PART 1 - GENERAL

1.1 GENERAL

A. It is the intent of these acceptance tests to assure that all Contractor supplied equipment is operational and within industry and manufacturer's tolerances and is installed in accordance with designed specifications. It is incumbent on the General Contractor or Electrical Sub-Contractor to retain the services of a National Electrical Testing Association (NETA) firm, to test the supplied equipment, and acquire the data / information needed to determine protective relay settings, to program said relays and to provide written confirmation that said relays and other protective components of the electrical system are operating as intended.

B. The acceptance tests and inspections shall determine suitability for energization of switchgear and cables.

C. Items that shall be checked, inspected, and tested include, but are not limited to, the following:
1. SF6 switches and overcurrent protection devices
2. 15kV Switchgear and associated breakers
3. Electro-mechanical Relays
4. Digital Multi-function Relays (i.e. Schweitzer Engineering Labs)
5. Ammeters
6. Voltmeter
7. Wattmeters
8. Varmeters
9. Voltage transducer
10. Current transducers
11. Watt transducers
12. Var transducers
13. AUX compartment with control power transformer
14. AUX compartment with potential transformer
15. AUX compartment with batteries and rectifier
16. Sets of Current Transformers
17. Surge arrestors
18. Grounding system
19. Power/Lighting panelboards
20. 15kV rated cable
21. 600V rated cable
22. Substations and distribution switchgear
23. Automatic Transfer Switches
24. Batteries / battery systems / Central battery equipment for emergency lighting

1.2 APPLICABLE CODES

A. All inspections and tests shall be in accordance with the following applicable codes and standards except as provided otherwise herein.
1. California Electrical Code - CEC 2010 Edition.
2. National Electrical Manufacturer's Association - NEMA.
3. American Society for Testing and Materials - ASTM.
4. Institute of Electrical and Electronic Engineers - IEEE.

5. National Electrical Testing Association - NETA.
6. American National Standards Institute - ANSI:
   a. C2, National Electrical Safety Code
   b. Z244-1, American National Standard for Personnel Protection
7. State Codes and Ordinances.
8. Insulated Cable Engineers Association - ICEA.
9. Association of Edison Illuminating Companies - AEIC.
10. Occupational Safety and Health Administration:
    a. Part 1910, Subpart S, 1910.308
    b. Part 1926, Subpart V, 1926.950 through 1926.960
11. National Fire Protection Association - NFPA:
    a. ANSI/NFPA 70B, Electrical Equipment Maintenance
    b. NFPA 70E, Electrical Safety Requirements for Employee Workplaces
    c. CEC, California Electrical Code 2013 Edition
    d. ANSI/NFPA 78, Lightning Protection Code
    e. ANSI/NFPA 101, Life Safety Code
12. All inspections and tests shall utilize the following references:
    a. Project Design Specification.
    b. Project Design Drawings.
    c. Manufacturer's instruction manuals applicable to each particular apparatus.

1.3 QUALIFICATIONS OF TESTING AGENCY

A. The testing firm shall be an independent testing organization which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems evaluated by the testing firm.

B. The testing firm shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.

C. The testing firm and all the testing personnel shall have been engaged in such practices for a minimum of ten years.

D. The testing firm shall meet federal OSHA criteria for accreditation of testing laboratories, Title 29, Parts 1907, 1910, and 1936. Full membership in the National Electrical Testing Association constitutes proof of such criteria.

E. The lead, on site, technical person shall be currently certified by the National Electrical Testing Associate (NETA) in Electrical Power Distribution System Testing.

F. Testing firm shall utilize only full-time technicians who are regularly employed by the firm for testing services. Electrically unskilled employees are not permitted to perform testing or assistance of any kind. Electricians may assist, but may not perform testing and/or inspection services.

G. The testing firm shall submit proof of the above qualifications.

H. The testing firm shall be an independent organization as defined by OSHA Title 29, Part 1936 and the National Electrical Testing Association.

I. All instruments used by the testing firm to evaluate electrical performance shall meet NETA's Specifications for Test Instruments. (See Section 1.7 of this specification).

J. The terms used herewith such as Test Agency, Testing Laboratory, or Contractor Test Company, shall be construed to mean testing firm.

1.4 RESPONSIBILITIES

A. The Contractor shall notify the Owner's Representative prior to commencement of any testing.

B. The testing firm shall gather all field data and equipment data, shall perform all required equipment testing and protective studies, shall perform all required calculations and analysis, shall determine all required overcurrent device settings (relay settings, breaker trip points, fuse sizes, etc.), shall implement said overcurrent device settings, and shall produce and affix all warning labels.

C. Any system, material or workmanship which is found defective on the basis of acceptance tests shall be reported.

D. The testing firm shall maintain a written record of all tests and upon completion of project, assemble and certify a final test report.

E. A stable source of 60 hertz power shall be provided for testing purposes by the Contractor. All tests shall be witnessed by Owner's Representative and a minimum of 14 days' notice shall be provided.

1.5 TEST EQUIPMENT

A. Test Instrument Calibration
1. The testing firm shall have a calibration program which assures that all applicable test instrumentation are maintained within rated accuracy.
2. The accuracy shall be directly traceable to the National Bureau of Standards.
3. Instruments shall be calibrated in accordance with the following frequency schedule:
   a. Field instruments: Analog - 6 months maximum
   b. Digital - 12 months maximum
   c. Laboratory Instruments - 2months
   d. Leased specialty equipment - 12 months (where accuracy is guaranteed by lessor)
4. Dated calibration labels shall be visible on all test equipment.
5. Records must be kept up-to-date which show date and results of instruments calibrated or tested.
6. An up-to-date instrument calibration instruction and procedure will be maintained for each test instrument.
7. Calibrating standard shall be of higher accuracy than that of the instrument tested.

1.6 TEST REPORTS

A. The test report shall include the following:
1. Summary of project.

2. Description of equipment/device tested.
3. Description of test, including date, time, and duration of test.
4. Test results.
5. Conclusions and recommendations.
6. Appendix, including appropriate test forms.
7. Identification of test equipment used.
8. Signature of responsible test organization authority.
9. Signature of the person witnessing the tests.
10. Furnish five copies of the complete report to the Owner's Representative no later than thirty (30) days after completion of project unless otherwise directed.

1.7 SAFETY AND PRECAUTIONS

A. Safety practices shall include, but are not limited to, the following requirements:
1. Occupational Safety and Health Act of 1970 - OSHA.
2. Accident Prevention Manual for Industrial Operations, National Safety Council, Chapter 4.
3. Applicable State safety operating procedures.
4. NETA Safety/Accident Prevention Program.
5. Owner's safety practices.
6. National Fire Protection Association - NFPA 70E.
7. ANSI Z244.1 American National Standards for Personnel Protection.

B. All tests shall be performed with apparatus de-energized except where otherwise specifically required.

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

1.8 PROTECTIVE DEVICE COORDINATION AND ARC-FLASH STUDY

A. A protective coordination study and arc-flash study shall be performed using SKM's Dapper or equal software to select or check the selection of power fuse ratings, protective relay characteristics and settings, ratios, characteristics of associated voltage breaker trip characteristics and settings, and arc-flash hazard levels.

B. The studies shall include all voltage classes of equipment from the Owner's main incoming line and down to and including panelboards. The entire electrical system shall be included in the studies including all emergency equipment and feeders. Verify characteristics and settings of existing devices in the field and from the manufacturer.

C. The time-current characteristics of the specified protective devices shall be plotted on the appropriate log-log paper. The plots shall include complete titles, representative one-line diagrams of both buildings and legends, associated relays or fuse characteristics, significant motor starting characteristics, complete parameters of transformers, complete operating bands of low voltage circuit breaker trip curves, and fuse curves. The coordination plots shall indicate the types of protective devices selected, proposed relay taps, time dial and instantaneous trip settings, cable damage curves, symmetrical and asymmetrical fault currents. All requirements of the current National Electrical Code shall be adhered to. Reasonable coordination intervals and separation of characteristic curves shall be

maintained. Separate coordination plots for phase and ground protective devices shall be provided on a system basis. Separate curves shall be used to clearly indicate the coordination achieved for feeder breakers with downstream fuses and circuit breakers in switchgear and substations. There shall be a maximum of six protective devices per plot.

D. The selection and setting of the protective devices shall be provided separately in a tabulated form listing circuit identification, IEEE device number, current transformer ratios, manufacturer, type, range of adjustment, and recommended settings. Discrepancies, problem areas, or inadequacies shall be promptly brought to the project Owner's Representative's attention.

E. Five copies of coordination curves and tabulated data indicating selection and settings of protective devices shall be submitted to the Owner's Representative for approval.

PART 2 - EQUIPMENT VERIFICATIONS, TESTS, AND CALIBRATIONS

2.1 GENERAL

A. As part of the contract, the Contractor shall perform tests of installed work as herein specified and specified in other Sections of these Specifications.

B. The Contractor shall provide all materials, equipment, labor and technical supervision to perform such tests and inspections.

C. All tests shall be performed in compliance with the recommendations and requirements of the National Electrical Testing Association, Inc. (NETA), and applicable codes and standards.

D. Upon completion of the tests and inspections noted in these Specifications, a label shall be attached to all serviced devices. These labels shall indicate date serviced and the service company responsible.

E. The test and inspections shall determine suitability for continued reliable operation.

F. All tests shall be conducted in the presence of the Owner's Representative. Provide a minimum of two weeks' notice to the Owner's Representative.

G. Furnish the necessary equipment and personnel to perform all required tests of all wiring and connections for continuity, short circuit, and improper grounds. Included, but not limited to, the following systems: switchgear, substations, SF6 switches, air interrupting switches, low voltage main and feeder circuit breakers, interlocking controls, panelboards, distribution transformers, branch circuits.

2.2 SWITCHGEAR, SUBSTATIONS, DISTRIBUTION BOARDS, AND EMERGENCY SYSTEM-GENERAL

A. Visual and mechanical inspection:
   1. Inspect for physical damage and code violations.
   2. Clean interior and exterior surfaces.
   3. Inspect for proper alignment, anchorage, and grounding.

4. Check tightness of accessible bolted bus joints by torque wrench method. Tighten connections in accordance with industry standard torque levels.
5. Make closure attempt on locked open devices. Make opening attempt on locked closed devices.
6. Make exchange with devices operated in off-normal positions.

B. Electrical tests:
1. Measure insulation resistance of each bus section phase-to-phase and phase-to-ground.
2. Inspect all accessible bus joints and cable connections by infrared scanner to detect loose or high-resistance connections and other circuit anomalies.
3. Inspect correctness of control wiring.

2.3 MEDIUM VOLTAGE SF6 SWITCHES AND OVERCURRENT PROTECTION

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. General Field Testing Requirements:
1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" chapter.
2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
3. After installing switchgear but before primary is energized, verify that grounding system at the switchgear is tested at the specified value or less.
4. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.

C. Medium-Voltage Switchgear Field Tests:
1. Visual and Mechanical Inspection:
   a. Verify that current and voltage transformer ratios correspond to Drawings.
   b. Inspect bolted electrical connections for high resistance using one of the following two methods:
2. Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
3. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
   a. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
4. Attempt closure on locked-open devices. Attempt to open locked-closed devices.
5. Make key exchange with devices operated in off-normal positions.
   a. Inspect control power transformers.
6. Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
7. Verify that primary and secondary fuse or circuit breaker ratings match Drawings.

8. Electrical Tests:
   a. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the temperature of the bus is other than plus or minus 20 degrees C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.
9. Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
10. Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.
    a. Perform a dielectric withstand voltage test on each bus section, each phase-to-ground with phases not under test grounded, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted according to NETA ATS, Table 100.2. Apply the test voltage for one minute.
11. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
    a. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 V dc for 300 V-rated cable and 1000 V dc for 600 V-rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
12. Minimum insulation-resistance values of control wiring shall not be less than two megohms.
    a. Voltage Transformers:
13. Perform secondary wiring integrity test. Verify correct potential at all devices.
14. Verify secondary voltages by energizing the primary winding with system voltage.
    a. Perform current-injection tests on the entire current circuit in each section of switchgear.
15. Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
16. Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
    a. Perform system function tests according to "System Function Tests" Article.
    b. Verify operation of space heaters.
    c. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Medium-Voltage Vacuum Interrupter Field Tests:
1. Visual and Mechanical Inspection:
   a. Inspect physical and mechanical condition.
   b. Inspect anchorage, alignment, grounding, and required clearances.

c. Verify that maintenance devices such as special tools and gages specified by the manufacturer are available for servicing and operating the breaker.
d. Verify the unit is clean.
e. Perform mechanical operation tests on operating mechanism according to manufacturer's published data.
f. Measure critical distances on operating mechanism as recommended by the manufacturer. Critical distances of the operating mechanism shall be according to manufacturer's published data.
g. Verify cell fit and element alignment.
h. Verify racking mechanism operation.
i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
k. Perform time-travel analysis. Travel and velocity values shall be according to manufacturer's published data.
l. Record as-found and as-left operation counter reading. Operation counter shall advance one digit per close-open cycle.

2. Electrical Tests:
a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than this table or manufacturer's recommendations. Dielectric-withstand-voltage tests shall not proceed until insulation-resistance levels are raised above minimum values.
b. Perform a contact/pole-resistance test. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value. Microhm or DC millivolt drop values shall not exceed the high levels of the normal range according to manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform minimum pickup voltage tests on trip and close coils according to manufacturer's published data. Minimum pickup voltage of the trip and close coils shall comply with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
d. Verify correct operation of any auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features shall operate according to manufacturer's published data.
e. Trip circuit breaker by operation of each protective device. Reset trip logs and indicators.

f. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed. Power-factor or dissipation-factor values shall comply with manufacturer's published data.
g. Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with the contacts in the "open" position according to manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the vacuum bottle integrity test, the specimen is considered to have passed the test.
h. Perform a dielectric-withstand-voltage test according to manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the specimen is considered to have passed the test.

E. Microprocessor-Based Protective Relay Field Tests:
1. Visual and Mechanical Inspection:
a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
b. Verify operation of light-emitting diodes, display, and targets.
c. Record passwords for each access level.
d. Clean the front panel and remove foreign material from the case.
e. Check tightness of connections.
f. Verify that the frame is grounded according to manufacturer's instructions.
g. Set the relay according to results in Section 260573 "Overcurrent Protective Device Coordination Study" and in Section 260574 "Overcurrent Protective Device Arc-Flash Study."
h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.
2. Electrical Tests:
a. Perform insulation-resistance tests from each circuit to the grounded frame according to manufacturer's published data.
b. Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.
c. Functional Operation: Check functional operation of each element used in the protection scheme.
d. Control Verification:
3. Functional Tests:
a. Check operation of all active digital inputs.
b. Check output contacts or silicone-controlled rectifiers, preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.
c. Check internal logic functions used in protection scheme.
d. Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.
4. In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

F. Ground Resistance Test:
   1. Visual and Mechanical Inspection:
      a. Verify ground system complies with the Contract Documents and NFPA 70 "Grounding and Bonding" Article.
      b. Inspect physical and mechanical condition. Grounding system electrical and mechanical connections shall be free of corrosion.
      c. Inspect bolted electrical connections for high resistance using one of the following two methods:
   2. Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   3. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
      a. Inspect anchorage.
   4. Electrical Tests:
      a. Perform fall-of-potential or alternative test according to IEEE 81 on the main grounding electrode or system. The resistance between the main grounding electrode and ground shall be no more than 5 ohms.
      b. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and derived neutral points. Investigate point-to-point resistance values that exceed 0.5 ohms. Compare equipment nameplate data with Contract Documents.
      c. Inspect physical and mechanical condition.
      d. Inspect anchorage.

G. Switchgear will be considered defective if it does not pass tests and inspections.

H. Prepare test and inspection reports.

I. System Function Tests
   1. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after "Field Quality Control" tests have been completed and all components have passed specified tests.
      a. Develop test parameters and perform tests for evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
      b. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
      c. Verify the correct operation of sensing devices, alarms, and indicating devices.

~~J. Follow-Up Service~~
   ~~1. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove all necessary covers prior to the inspection.~~

~~a. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of the switchgear.~~

~~b. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C.~~

~~c. Record of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used, and lists the results as follows:~~

~~1) Description of equipment to be tested.~~

~~2) Discrepancies.~~

~~3) Temperature difference between the area of concern and the reference area.~~

~~4) Probable cause of temperature difference.~~

~~5) Areas inspected. Identify inaccessible and unobservable areas and equipment.~~

~~6) Identify load conditions at time of inspection.~~

~~7) Provide photographs and thermograms of the deficient area.~~

~~d. Act on inspection results according to the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.~~

2.4 SURGE ARRESTERS

A. Visual and mechanical inspection:
1. Inspect for physical damage such as chipped or fractured porcelain.
2. Inspect ground and discharge counter connections for integrity.

B. Electrical tests:
1. Perform a 60Hz sparkover test.
2. Perform a radio influence voltage (RIV) test.
3. Perform an insulation power factor test.
4. Perform ground continuity test to ground grid system.

~~2.5 BATTERY SYSTEM / CENTRAL BATTERY EQUIPMENT FOR EMERGENCY LIGHTING~~

~~A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.~~

~~B. Perform tests and inspections and prepare test reports.~~

~~1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.~~

~~C. Tests and Inspections:~~

~~1. Inspect central battery equipment, wiring, components, connections, and equipment installation. Test and adjust components and equipment.~~

~~2. Test insulation resistance for all external branch circuit, feeder, control, and alarm wiring connected to central battery equipment element and component.~~

~~3. Test continuity of each circuit.~~

~~4. Verify that input voltages and frequencies at central battery equipment locations are within voltage and frequency limits specified in Part 2. If outside this range, notify Construction Manager before closing input OCPDs.~~

~~5. Perform each visual and mechanical inspection and electrical test stated in manufacturer's written instructions and in NETA Acceptance Testing Specification, including specifically those for batteries, battery chargers, and UPS, regardless of the type of central battery equipment provided. Certify compliance with test parameters.~~

~~6. Perform a load-duration test at rated voltage and rated output current to verify the correct functional operation of the unit under full-load stable operating conditions for the minimum time limits required by UL 924. Monitor and record ambient temperature and temperatures within the unit.~~

~~7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.~~

~~8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:~~

~~a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of central battery equipment. Remove front panels so joints and connections are accessible to portable scanner.~~

~~b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of central battery equipment 11 months after date of Substantial Completion.~~

~~c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.~~

~~9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.~~

~~D. Central battery equipment will be considered defective if it does not pass tests and inspections.~~

~~E. Prepare test and inspection reports, including a certified report that identifies central battery equipment and describes all test results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.~~

~~2.6~~2.5 INSTRUMENT TRANSFORMER

A. Visual and mechanical inspection:
1. Inspect for physical damage and connection tightness.
2. Check transformer nameplate with singleline diagram.
3. Check proper operation of grounding or shorting devices.

B. Electrical tests:
1. Measure current transformer ratio by primary current injection.
2. Measure potential transformer ratio.
3. Measure insulation resistance primary-to-ground, secondary-to-ground and primary-to-secondary.
4. Verify secondary wiring connections by secondary current injection.
5. Verify transformer polarity markings.

6. Perform current transformer saturation test. Plot transformer voltage current curve.

~~2.7~~2.6 METERING AND INSTRUMENTATION

A. Visual and mechanical inspection:
   1. Check all devices for physical damage and connection tightness.
   2. Verify meter nameplate designation.

B. Electrical tests:
   1. Check calibration of all panel meters at zero, midscale and full scale deflections by transfer standard.
   2. Test Digital Instrumentation Package per manufacturer's requirements.
   3. Verify all instrument multipliers and scale factors.
   4. Check polarities and correct rotations.

~~2.8~~2.7 CONTROL POWER TRANSFORMERS - ENCAPSULATED TYPE

A. Visual and mechanical inspection:
   1. Inspect for physical damage, proper installation, anchorage, and grounding.
   2. Clean interior and all bushing and insulator surfaces.
   3. Verify proper auxiliary device operation such as fans and indicators.
   4. Check tightness of accessible bolted electrical joints. Tighten connections in accordance with industry standards.

B. Electrical tests:
   1. Perform insulation resistance tests winding-to-winding and winding-to-ground. Apply appropriate guard circuit over all bushings.
   2. Perform dielectric absorption test winding-to-winding and winding-to ground for ten (10) minutes. Compute the polarization index.
   3. Perform turns ratio test between windings for all top positions.
   4. Perform insulation power factor tests on all high and low-voltage windings.
   5. Check output voltages.

~~2.9~~2.8 PROTECTIVE RELAYS

A. Visual and mechanical inspection:
   1. Inspect relays for physical damage, presence of foreign material, moisture, condition of spiral spring, disc clearance and corrosion.
   2. Clean cover glass interior and relay components.
   3. Check for freedom of movement, proper travel and alignment, and tightness of mounting hardware and top screws.

B. Electrical test:
   1. Perform insulation resistance tests on each circuit branch to frame.
   2. Perform the following tests at the settings specified by Owner's Representative:
      a. Pickup parameters on each operating element.
      b. Timing at three (3) points on time dial curve.
      c. Pickup target and seal in units.
      d. Special test as required to check operation of restraint, and other elements per manufacturer's instructions.

3. Perform phase angle and magnitude contribution tests on all differential type relays after energization to vectorially prove proper polarity and connection.
4. Check polarity and correctness of control wiring.

C. Relay calibration and tests:
1. Two relay wiring tests shall be made.
   a. Primary circuit polarity test shall include a DC test from the current transformer to each terminal block and relay terminal.
   b. Relay and circuit breaker operation test by application of power from the portable relay test set.

D. Relay testing shall be accomplished after completion of the switchgear installation, using standard portable test set equipment and the relay manufacturer's testing directions and parameters to determine conformance of the relay to the time-overcurrent information given in the manufacturer's performance curves and the tap settings provided by coordination study. Overcurrent relay testing shall include:
1. Zero set tests.
2. Pickup tests.
3. Time-current characteristic (operation at currents 3 and 4 times the directed tap settings), and instantaneous at the directed tap setting.
4. Target and seal-in operation.

E. Target differential relays shall be tested similarly, except for the following additional tests:
1. Low voltage "through-currents" of approximately "full load" and "fault" magnitudes shall be circulated in HV busses. Bus differential relays shall not trip.
2. Low voltage currents shall be circulated within the differential zones of "low-fault" and "high-fault" magnitudes. Bus differential relays shall initiate tripping momentarily.

~~2.10~~2.9 CABLES 15KV

A. Testing of cables shall be performed by an independent testing agency at the Contractor's expense. The testing agency shall have a minimum of 5 years' experience. Each person engaged in the testing procedures shall also meet the experience requirements. Provide to Owner's Representative documentation, including references of the testing agency and agency's personnel experience, for approval.

B. Visual and mechanical inspections:
1. Inspect exposed section for tracking corona, and physical damage.
2. Clean all creepage from surfaces of termination.

C. Inspect shield grounding, cable support, and termination.
1. Perform infrared scan of all connections under loaded conditions.

D. Electrical tests:
1. Perform shield and conductor continuity test by ohmmeter method. Record ohmic value.
2. Perform insulation-resistance test of each cable with respect to ground and adjacent cables.

3. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
4. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
5. Perform DC hypotential test on all new cable, supplied and installed as part of the project:
   a. Test each conductor individually with all other conductors grounded. All shields to be grounded.
   b. Corona at terminations will be suppressed with guard rings, field reduction spheres, or other suitable methods.
   c. Apply DC hypotential in at least eight (8) equal increments until maximum test voltage is reached. Record DC leakage current at each step after a constant stabilization time, consistent with system charging current decay. Plot leakage current (X axis) versus voltage (Y axis) at each increment.
   d. Raise the test conductor to a maximum test voltage and hold for a total of fifteen (15) minutes. Record readings of leakage current (Y axis) versus time (X axis) and plot on thirty (30) second intervals for the first two (2) minutes and every minute thereafter. Perform maximum voltage decrement test by reducing the applied voltage to zero and monitoring voltage decay versus time. Apply grounds upon completion to drain all absorpic potential to zero.
   e. Test each conductor in accordance with Section E of AEIC C56.
   f. All existing cables that are part of the system and connected to new cables or utilized and are part of the project shall be subject to DC Hipot tests. Contractor shall perform VLF testing on these cables to confirm their integrity and proper installation.

~~2.11~~2.10 LOW VOLTAGE CIRCUIT BREAKERS 100AMPS AND GREATER

A. Visual and mechanical inspection:
   1. Inspect for physical condition.
   2. Inspect alignment and grounding.
   3. Perform mechanical operator and contact alignment tests on the breaker and its operating mechanism in accordance with manufacturer’s instructions.
   4. Perform insulation resistance test on control wiring.
   5. Clean mechanism, insulating surfaces and contacts.

B. Electrical tests:
   1. Measure contact resistance.
   2. Trip overcurrent protective device by operation of each protective device.
   3. Perform an insulation resistance test phase-to-ground, phase-to-phase and across open contacts.
   4. Perform insulation resistance test in accordance with Doble procedure.
   5. Perform timing test with Travel Analyzer to insure proper contact overtravel and pressure.

~~2.12~~2.11 CABLES, LOW VOLTAGE (600 VOLTS AND LESS)

A. Visual and mechanical inspections:

1. Inspect cables for physical damage and proper connection.
2. Torque test cable connection. Tighten connections in accordance with industry standards.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. ~~Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.~~
   a. ~~Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.~~
   b. ~~Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.~~
   c. ~~Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.~~

B. Electrical tests:
   1. Perform insulation resistance test of each cable with respect to ground and adjacent cables.

C. Cables will be considered defective if they do not pass tests and inspections.

~~2.13~~2.12 GROUNDING SYSTEMS

A. Visual and mechanical inspection:
   1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
   2.

B. Electrical tests:
   1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
   2. Perform “fall of the potential” test per IEEE No. 81, Section 9.03 to determine the ground resistance between the main grounding system and all major electrical equipment frames, system neutral and/or derived neutral points.
   3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.
      a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
      b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 ohms.

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

~~Contractor will provide additional measures as required to meet the requirements.~~

~~2.14 INFRARED INSPECTION~~

~~A. All doors and cover shall be removed and upon completion of test be reinstalled by testing agency technicians.~~

~~B. A load bank shall be furnished to circulate low voltage currents of 400A magnitude through each bus, main breaker and feeder breaker. After two hours infrared scans shall be made of all bus joints. Problem area shall be photographed before and after corrections. After corrections, another current test of two hours duration shall be made. Again an infrared scan shall be made to confirm correct operation.~~

~~C. Upon completion, the switchgear shall be energized at 12kV. After 4 hours, infrared scans shall be made to determine areas of excessive corona. Problem area shall be treated the same as under B., above.~~

~~D. Upon completion of infrared scans, all covers and doors shall be reinstalled.~~

~~2.15~~2.13 REPORTS

A. Provide (5) copies of all test reports, field note, photographs, calculations, daily logs, etc. to the Owner at the completion of all testing.

END OF SECTION