent marker to indicate a decimal point where required. Labels shall include all information required in detail provided in the project plans.
   2. Copper Communication/Data Cable: Designation of total copper cable pair count.
   3. Line Count (when cable is part of branch connection from phone switch).
   4. Fiber Optic Cable: Designation of fiber cable total strands and mode type. If multi-mode, micrometer value shall be included (i.e. 50 or 62.5).
   5. Building numbers of final termination points.

F. 600 V Conductor identification:
   1. Feeders: Identify with the corresponding circuit designation at overcurrent device and load ends, at all splices and in pull boxes.
   2. Branch circuits: Identify with the corresponding circuit designation at the overcurrent device and at all splices.
   3. Control wires: Identify with the indicated number and or letter designation at all terminal points and connections, including manufacturer pre-wired control sections and cabinets.
   4. For identification of conductors use plastic coated self-sticking markers such as Thomas & Betts E-Z Code, or field marked labels such as manufactured by Tech Products.

G. Medium Voltage Cables and Equipment:
   1. Lettering on each tag shall be engraved at least ¼ inch high. Reflective vinyl markers such as manufactured by Tech Products, Inc., with black legend with
yellow background, shall be used when applied to a heavy vinyl sheeting and attached with tie-wrap at four points.

2. MV Cable Tags shall be connected to cables by non-ferrous cable ties and include the following minimum information at each termination, splice and where exposed in manholes, vaults and pullboxes. The following minimum information shall be provided at each location:
   a. Circuit Identification based on the Campus Numbering Scheme
   b. Phase of each conductor by letter (A, B, C)
   c. Phase by Color Code
      (1) A = Yellow Tape – 1 ring
      (2) B = Red Tape – 2 rings
      (3) C = Blue Tape – 3 rings
   d. Both end termination points of a cable segment (e.g., Main Sub, HV-3, & MH8) shall be identified in manholes and pullboxes. e. The total cable length shall be provided at each termination end. Where cables include T-splices, the length to the T-splice location from each termination end to the location of the T-splice shall be provided.

3. Equipment in manholes, buildings, and substations shall be labeled with engraved nameplates having red background and white letters. The Contractor shall provide new nameplates to replace existing nameplates on existing equipment where the equipment or circuit designation has changed. The new nameplates shall match existing nameplates in size, color, and font size, and material. Nameplates shall be permanently attached using silicone adhesive.

4. An embossed brass tag with manhole number shall be permanently mounted inside the manhole and legible from outside the manhole with the cover removed.

H. Medium Voltage Equipment Identification:

1. The Contractor shall provide identification labeling in accordance with the Campus provided numbering scheme and as required by the Campus in order to accomplish the following:
   a. Establish a unique identifier for all system components and eliminate possible duplication.
   b. Identify equipment by type as listed in the following table:
<table>
<thead>
<tr>
<th>Mark or Tag</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>12 kV or 4.16 kV Distribution Circuit</td>
<td>A</td>
</tr>
<tr>
<td>RFI</td>
<td>Resettable Fault Interrupter</td>
<td>RFI-01</td>
</tr>
<tr>
<td>MH</td>
<td>Electrical Manhole</td>
<td>MH-1</td>
</tr>
<tr>
<td>PB</td>
<td>Electrical Pullbox</td>
<td>PB-1</td>
</tr>
<tr>
<td>S</td>
<td>Sulfur Hexaflouride Gas Switch</td>
<td>S-001-14-A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(S=Switch,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>001=Building 001,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14=4 Way Switch,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A=First Switch at</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Building 001.</td>
</tr>
<tr>
<td>PANEL</td>
<td>Power/Lighting Panel</td>
<td>PANEL-PR</td>
</tr>
<tr>
<td>T</td>
<td>Transformer</td>
<td>T-033-134Y-A</td>
</tr>
</tbody>
</table>

c. Allows for the addition of new devices by type in an ordered manner.
d. Facilitates the creation of computer database to keep records on equipment.
e. Reduces confusion when referring to a piece of equipment and enhance communication.

2. Existing device numbers shall be reused when replacing equipment. Consult with the Campus on device number assignment before labeling equipment. The Campus is continually adding device numbers so tracking and controlled assignment of identification information is required.

3. New and future equipment shall be assigned a number during the design phase of a project to minimize the need for new nameplates after construction.

END OF SECTION 26 05 53