26 08 01 - Electrical Acceptance Testing

1. Introduction

   A. This section is included for reference purposes only. The testing shall be conducted under a separate contract directly with the Owner. The contractor's responsibilities under this contract are to ensure that the equipment and installation governed by this contract is able to meet the testing requirements in this section. The contractor is responsible for coordinating testing with the testing organization to complete tests and to correct any deficiencies before putting equipment into service.

2. References

   A. NFPA 70 National Electrical Code

   B. National Electrical Testing Association (NETA) ATS-2009 - "Standard for Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems".

3. Design Standards

   A. General Test Conditions:

      1. Testing begins at the load side of the 15kV distribution switchgear.

      2. All testing must be conducted on site.

      3. The testing firm shall provide their own generator for primary injection testing of unit substation power circuit breakers. All other testing power will be available inside the building.

   B. Testing Firm:

      1. Must be an independent organization unrelated to the equipment manufacturer, supplier or installer. All testing personnel shall be NETA certified.

      2. Regularly engaged for minimum of five (5) years in testing of electrical materials, devices, electrical installations and systems for purpose of preventing injury to persons or damage to property and other equipment.

      3. Meet OSHA criteria for accreditation of testing laboratories, 29 CFR Parts 1907, 1910 and 1936.

      4. Must have a calibration program to maintain applicable test instrumentation within rated accuracy. Accuracy shall be traceable to National Institute of Standards and Technology (NIST) in an unbroken chain. Instruments shall be calibrated as follows:

a. Field instruments - 6 months maximum

b. Laboratory instruments - 12 months maximum

c. Specialty leased equipment - 12 months maximum

d. Dated calibration labels shall be visible on test equipment

C. The testing firm shall have a designated safety representative present on site to supervise operations with respect to safety. Do **not** proceed with work until safety representative has determined it is safe to do so.

D. All inspections and acceptance tests will utilize the following documents:

1. Project contract documents
2. Manufacturer's instruction manuals applicable to each piece of equipment
3. All factory and field test reports
4. Short circuit and coordination study report conducted by electrical equipment manufacturer or engineer

E. Perform tests with apparatus de-energized except where otherwise specifically required.

F. All equipment shall be inspected for the following:

1. Shipping blocks, bolts and jumpers have been removed
2. Unused penetrations in enclosures have been closed
3. Bolted connections have been torqued to manufacturer's required values
4. Surfaces and interiors of equipment are clean of moisture, debris and dirt
5. Doors, panels and sections are free from dents and scratches.
6. Seal at doors and assembly joints meet expected service duty requirements
7. Proper equipment anchorage and required area working clearances exist
8. Nameplates attached throughout and nameplate data conform to Contract Documents
9. Maintenance devices required for servicing and operating equipment are stored in readily accessible location or otherwise have been delivered to Owner
10. Breaker settings are per the coordination study report
11. Cabling has been properly routed and is not adjacent to sharp or moving objects

G. Grounding Electrodes:

1. Inspection:

a. Verify size and length conforms to Contract Documents.

b. Grounding electrode to grounding electrode conductor bond using exothermic weld without spalling or as indicated on the Contract Documents.

c. Grounding electrode conductors sized as indicated on the Contract Documents.

2. Testing:

a. Fall-of-Potential test, 1.0 ohms maximum reference rod-to-earth when connected to building foundation grounding electrode system.

H. Lightning Protection:

1. Inspection:

a. Verify rods, terminals and connections conform to Contract Documents.

b. All roof penetrations sealed as specified.

2. Testing:

a. Verify all tests are complete for UL Master Label Certification.

b. Prior to bonding Lightning Protection to Building Ground Loop, perform a fall-of-potential test (25 ohms maximum reference rod-to-earth resistance).

I. Cathodic Protection:

1. Testing:

a. Record rectifier voltage and current and verify proper rectifier operation.

b. Check for interference during potential tests and record values of any stray AC or DC currents.

c. Verify isolation and conductivity. Use a High Impedance (10 Megohms minimum) Digital Voltmeter or AC Null Balance Resistance Meter. For Fixed Cell - Moving Ground Method, record readings on a 2 VDC scale. When structures are electrically isolated from each other, their measured potentials must differ by more than 5 millivolts. For structures which are electrically continuous potentials measured should differ by not more than 1 millivolt. Retest if values fall between 2 and 5 millivolts. For AC Null Balance tests, measure the resistance between structures. For structures which are electrically continuous the resistance should be less than 0.5 ohms. For structures which are electrically isolated from each

other the resistance measured should be greater than 2 ohms. Investigate and report structures where the values measured fall between 0.5 and 2 ohms.

J. Surge Arresters:

1. Inspection:

a. Inspect for proper orientation of vents, proper mounting and adequate clearances.

b. Verify terminations are torqued to manufacturer's specifications.

c. Verify ground lead on each device is attachment to ground bus.

2. Testing:

a. Inspect for physical damage

b. Perform leakage current and watt loss test. Test at 2500 VAC. Investigate and report any values that deviate from manufacturer's data by greater than 5%.

K. Switchboards and Panels (100A and above):

1. Inspection:

a. Verify size and rating of enclosures, panels and circuit breakers conform to Contract Documents.

b. Verify terminations are torqued to manufacturer's specifications.

2. Testing:

a. Exercise all active components such as breakers and switches.

b. Perform an insulation resistance (Megger) test if acceptable to the manufacturer (L-G and L-L at 1000 VDC for a minimum of 1 minute). Investigate and report any values below 50 megohms.

L. Building Wire and Cable (100A and above):

1. Inspection:

a. Verify color coding, labels and arrangements conform to Contract Documents.

b. Check for physical damage to cable.

c. Verify cable supports, sleeves and racks conform to Contract Documents.

d. Cable minimum bending radius maintained throughout.

e. Verify terminations use proper connectors and terminal blocks.

f. Verify all temporary jumpers/grounds are removed.

2. Testing:

a. Check continuity of equipment grounding conductors.

b. Check continuity of all ungrounded conductors.

c. Perform an insulation resistance (Megger) test power cables (200A and above) at 1000 VDC for period of 1 minute. Investigate and report any values less than 50 megohms.

d. Perform a resistance test between all sets of parallel conductors.

M. Transformers, Power (500kVA and above):

1. Inspection:

a. Check for damage to enclosure, insulators or windings.

b. Verify terminations are torqued to manufacturer's specifications.

c. Verify neutral and/or equipment grounding conform to Contract Documents.

d. Verify nameplate voltage, KVA and winding type conforms to Contract Documents.

e. Verify tap settings conform to Contract Documents.

f. Ensure that resilient mounts are free (vibration isolators).

g. Verify proper core grounding.

2. Testing:

a. Isolate primary and secondary conductors from transformer bushings. Record position of these cables and return them to same location (properly torqued) following tests requiring isolation.

b. Perform a winding resistance test of primary and secondary windings at rated voltage taps. Investigate and report any results that vary from manufacturer's test data by greater than 0.5%.

c. Perform an insulation resistance (Megger) test of primary and secondary windings-to-ground. Test primary at 10,000 VDC and secondary at 1000 VDC. Investigate and report any results that are less than 90% of manufacturer's test data.

d. Perform a transformer turns ratio test for windings at rated taps. Investigate and report any results that deviate from manufacturer's data by more than 0.5%.

e. Verify polarity and phase relation for primary and secondary windings at rated tap.

f. Perform an excitation current test for primary winding at rated tap. Investigate and report any results that deviate from manufacturer's data by more than 1%.

g. Perform a dissipation (or power) factor test of primary and secondary windings. Test primary at 2500 VAC and secondary at 500 VAC. Investigate and report any results that deviate from manufacturer's data by more than 1%.

N. Transformers, Dry Type (from 30KVA to 300KVA):

1. Inspection:

a. Check for damage to enclosure, insulators or windings.

b. Verify terminations are torqued to manufacturer's specifications.

c. Verify neutral and/or equipment grounding conform to Contract Documents.

d. Verify nameplate voltage, KVA and winding type conform to Contract Documents.

e. Verify tap settings conform to Contract Documents.

f. Ensure that resilient mounts are free (vibration isolators).

g. Verify proper core grounding.

2. Testing:

a. Perform a transformer turns ratio test for windings at rated taps. Investigate and report any results that deviate from manufacturer's data by more than 0.5%.

b. Perform an insulation resistance (Megger) test H-G, H-L, and L-G at 1000 VDC for period of 1 minute. Investigate and report any values less than 50 megohms.

c. Verify polarity and phase relation at rated tap matches nameplate diagram.

O. Switches (100A and above):

1. Inspection:

a. Check switch blades to ensure all three phases are engaged at the same time and all three break at the same time.

b. Inspect and operate the operating handle; apply lubrication if required.

c. Verify terminations are torqued to manufacturer's specifications.

d. Verify type, quantity and sizes of fuses conform to Contract Documents.

2. Testing:

a. Perform an insulation resistance (Megger) test with blades closed (may be done at same time cable is tested), L-G and L-L for all three poles at 1000 VDC for a minimum of 1 minute. Investigate and report any values less than 50 megohms.

b. Perform a contact resistance test.

P. Fuses (100A and above):

1. Inspection:

a. Check for all fuse holder elements such as blade retaining devices, snuffers or electronic control elements.

b. Verify terminations are torqued to manufacturer's specifications.

c. Verify type, quantity and sizes of fuses conform to Contract Documents.

2. Testing:

a. Check for continuity of all fuses.

b. Perform a contact resistance test across all connections on each fuse from line-side to load-side terminal. Investigate and report any values greater than 50 microhms.

Q. Circuit Breakers: Low-Voltage, Power (Unit Substation Breakers):

1. Inspection:

a. Inspect for physical damage. Clean and lubricate as required.

b. Inspect anchorage, alignment and grounding.

c. Inspect arc chutes.

d. Inspect moving and stationary contacts for condition, wear and alignment.

e. Verify the primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

f. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

g. Check cell fit and element alignment.

h. Check racking mechanism.

i. Lubricate all moving current carrying parts.

2. Testing:

a. Perform a contact resistance test.

b. Perform an insulation-resistance test at 1000 volts from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase.

c. Determine minimum pickup current by primary injection.

d. Determine long-time pickup and delay by primary current injection.

e. Determine short-time pickup and delay by primary current injection.

f. Determine ground-fault pickup and delay by primary current injection.

g. Determine instantaneous pickup value by primary current injection.

h. Activate auxiliary protective devices such as fault or under voltage relays to ensure operation of shunt trip devices. Check the operation of breaker in cubicle.

i. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and operation, trip-free and anti-pump function.

j. Check charging mechanism.

R. Circuit Breakers: Low-Voltage, Insulated-Case (100A and above):

1. Inspection:

a. Verify mounting, conductors and designation conforms to Contract Documents.

b. Perform a minimum of three (3) **Open** and **Close** operations.

c. Verify terminations are torqued to manufacturer's specifications.

d. Inspect case for cracks or other defects.

2. Testing:

a. Perform a contact resistance test.

b. Perform an insulation resistance (Megger) test with circuit breaker closed (may be done at same time cable is tested), L-G and L-L for all poles (3-pole, 2-pole, or 1-pole) for a minimum of 1 minute. Investigate and report any values less than 50 megohms.

c. Perform primary injection for all available functions on solid-state circuit breakers.

S. Motor Controllers (100A and above):

1. Inspection:

a. Inspect for physical damage.

b. Verify that nameplate information conforms to Contract Documents.

c. Exercise mechanical parts and interlocks and confirm proper operation.

d. Verify terminations are torqued to manufacturer's specifications.

e. Verify that type, quantity and sizes of fuses conform to Contract Documents.

f. Verify overloads sizing conforms to Contract Documents.

2. Testing:

a. Operate and test all control operators and switches (electromechanical and solid-state).

b. Perform an insulation resistance (Megger) test if acceptable to the manufacturer (L-G and L-L at 1000 VDC for a minimum of 1 minute). Investigate and report any values below 50 megohms.

c. Test all resettable overloads.

T. Motor Control Centers (100A and above):

1. Inspection:

a. Inspect for physical damage.

b. Verify that nameplate information conforms to Contract Documents.

c. Exercise mechanical parts and interlocks and confirm proper operation.

d. Verify terminations are torqued to manufacturer's specifications.

e. Verify type, quantity and sizes of fuses conform to Contract Documents.

f. Verify overloads sizing conforms to Contract Documents.

2. Testing:

a. Operate and test all control operators and switches (electromechanical and solid-state).

b. Perform an insulation resistance (Megger) test if acceptable to the manufacturer (L-G and L-L at 1000 VDC for a minimum of 1 minute). Investigate and report any values below 50 megohms.

c. Test all resettable overloads.

d. Verify phase rotation matches rotation at source.

U. Contactors (100A and above):

1. Inspection:

a. Check mechanical operation

b. Inspect/ adjust contact gap, wipe, alignment and pressure, if required.

c. Verify terminations are torqued to manufacturer's specifications.

d. Verify auxiliary contacts provided conform to Contract Documents.

2. Testing:

a. Perform a contact resistance test across each pole. Investigate and report any values in excess of 50 microhms or any deviations from adjacent poles greater than 50%.

V. Motors (40HP and above):

1. Inspection:

a. Check for damage to housing, shaft or windings.

b. Verify terminations are torqued to manufacturer's specifications.

c. Verify grounding and phase terminations conform to Contract Documents

d. Verify voltage, hp, speed and winding type conforms to Contract Documents.

e. Verify installation of foundation and base plate conforms to the Contract Documents. Check for proper anchorage, alignment, and lubrication.

2. Testing:

a. Perform insulation resistance (Megger) test in accordance with ANSI/IEEE Std 43. Test at DC voltage equal to twice rated voltage plus 1000 V. Investigate and report any values below 50 megohms.

b. Perform a rotation test to ensure proper shaft direction.

c. Measure running current and compare to nameplate full load amperes; evaluate relative to load conditions.

d. Perform surge comparison test.

e. Perform an insulation resistance test across any insulating bearings or pedestals per manufacturer's instructions.

f. Verify that resistance temperature detector (RTD) circuits conform to Contract Documents. Check that metering or relaying devices using the RTD's are properly rated.

g. Check that any space heaters function properly.

h. Verify that all protective devices operate properly.

W. Motors (39HP and below):

1. Inspection:

a. Check for damage to housing, shaft or windings.

b. Verify terminations are torqued to manufacturer's specifications.

c. Verify grounding and phase terminations conform to Contract Documents.

d. Verify voltage, hp, speed and winding type conforms to Contract Documents.

e. Verify installation of foundation and base plate conforms to the Contract Documents. Check for proper anchorage, alignment and lubrication.

X. Variable Frequency Drives (VFD's)

1. Inspection:

a. Inspect for physical damage.

b. Verify nameplate information conforms to Contract Documents.

c. Exercise mechanical parts and interlocks; confirm proper operation.

d. Verify terminations are torqued to manufacturer's specifications.

2. Testing:

a. Perform electrical tests as recommended by the manufacturer so as to verify settings and capability of drive to control the motor under the load specified.

b. Test line-side of the VFD for voltage waveform, voltage rms, voltage peak, current waveform, current rms, current peak, power factor and total harmonic

distortion for both voltage and current. All tests shall be performed at 50% and 100% rated load. Test load-side of the VFD for voltage waveform and current waveform; this waveform will be captured as follows:

i. One sample over the entire ramp-up (up to 300 seconds).

ii. One sample at 50% rated load for a minimum of one.

iii. One sample at 100% rated load for a minimum of one.

c. Test units with bypass to line feature to insure proper operation.

d. Remove input signal and verify proper operation of “loss-of-signal” circuit.

Y. Static Transfer Switches

1. Inspection:

a. Inspect for physical damage.

b. Verify nameplate information conforms to Contract Documents.

c. Exercise mechanical parts and interlocks and confirm proper operation.

d. Verify terminations are torqued to manufacturer’s specifications.

2. Testing:

a. Verify settings and operation of control devices conform to Contract Documents.

b. Verify settings and operation of all timers and variable settings conform to Contract Documents.

c. Perform operational test of transfer switch to insure proper Source 1 to Source 2 transfer and Source 1 to Source 2 retransfer. Adjust time delay and other settings to conform to Contract Documents. (Note: the three-source static switches shall have their time delays staggered so all the static switches do not transfer to the generators at the same time). Record transfer times. On the three-source switches, simulate transfer from Source 1 to Source 2 and insure that the engine start signal is activated when Source 1 or Source 2 is lost.

d. Operate and test all control operators and switches.

e. Perform an insulation resistance (Megger) test if acceptable to the manufacturer (L-G and L-L at 1000 VDC for a minimum of 1 minute). Investigate and report any values below 50 megohms.

f. Perform a contact resistance test across each pole. Investigate and report any values in excess of 50 microhms or any deviations from adjacent poles greater than 50%.

Z. Engine Generator Systems

1. Inspection:

   a. Inspect for physical damage.

   b. Verify nameplate information conforms to Contract Documents.

   c. Verify installation of foundation and grounding conforms to the Contract Documents. Check for proper anchorage and alignment.

   d. Verify terminations are torqued to manufacturer's specifications.

   e. Coordinate all inspections and tests for prime mover with all other electrical testing activities. Prime mover tests shall comply with manufacturer's instructions.

2. Testing:

   a. Perform an insulation resistance (Megger) test if acceptable to the manufacturer (L-G and L-L at 1000 VDC for a minimum of 1 minute). Determine dielectric absorption ratio. Investigate and report any values below 50 megohms.

   b. Test all control and protective relay devices in accordance with manufacturer's instructions.

   c. Perform phase rotation test. Verify compatibility with load requirements.

   d. Functionally test engine shutdown for low oil pressure, over temperature, over speed and other features (as applicable). Test the generator remote alarm contacts.

   e. Witness NFPA 110 functional testing performed by Commissioning Agent.

AA. Lighting and Lighting Control

1. Inspection:

   a. Inspect for physical damage.

   b. Verify nameplate information conforms to Contract Documents.

   c. Exercise mechanical parts and interlocks and confirm proper operation.

   d. Verify terminations are torqued to manufacturer's specifications.

2. Testing:

   a. Verify proper operation of photocell controllers.

b. Verify proper operation of lighting contactors controlled by photocells, PLC's or switches.

BB. Battery Systems

1. Inspection:

a. Inspect battery enclosure, battery support system, charger and interconnection wiring for damage.

b. Verify battery sizes conform to Contract Documents.

c. Verify charger nameplate data conform to Contract Documents.

d. Check battery intercell bus link integrity.

e. Verify terminations are torqued to manufacturer's specifications.

2. Testing:

a. Measure charging voltage and current and each individual cell voltage. Compare to manufacturer's specifications.

b. Perform a contact resistance test across all connections between adjacent terminals. Investigate and report any values greater that 50 microhms.

c. Confirm that charging rate from charger during recharge conforms to manufacturer's specification.

CC. Metering and Instrumentation

1. Inspection:

a. Inspect for physical damage.

b. Verify nameplate information conforms to Contract Documents.

c. Verify connections of instrument transformers (voltage transformers, VT's and current transformers, CT's) are in conformance with Contract Documents.

d. Verify terminations are torqued to manufacturer's specifications.

e. Verify that all required grounding and shorting connections are in conformance with Contract Documents.

f. Test proper operation of control power transformer withdrawal mechanism (tip out) and grounding operation when applicable.

g. Verify proper primary and secondary fuse sizes for VT's.

h. Verify that VT and CT turn ratios conform to Contract Documents.

i. Verify all VT and CT insulation and accuracy classes conform to Contract Documents.

j. Verify proper polarity of all VT's and CT's.

k. Verify that all gauge types and scales conform to Contract Documents for all instruments including but not limited to: voltmeters, ammeters, wattmeters, varmeters, power factor meters, watthour meters, varhour meters, watthour demand meters and varhour demand meters.

2. Testing:

a. Perform a polarity test of each VT and CT.

b. Perform a CT ratio test using the voltage or current method in accordance with ANSI C57.13.1. Ratio accuracy's shall be within the ANSI accuracy class percentages.

c. Perform a VT ratio test using a Transformer-Turns-Ratio (TTR) set or by voltage comparison method.

d. Perform an excitation test on CT's used for relaying application in accordance with ANSI C57.13.1.

e. Measure relaying circuit burdens at CT terminals and record the total burden in ohms at 60 Hz.

f. Verify wiring of all instruments conforms to Contract Documents from all instrument terminals back one device (Example: Ammeter back to Ammeter Switch and back to CT).

DD. Circuit Breakers: Medium Voltage (Vacuum):

1. Inspection:

a. Inspect for physical damage. Clean and lubricate as required.

b. Check alignment of drawout, racking mechanism and grounding stabs.

c. Verify terminations are torqued to manufacturer's specifications.

d. Perform a minimum of three (3) **Open** and **Close** operations.

e. Perform mechanical operational tests

f. Check vacuum bottle wear indicator gauge. Report any differences between poles.

2. Testing:

    a. Perform a circuit breaker time-travel velocity analysis. Verify time-travel velocity data conforms to manufacturer's specifications.

    b. Perform minimum pickup voltage test on all trip and close coils.

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

    d. Perform vacuum bottle integrity test (overpotential) across each vacuum bottle with the breaker in the open position in strict accordance with manufacturer's instructions. **Do not** exceed maximum voltage stipulated for this test.

    e. Perform an insulation resistance (Megger) test (L-G and L-L at 2500 VDC for a minimum of 1 minute). Investigate and report any values below 200 megohms.

    f. Perform an insulation resistance (Megger) test at 1000 VDC on all control wiring. **Do not** perform this test on wiring connected to solid-state relays.

    g. Perform a contact resistance test across each pole. Investigate and report any values in excess of 50 microhms or any deviations from adjacent poles greater than 50%.

EE. Switches: Medium Voltage:

1. Inspection:

    a. Check switch blades to ensure all three phases are engaged at the same time and all three break at the same time.

    b. Inspect and operate the operating handle; apply lubrication if required.

    c. Verify terminations are torqued to manufacturer's specifications.

    d. Verify current carrying contact blades are lightly lubricated with conductive electrical grease.

    e. Check all insulators, insulating barriers, cable and cable terminations for signs of cracking, missing insulation or other errors.

    f. Check proper phasing of switch and cable.

    g. Verify that the type, quantity and sizes of fuses conform to Contract Documents.

2. Testing:

    a. Perform a contact resistance test across each blade of each phase in the closed position. Investigate and report any values greater than 50 microhms.

b. Perform an insulation resistance (Megger) test (L-G and L-L at 10,000 VDC for a minimum of 1 minute). Investigate and report any values below 200 megohms.

c. High Potential (Hi-Pot) direct current (DC) tests shall be performed on all medium voltage (5kV - 15kV class) switches installed.

FF. Protective Relays

1. Inspection:

a. Inspect for physical damage.

b. Verify nameplate information conforms to Contract Documents.

c. Inspect cover gasket for proper seal, clean glass, check for foreign material (particularly in disc slots of permanent and electromagnets), check disc clearance, check condition of spiral springs and case contacts, check for proper travel and alignment and check tightness of mounting hardware and tap plugs.

d. For electronic relays, inspect solid-state plug-in feature for reliable connection. Check relay test switches to ensure proper operation of shorting or grounding features.

2. Testing:

a. Perform the following tests per NETA ATS-2009 procedures and acceptable parameters.

i. Pickup parameters on each operating element.

ii. Perform timing test at three (3) points of time-current curve, typically 150%, 300%, and 600%.

iii. Pickup target and seal-in units.

iv. Special tests as required to check operation of restraint, directional and other elements per manufacturer's instruction manual.

b. Perform phase-angle and magnitude contribution test on all differential and directional-type relays after energization to vectorially prove proper polarity and connection.

GG. Medium Voltage Cables, Junction Boxes, Terminations and Splices

1. Inspection:

a. Verify size, type, rating, jacket, etc. of cable conform to Contract Documents.

b. Record the length of each cable, type of insulation, type of construction, cable manufacturer and location of the cable in the system. Record the type of splice and termination at each location.

c. Inspect for physical damage while on shipping reel, during installation and after installation. Check cables on reels for proper sealing of ends against moisture.

d. Verify cable is connected in conformance with Contract Documents.

e. Inspect for shield grounding, cable support and termination.

f. Inspect for fireproofing in common cable areas (such as manholes and splice boxes).

g. Verify cable shields are routed through window type current transformers (CT's) and terminated for proper operation of protective devices.

h. Verify proper phase identification and phase orientation.

i. Visually inspect all termination stress reliefs are constructed properly.

j. Visually inspect all cable splices, grounds and cable armors to verify they are continuous mechanically and electrically and installed in conformance with Contract Documents.

k. Verify cable bends do not exceed ICEA or manufacturer's minimum allowable bending radius.

l. Medium voltage junction boxes: Before any cables are connected thoroughly clean all surfaces and hi-pot at 37.5 KV.

m. Complete circuit test: After all terminations have been installed and all cable connections made except at the existing junction boxes perform a DLRO test on the complete medium voltage circuit.

2. Testing:

a. Perform a shield continuity test on each power cable by ohmmeter method; record value. Investigate and report resistance values in excess of 10 ohms per 1000 feet of cable.

b. High Potential (Hi-Pot) direct current (DC) tests shall be performed on all medium voltage (5kV - 15kV class) cables installed. All medium voltage cables shall be DC Hi-Pot tested within 30 days of delivery to site while still on the original shipping reel.

c. Power for test equipment will be supplied from a stable, constant voltage (+/- 5%) source.

d. Before performing DC Hi-Pot tests observe the following precautions:

   i. The circuit must be de-energized, tested for voltage and grounded. Ground all remaining cables located in the same ducts or trays.
   ii. All cables to be tested must be disconnected from the equipment (including arrestors and instrument transformers).
   iii. Establish adequate clearance (a minimum of 10 inches) between the circuit test ends and ground or any grounded object and to other equipment not under test.
   iv. The ends of conductors under test should be cleaned as recommended by the manufacturer and bagged in dry plastic bags to prevent partial discharge during test.
   v. Consult cable and termination manufacturers for maximum safe test voltage and time limitations.

e. The maximum values of DC test voltage will be applied at one-minute increments as follows:

   i. Apply test voltage slowly with not less than 8 equal increments of not greater than 5kV maximum per increment, to the specified level. Allow sufficient time (approximately one-minute between each step) for the saturation current to stabilize. Readings should be taken after the charging current has reached a steady level.
   ii. Record the leakage current (in microamperes) at one-minute intervals.
   iii. When the final test voltage is reached, the DC Hi-Pot should be left **On** to plot a current vs. time curve. Record the leakage current at fixed increments (1 minute) for a minimum of 15 minutes.

f. At the end of the test period, set the test set voltage control to zero. Allow the residual voltage on the circuit to decay to at least 20% of the test value before applying manual grounds. **Caution**: It must be recognized that DC charges on cable can build up to potentially dangerous levels if grounds are removed too quickly. To minimize this danger, maintain solid grounds on the cable for at least 4 times the duration of the test.

g. DC Test Voltages:

Cable	DC Test Voltage (Solid Dielectric)
Rated Voltage	(On reel and after installation)

5000V	8KV - 90 mil	32KV - 100 mil
15000V	50KV - 175 mil	64KV - 220 mil

HH. Cleaning: Medium Voltage Switches

1. Verify power is off and equipment is grounded.
2. Vacuum top of entire substation prior to removing covers and clean with a cloth moistened with multi-mist solvent.
3. Wipe dust from all bussing, insulators, arc barriers, compartment interiors and floors.
4. Clean the stand-off insulators with multi-mist solvent and apply #5 silicon grease. "Shoeshine" off excess (apply a very small amount).
5. Remove glastic separators supporting high tension leads (if present) and:
    a. Clean with "multi-mist" solvent.
    b. Paint rough sawed edges with an insulating enamel.
    c. Tape the high tension leads with anti-tracking tape for 16 inch centering the tape at the plastic separator.
    d. Check separation of high tension leads from the secondary of the interrupter switch to the primary of the transformer and make sure that there is 7 1/2 inch phase to phase and 5 inch phase to ground clearance.
6. Remove excess contact grease at buss section joints, lug attachment plates, etc. with cleaning solvent and lintless rag.
7. Clean interrupter switch contacts with denatured alcohol and “Scotchbrite” brand pad.
8. Verify terminations are torqued to manufacturer’s specifications.
9. Check fuse holder for alignment and make sure fuse is securely locked-in. Clean contact area on fuse and fuse holder and apply light coat of contact grease.
10. Check front to rear barriers in both compartments to make sure all bolts are installed tightly.
11. Make sure all captive nuts are installed in rear compartments and you have enough 2 inch x 3/8 inch diameter bolts to secure the covers.
12. Check all ground connections for proper lugs and tightness.
13. Make sure no grounds are draped below the midpoint of the stress relief cones. Train them up and secure then with nylon tie wraps.

14. Check the leading edge of the arcing blade to make sure that the tungsten tip is solidly affixed and not cracked. Do not apply contact grease to the arcing blade.

II. Cleaning: Transformer Core Section

1. Verify power is off and equipment is grounded.
2. Remove all bolt-on panels both outside and inside to expose bussing.
3. Use dry nitrogen or compressed air at no more than 25 psi to blow out transformer winding coiling vents and squirrel cage blower motor.
4. Wipe dust from the interior walls with a lintless cloth. Use a vacuum cleaner with an upholstery brush attachment to pull away loosened dust. Use a lintless cloth moistened with deionized (DI) water to wipe down exterior of core.
5. Check core pressure pads for tightness. **Do not** tighten because core expansion will cause damage.
6. Check under the core mounting cross members to make sure that the neoprene rubber isolation pads are in place and shipping bolts have loosened to isolate the core from the frame.
7. Make sure that the hot spot indicator thermocouples are securely inserted in the tube provided at the windings. Make sure that the probe lead is securely clamped in place sway from any exposed bus. **Do not** pull out.
8. Check tightness and torque to specification bolts connecting high tension leads to core and flex bus connections to the breaker section bus.
9. Closely inspect all insulators for cracks or tracking.
10. Check clearance of high voltage bussing to side panels. It should be at least 5 inches.
11. Check clearance of blower to transformer core and condition of squirrel cage (cracked, loose, in alignment? etc.). Apply two drops of light weight spindle oil in oil hole in motor (if oiling holes are provided).

JJ. Cleaning: Low Voltage Breaker Section

1. Verify power is off and equipment/building feeder cables are grounded at each breaker connection (at cable to bus connection) before working on them. Some emergency or other building electrical systems can back feed these cables.
2. Identify breakers and the cubicle they are in (make sure both breakers and compartments are marked so that the same breaker will go back into its original cubicle) - **this is extremely important!**

3. Remove all low voltage breakers and clean.
4. Verify terminations are torqued to manufacturer's specifications.
5. Clean the low voltage compartments using small dry paint brush, lintless cloth and vacuum cleaner.
6. Remove excess contact grease on breaker and bus stabs.
    a. Use multi-mist safety solvent to remove soft grease
    b. Use "Scotchbrite" brand pad to remove hardened grease
    c. Re-coat fingers and stabs lightly with contact grease
7. Check all fuses in auxiliary compartment and check tightness of wire connections.
8. Operate all breakers manually to check smoothness of operation.
9. Check alignment of control contact block in main breaker compartment to make sure that the cubicle and breaker contacts match and all contacts are made.
10. Replace all breakers in their respective compartments following cleaning and testing.
11. Check all compartments for tools, trash and other debris. Call designated individual for inspection before replacing covers.

4. Documentation and Review Requirements

A. Provide list of test equipment used and calibration dates for each piece of equipment prior to testing. Provide any changes to list at end of project.

B. Use industry standard test report forms whenever practical.

C. Provide inspection and test data sheet forms for approval prior to testing or inspection.

D. The following data should be obtained and recorded at the time of testing:

1. Name of Test Operator.
2. Date and Time of Day.
3. Ambient Temperature.
4. Relative Humidity.

E. Provide copies of NETA certificates.

F. Provide copies of test equipment calibration certificates.

G. Provide weekly copies of handwritten test reports completed that week.

H. Provide typed summary and progress reports each week.

I. Owner and test personnel shall review test data. Test results must be judged as satisfactory by Owner and test personnel before the equipment may be placed into service.

5. Installation and Performance Requirements

A. All test values shall be within those listed in the National Electrical Testing Association (NETA) ATS-2009 - “Standard for Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems”.

B. All equipment shall be operationally tested to verify it functions as intended. Examples of operational testing include but are not limited to the following:

1. Key and mechanical interlock systems
2. Automatic roll schemes
3. Local and remote control device operation
4. Lighting control
5. UPS operation and external maintenance bypass operation
6. Alarm system simulations

6. As-Built Requirements

A. Upon completion of project, provide complete test report within 30 days. Test report should be prefaced with summary of conclusions, discrepancies and actions necessary to correct non-conformance to acceptable test values.

B. All devices and equipment shall be labeled with a self-adhesive label that indicates the Test Date, Testing Company and the Testing Technician’s initials.