SECTION 16080 – ELECTRICAL ACCEPTANCE TESTS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. All of the Contract Documents, as listed on the Table of Contents and including General and Supplementary Conditions and Division 1, General Requirements, shall be included in, and made part of, this Section.

1.2 DESCRIPTION OF WORK

A. The Electrical Subcontractor shall engage the services of a recognized independent NETA testing firm for the purpose of performing inspections and tests as herein specified.

B. The testing firm shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections. It is the purpose of these specifications to assure that all tested electrical equipment, both Electrical Subcontractor and Owner supplied, is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.

C. The tests and inspections shall determine suitability for energization.

D. An itemized description of equipment to be inspected and tested follows:

1. Grounding system.
2. Ground fault protection systems.
3. Conductors

    a. 600 volt conductors. (60 amperes and larger)

4. Low voltage distribution equipment

    a. Metering.
    b. Motor control centers.
    c. Panelboards.
    d. Switchboards.
    e. Enclosed circuit breakers.

5. Motors.
6. Emergency system equipment

    a. Automatic transfer switches.

b. Emergency generator.
c. Emergency generator batteries.

7. Surge arresters.

1.3 RELATED WORK

A. For work to be included as part of this Section, to be furnished and installed by the Electrical Subcontractor, refer to the Related Work section of Specification Section 16010.

B. Carefully examine all of the Contract Documents, criteria sheets and all other Sections of the specifications for requirements which affect work under this Section, whether or not such work is specifically mentioned in this Section.

1.4 REFERENCES

A. All inspections and field tests shall be in accordance with the latest adopted edition of the following codes, standards, and specifications except as provided otherwise herein.

1. American National Standards Institute - ANSI
2. Association of Edison Illuminating Companies - AEIC
3. Institute of Electrical and Electronic Engineers - IEEE

a. ANSI/IEEE C2, National Electrical Safety Code
b. ANSI/IEEE C37, Guides and Standards for Circuit Breakers, Switchgear, Relays, Substations, and Fuses.
c. ANSI/IEEE C57, Distribution, Power, and Regulating Transformers.
d. ANSI/IEEE C62, Surge Protection.
e. ANSI/IEEE Std. 43 (R1992). IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
f. ANSI/IEEE Std. 81. IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
g. ANSI/IEEE Std. 142. IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (IEEE Green Book.).
h. ANSI/IEEE Std. 241. IEEE Recommended Practice for Electric Power Systems in Commercial Buildings (Gray Book).
i. ANSI/IEEE Std. 242. IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).
j. ANSI/IEEE Std. 399. IEEE Recommended Practice for Power Systems Analysis (Brown Book).
k. ANSI/IEEE Std. 446. IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications (Orange Book).
l. ANSI/IEEE Std. 493. IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems (Gold Book).

m. ANSI/IEEE Std. 602. IEEE Recommended Practice for Electric Systems in Health Care Facilities (White Book).
n. ANSI/IEEE Std 1100. IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (Emerald Book).

4. Insulated Cable Engineers Association - ICEA
5. InterNational Electrical Testing Association - NETA

a. NETA Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems.

6. National Electrical Manufacturer's Association - NEMA

a. NEMA Standard for Publication No. AB4: Guidelines for Inspection and Preventive Maintenance of Molded-Case Circuit Breakers Used in Commercial and Industrial Applications.
b. NEMA Publication MG1: Motors and Generators

7. National Fire Protection Association - NFPA

a. ANSI/NFPA 70: National Electrical Code.
b. ANSI/NFPA 70B: Recommended Practice for Electric Equipment Maintenance.
c. ANSI/NFPA 70E: Electrical Safety Requirements for Employee Workplaces.

d. ANSI/NFPA 99: Standard for Healthcare Facilities.
e. ANSI/NFPA 101: Life Safety Code.
f. ANSI/NFPA 110: Emergency and Standby Power Systems.
g. ANSI/NFPA 780: Lightning Protection Code.

8. Occupational Safety and Health Administration - OSHA
9. State and local codes and ordinances
10. Underwriters Laboratory - UL

1.5 QUALIFICATIONS OF THE TESTING FIRM

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 shall meet the criteria for Full Membership or be a Full Member company of the InterNational Electrical Testing Association.

D. The lead, on site, technical person shall be currently certified by the InterNational Electrical Testing Association (NETA) or the National Institute for Certification in Engineering Technologies (NICET) in electrical power distribution system testing.

E. The testing firm shall utilize technicians who are regularly employed by the firm for testing services.

F. The testing firm shall submit proof of the above qualifications with bid documents when requested.

1.6 DIVISION OF RESPONSIBILITY

A. The Electrical Subcontractor shall perform routine insulation-resistance, continuity, and rotation tests for all distribution and utilization equipment prior to, and in addition to, tests performed by the testing firm specified herein.

B. The Electrical Subcontractor shall supply a suitable and stable source of electrical power to each test site. The testing firm shall specify the specific power requirements.

C. The Electrical Subcontractor shall notify the testing firm when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project scheduling.

D. The Electrical Subcontractor shall supply a short-circuit analysis and coordination study, a protective device setting sheet, a complete set of electrical plans, specifications, and any pertinent change orders to the testing firm prior to commencement of testing.

E. The Architect shall be notified prior to commencement of any testing.

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

G. The testing firm shall maintain a written record of all tests and shall assemble and certify a final test report.

H. Safety and Precautions

1. Safety practices should include, but are not limited to, the following requirements:

a. Occupational Safety and Health Act.
b. Accident Prevention Manual for Industrial Operations, National Safety Council.
c. Applicable state and local safety operating procedures.
d. Owner's safety practices.
e. ANSI/NFPA 70E, Electrical Safety Requirements for Employee Workplaces.

f. American National Standards for Personnel Protection: Lockout/Tagout.

2. All tests shall be performed with apparatus de-energized except where otherwise specifically required.
3. The testing organization shall have a designated safety representative on the project to supervise operations with respect to safety.

1.7 SUITABILITY OF TEST EQUIPMENT

A. All test equipment shall be in good mechanical and electrical condition.

B. Split-core current transformers and clamp-on or tong-type ammeters require careful consideration of the following in regard to accuracy:

1. Position of the conductor within the core.
2. Clean, tight fit of the core pole faces.
3. Presence of external fields.
4. Accuracy of the current transformer ratio in addition to the accuracy of the secondary meter.

C. Selection of metering equipment should be based on a knowledge of the waveform of the variable being measured. Digital multimeters may be average or RMS sensing and may include or exclude the dc component. When the variable contains harmonics or dc offset and, in general, any deviation from a pure sine wave, average sensing, RMS scaled meters may be misleading.

D. Field test metering used to check power system meter calibration must have an accuracy higher than that of the instrument being checked.

E. Accuracy of metering in test equipment shall be appropriate for the test being performed but not in excess of two percent of the scale used.

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

1.8 TEST INSTRUMENT CALIBRATION

A. The testing firm shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

B. The accuracy shall be directly traceable to the National Institute of Standards and Technology. (NIST).

C. Instruments shall be calibrated in accordance with the following frequency schedule:

1. Field instruments: Analog, 6 months maximum; Digital, 12 months maximum
2. Laboratory instruments: 12 months
3. Leased specialty equipment: 12 months where accuracy is guaranteed by lessor.

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.

F. Up-to-date instrument calibration instructions and procedures shall be maintained for each test instrument.

G. Calibrating standard shall be of higher accuracy than that of the instrument tested.

1.9 TEST REPORT

A. The test report shall include the following:

1. Summary of project.
2. Description of equipment tested.
3. Description of test.
4. Test results.
5. Analysis and recommendations.

B. Furnish a copy or copies of the complete report to the Owner as required in the acceptance Contract.

PART 2 – PRODUCTS NOT USED

PART 3 - EXECUTION

3.1 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES

A. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical, electrical, and mechanical condition.
3. Confirm correct application of manufacturer's recommended lubricants.
4. Verify appropriate anchorage, required area clearances, physical damage, and correct alignment.
5. Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.
6. 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.
7. Verify that current and potential transformer ratios correspond to drawings.
8. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.

9. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

    a. Attempt closure on locked-open devices. Attempt to open locked-closed devices.
    b. Make key exchange with devices operated in off-normal positions.

10. Inspect insulators for evidence of physical damage or contaminated surfaces.
11. Verify correct barrier and shutter installation and operation.
12. Exercise all active components.
13. Inspect all mechanical indicating devices for correct operation.
14. Verify that filters are in place and/or vents are clear.
15. Test operation, alignment, and penetration of instrument transformer withdrawal disconnects, current-carrying and grounding, as indicated elsewhere in these specifications.
16. Inspect control power transformers.

    a. Inspect physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
    b. Verify that primary and secondary fuse ratings or circuit breakers match drawings.
    c. Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

B. Electrical Tests

1. Perform tests on all instrument transformers as indicated elsewhere in these specifications.
2. Perform ground resistance tests as indicated elsewhere in these specifications.
3. Perform resistance tests through all bus joints with a low-resistance ohmmeter. Any joints that cannot be directly measured due to permanently installed insulation wrap shall be indirectly measured from closest accessible connection.
4. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground.
5. After insulation resistance test levels are above minimum published values, 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. The test voltage shall be applied for one minute.
6. Perform insulation-resistance tests at 1000 volts dc on all control wiring. Do not perform this test on wiring connected to solid-state components.
7. Perform control wiring performance test in accordance with System Function Tests indicated elsewhere in these specifications.
8. Perform current injection tests on the entire current circuit in each section of switchgear.

    a. Perform current tests by primary injection, where possible, with magnitudes such that a minimum of 1.0 ampere flows in the secondary circuit.
    b. Where primary injection is impractical, utilize secondary injection with a minimum current of 1.0 ampere.
    c. Test current at each device.

9. Determine accuracy of all meters and calibrate watt-hour meters in accordance with the metering section of these specifications. Verify multipliers.
10. Perform phasing check on double-ended switchgear to insure correct bus phasing from each source.
11. Perform the following tests on control power transformers.

    a. Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with manufacturers published data.
    b. Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage. Confirm potential at all devices.
    c. Verify correct secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.

    d. Verify correct function of control transfer relays located in switchgear with multiple power sources in following energized source for control power transformers.

12. Potential Transformer Circuits

    a. Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage. Confirm correct potential at all devices.
    b. Verify secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.

13. Verify operation of switchgear/switchboard heaters.

C. Test Values

1. Bolt-torque levels shall be in accordance with manufacturers published data.
2. Compare bus connection resistances to values of similar connections.
3. Insulation-resistance values for bus, control wiring, and control power transformers shall be in accordance with manufacturer's published data. Values of insulation resistance less than manufacturer's minimum should be investigated. Overpotential tests should not proceed until insulation-resistance levels are raised above minimum values.

4. Apply overpotential test voltages in accordance with manufacturer's recommendations. The insulation shall withstand the overpotential test voltage applied.

3.2 DRY TYPE TRANSFORMERS

A. Air-Cooled, 600 Volt and Below - Small (167 kVA Single-Phase, 500 KVA Three-Phase, and Smaller)

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.
3. Verify that resilient mounts are free and that any shipping brackets have been removed.

4. Perform insulation-resistance test. Calculate polarization index. Measurements shall be made from winding-to-winding and each winding-to-ground. Test voltages and minimum resistance shall be in accordance with manufacturers published data. Results shall be temperature corrected as applicable.

3.3 CABLES - 600 VOLT, 60 AMPERES AND ABOVE

A. Visual and Mechanical Inspection

1. Compare cable data with drawings and specifications.
2. Inspect exposed sections of cables for physical damage and correct connection in accordance with single-line diagram.
3. Verify tightness of accessible bolted connections by calibrated torque wrench in accordance with manufacturer's published data.
4. Inspect compression-applied connectors for correct cable match and indention.
5. Verify cable color coding with applicable engineer's specifications and National Electrical Code standards.

B. Electrical Tests

1. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential to be 1000 volts dc for one minute.
2. Perform continuity test to insure correct cable connection.

C. Test Values

1. Bolt-torque levels shall be in accordance with manufacturers published data.
2. Minimum insulation-resistance values shall be not less than 50 megohms.
3. Investigate deviations between adjacent phases.

3.4 INSULATED CASE/MOLDED CASE CIRCUIT BREAKERS (400 AMPERES AND ABOVE)

A. Visual and Mechanical Inspection

1. Compare nameplate data with drawings and specifications.
2. Inspect circuit breaker for correct mounting.
3. Operate circuit breaker to insure smooth operation.
4. Inspect case for cracks or other defects.
5. Verify tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method in accordance with manufacturer's published data.

6. Inspect mechanism contacts and arc chutes in unsealed units.

B. Electrical Tests

1. Perform a contact-resistance test.
2. Perform an insulation-resistance test at 1000 volts dc from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase.
3. Perform adjustments for final settings in accordance with coordination study supplied by Electrical Subcontractor.
4. Perform long-time delay time-current characteristic tests by passing 300 percent rated current through each pole separately unless series testing is required to defeat ground fault functions.
5. Determine short-time pickup and delay by primary current injection.
6. Determine ground-fault pickup and time delay by primary current injection.
7. Determine instantaneous pickup current by primary injection using run-up or pulse method.
8. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.

C. Test Values

1. Bolt-torque levels shall be in accordance with manufacturers published data.
2. Compare microhm or millivolt drop values to adjacent poles and similar breakers. Investigate deviations of more than 25 percent. Investigate any value exceeding manufacturer's recommendations.
3. Insulation resistance shall not be less than 100 megohms.
4. Trip characteristic of breakers shall fall within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
5. For molded-case circuit breakers all trip times shall fall within times indicated in Table 5-3 of NEMA Standard AB4-1991. Circuit breakers exceeding specified trip time at 300 percent of pickup shall be tagged defective.
6. For molded-case circuit breakers instantaneous pickup values shall be within values shown on Table 5-4 of NEMA Standard AB4-latest adopted edition.

3.5 POWER CIRCUIT BREAKERS

A. Visual and Mechanical Inspection

1. Compare nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Confirm correct application of manufacturer's recommended lubricants.
4. Inspect anchorage, alignment, and grounding. Inspect arc chutes. Inspect moving and stationary contacts for condition, wear, and alignment.
5. Verify that all maintenance devices are available for servicing and operating the breaker.
6. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

7. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.
8. Verify tightness of accessible bolted bus connections by calibrated torque-wrench method. Refer to manufacturer's instructions for correct torque levels.
9. Check cell fit and element alignment.
10. Check racking mechanism.

B. Electrical Tests

1. Perform a contact-resistance test.
2. Perform an insulation-resistance test at 1000 volts dc from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase.
3. Make adjustments for the final settings in accordance with the coordination study supplied by the Electrical Subcontractor.
4. Determine minimum pickup current by primary current injection.
5. Determine long-time delay by primary current injection.
6. Determine short-time pickup and delay by primary current injection.
7. Determine ground-fault pickup and delay by primary current injection.
8. Determine instantaneous pickup value by primary current injection.
9. Activate auxiliary protective devices, such as ground-fault or undervoltage relays, to insure operation of shunt trip devices. Check the operation of electrically-operated breakers in their cubicles.
10. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.
11. Check charging mechanism.

C. Test Values

1. Bolt-torque levels shall be in accordance with manufacturers published data.
2. Compare microhm or millivolt drop values to adjacent poles and similar breakers. Investigate deviations of more than 25 percent.
3. Insulation resistance shall not be less than 100 megohms. Investigate values less than 100 megohms.
4. Trip characteristics of breakers shall fall within manufacturer's published time-current tolerance bands.

3.6 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Verify correct connection of transformers with system requirements.
4. Verify that adequate clearances exist between primary and secondary circuit wiring.

5. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
6. Verify that all required grounding and shorting connections provide contact.
7. Verify correct operation of transformer withdrawal mechanism and grounding operation.

8. Verify correct primary and secondary fuse sizes for potential transformers.

B. Electrical Tests - Current Transformers

1. Perform insulation-resistance test of the current transformer and wiring-to-ground at 1000 volts dc. Do not perform this test on solid-state devices.
2. Perform a polarity test of each current transformer.
3. Perform a ratio-verification test using the voltage or current method in accordance with ANSI C57.13.1 (IEEE Guide for Field Testing of Relaying Current Transformers).

4. Perform an excitation test on transformers used for relaying applications in accordance with ANSI C57.13.1. (IEEE Guide for Field Testing of Relaying Current Transformers).

5. Measure current circuit burdens at transformer terminals and determine the total burden.

6. When applicable, perform insulation-resistance and dielectric withstand tests on the primary winding with secondary grounded. Test voltages shall be in accordance with NETA standards and ANSI C57.13-1993 respectively.

C. Electrical Tests - Voltage Transformers

1. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages shall be applied for one minute in accordance with NETA standards. Do not perform this test with solid-state devices connected.
2. Perform a polarity test on each transformer to verify the polarity marks or H1-X1 relationship as applicable.
3. Perform a turns ratio test on all tap positions, if applicable.
4. Measure potential circuit burdens at transformer terminals and determine the total burden.

D. Test Values
1. Insulation-resistance measurement on any instrument transformer shall be not less than NETA standards.
2. Polarity results shall agree with system drawings.
3. Compare measured burdens to calculated burdens supplied by owner.
4. Ratio accuracy shall be within 0.5 percent of nameplate or manufacturer's published data.

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

3.7 METERING

A. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Verify tightness of electrical connections.
4. Inspect cover gasket, cover glass, condition of spiral spring, disc clearance, contacts, and case-shorting contacts, as applicable.

5. Verify mechanically for freedom of movement, correct travel and alignment, and tightness of mounting hardware.

B. Electrical Tests

1. Check calibration of meters at all cardinal points.
2. Calibrate watthour meters according to manufacturer's published data.
3. Verify all instrument multipliers.

C. Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.8 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection

1. Verify ground system is in compliance with drawings and specifications.

B. Electrical Tests

1. Perform fall-of-potential test or alternative in accordance with IEEE Standard 81-1991 on the main grounding electrode or system.
2. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.

C. Test Values

1. The resistance between the main grounding electrode and ground should be no greater than five ohms for commercial or industrial systems and one ohm or less for generating or transmission station grounds unless otherwise specified by the owner. (Reference: IEEE Standard 142.)
2. Investigate point-to-point resistance values which exceed 0.5 ohm.

3.9 GROUND-FAULT PROTECTION SYSTEMS

A. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.
2. Visually inspect the components for damage and errors in polarity or conductor routing.

    a. Verify that ground connection is made ahead of neutral disconnect link and on the line side of any ground fault sensor.
    b. Verify that neutral sensors are connected with correct polarity on both primary and secondary.
    c. Verify that all phase conductors and the neutral pass through the sensor in the same direction for zero sequence systems.
    d. Verify that grounding conductors do not pass through zero sequence sensors.

    e. Verify that the grounded conductor is solidly grounded.

3. Verify tightness of all electrical connections including control circuits.
4. Verify correct operation of all functions of the self-test panel.
5. Verify that the control power transformer has adequate capacity for the system.
6. Set pickup and time-delay settings in accordance with the settings provided in the Owner's specifications. Record appropriate operation and test sequences as required by NEC Article 230-95.

B. Electrical Tests

1. Measure the system neutral-to-ground insulation resistance with the neutral disconnect link temporarily removed. Replace neutral disconnect link after testing.

2. Perform the following pickup tests using primary injection:

    a. Verify that the relay does not operate at 90 percent of the pickup setting.
    b. Verify pickup is less than 125 percent of setting or 1,200 amperes, whichever is smaller.

3. For summation type systems utilizing phase and neutral current transformers, verify correct polarities by applying current to each phase-neutral current transformer pair. This test also applies to molded-case breakers utilizing an external neutral current transformer.

    a. Relay should operate when current direction is the same relative to polarity marks in the two current transformers.
    b. Relay should not operate when current direction is opposite relative to polarity marks in the two current transformers.

4. Measure time delay of the relay at 150 percent or greater of pickup.

5. Verify reduced control voltage tripping capability: 55 percent for ac systems and 80 percent for dc systems.
6. Verify blocking capability of zone interlock systems.

C. Test Values

1. System neutral-to-ground insulation shall be a minimum of one megohm.
2. Insulation resistance values shall be in accordance with NETA standards.
3. Relay timing shall be in accordance with manufacturer's specifications but must be no longer than one second at 3,000 amperes.

3.10 MOTOR CONTROL CENTERS - LOW VOLTAGE

A. Motor Starters

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.
b. Inspect physical and mechanical condition.
c. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.

2. Motor-Running Protection

a. Compare overload element rating with motor full-load current rating to verify correct sizing.
b. If motor-running protection is provided by fuses, verify correct rating considering motor characteristics and power-factor correction capacitors, if applicable.

3. Electrical Tests

a. Insulation Tests

1) Measure insulation resistance of each combination starter, phase-to-phase and phase-to-ground, with the starter contacts closed and the protective device open. Test voltage shall be in accordance with Table 13. Refer to manufacturer's instructions for devices with solid-state components.

b. Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
c. NOTE: Test times for thermal trip units will, in general, be longer than manufacturer's curve if single-pole testing is performed. Optionally test with all poles in series for time test and each pole separately for comparison. (Refer to NEMA ICS 2-1993, Part 4.)
d. Test circuit breakers as indicated elsewhere in these specifications.

e. Perform operational tests by initiating control devices.

4. Test Values

a. Bolt-torque levels shall be in accordance with manufacturers published data.

b. Insulation-resistance values shall be in accordance with NETA standards.
c. Control wiring insulation test voltage shall be 1,000 volts dc. Manufacturer shall be consulted for test voltage where solid-state control devices are utilized.

d. Overload trip times shall be in accordance with manufacturer's published data.

B. Motor control center assembly.

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.
b. Inspect physical, electrical, and mechanical condition.
c. Confirm correct application of manufacturer's recommended lubricants.
d. Verify appropriate anchorage, required area clearances, physical damage, and correct alignment.
e. Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.
f. 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.
g. Verify that current and potential transformer ratios correspond to drawings.

h. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
i. 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.

j. Clean switchgear.
k. Inspect insulators for evidence of physical damage or contaminated surfaces.
l. Verify correct barrier and shutter installation and operation.
m. Exercise all active components.
n. Inspect all mechanical indicating devices for correct operation.
o. Verify that filters are in place and/or vents are clear.
p. Test operation, alignment, and penetration of instrument transformer withdrawal disconnects, current-carrying and grounding, as indicated elsewhere in these specifications.

q. Inspect control power transformers.

1) Inspect physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
2) Verify that primary and secondary fuse ratings or circuit breakers match drawings.
3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests

a. Perform tests on all instrument transformers as indicated elsewhere in these specifications.
b. Perform ground-resistance tests.
c. Perform resistance tests through all bus joints with a low-resistance ohmmeter. Any joints that cannot be directly measured due to permanently installed insulation wrap shall be indirectly measured from closest accessible connection.

d. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground.
e. After insulation resistance test levels are above minimum values recommended by NETA, 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. The test voltage shall be applied for one minute.

f. Perform insulation-resistance tests at 1000 volts dc on all control wiring. Do not perform this test on wiring connected to solid-state components.
g. Perform control wiring performance test.
h. Perform current injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by primary injection, where possible, with magnitudes such that a minimum of 1.0 ampere flows in the secondary circuit.
2) Where primary injection is impractical, utilize secondary injection with a minimum current of 1.0 ampere.
3) Test current at each device.

i. Determine accuracy of all meters and calibrate watt-hour meters as indicated elsewhere in these specifications. Verify multipliers.
j. Perform phasing check on double-ended switchgear to insure correct bus phasing from each source.
k. Perform the following tests on 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 manufacturers published data.

2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage. Confirm 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 power sources in following energized source for control power transformers.

l. Potential Transformer Circuits

1) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage. Confirm correct potential at all devices.
2) Verify secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.

m. Verify operation of switchgear/switchboard heaters.

3. Test Values

a. Bolt-torque levels shall be in accordance with manufacturers published data.

b. Compare bus connection resistances to values of similar connections.
c. Insulation-resistance values for bus, control wiring, and control power transformers shall be in accordance with manufacturer's published data. Values of insulation resistance less than manufacturer's minimum should be investigated. Overpotential tests should not proceed until insulation-resistance levels are raised above minimum values.
d. Apply overpotential test voltages in accordance with manufacturer's recommendations. The insulation shall withstand the overpotential test voltage applied.

3.11 LOW-VOLTAGE SURGE PROTECTION DEVICES

A. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Inspect for correct mounting and adequate clearances.
4. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
5. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

B. Electrical Tests

1. Perform insulation-resistance tests. Use manufacturer's recommended values.

C. Test Values

1. Bolt-torque levels shall be in accordance with manufacturers published data.
2. Insulation-resistance values shall be in accordance with NETA standards.

3.12 ENGINE GENERATOR

A. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Inspect correct anchorage and grounding.

B. Electrical and Mechanical Tests

1. Perform an insulation-resistance test on generator winding with respect to ground in accordance with ANSI/IEEE Standard 43. Calculate polarization index.
2. Test protective relay devices as indicated elsewhere in these specifications.
3. Perform phase-rotation test to determine compatibility with load requirements.
4. Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other features as applicable.
5. Perform vibration baseline test. Plot amplitude versus frequency for each main bearing cap.
6. Conduct performance test in accordance with ANSI/NFPA Standard 110, (Installation Acceptance). Refer to specification Section 16225.
7. Verify correct functioning of governor and regulator.

C. Test Values

1. Polarization index values shall be in accordance with IEEE Standard 43.
2. Vibration levels shall be in accordance with manufacturer's published data.
3. Performance tests shall conform to manufacturer's published data.

3.13 AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Confirm correct application of manufacturer's recommended lubricants.
4. Verify that manual transfer warnings are attached and visible.
5. Verify tightness of all control connections.

6. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
7. Perform manual transfer operation.
8. Verify positive mechanical interlocking between normal and alternate sources.

B. Electrical Tests

1. Measure contact-resistance.
2. Perform insulation-resistance tests, phase-to-phase and phase-to-ground, with switch in both source positions.
3. Verify settings and operation of control devices.
4. Calibrate and set all relays and timers as indicated elsewhere in these specifications.

5. Perform automatic transfer tests:

   a. Simulate loss of normal power.
   b. Return to normal power.
   c. Simulate loss of emergency power.
   d. Simulate all forms of single-phase conditions.

6. Verify correct operation and timing of the following functions:

   a. Normal source voltage-sensing relays.
   b. Engine start sequence.
   c. Time delay upon transfer.
   d. Alternate source voltage-sensing relays.
   e. Automatic transfer operation.
   f. Interlocks and limit switch function.
   g. Time delay and retransfer upon normal power restoration.
   h. Engine cooldown and shutdown feature.

C. Test Values

1. Bolt-torque levels shall be in accordance with manufacturers published data.
2. Insulation-resistance test voltages and minimum values shall be in accordance with NETA standards.
3. Compare microhm values to adjacent poles and similar switches. Investigate deviations of more than 25 percent.

3.14 SYSTEM FUNCTION TESTS

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

B. Implementation

1. Develop test parameters for the purpose of evaluating performance of all integral components and their functioning as a complete unit within design requirements. Perform these tests.
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.

END OF SECTION