

7. INSPECTION AND TEST PROCEDURES**7.1 Switchgear and Switchboard Assemblies****A. Visual and Mechanical Inspection**

1. Inspect physical, electrical, and mechanical condition including evidence of moisture or corona.
2. Inspect anchorage, alignment, grounding, and required area clearances.
3. Prior to cleaning the unit, perform as-found tests, if required.
4. Clean the unit.
5. 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.
6. Verify that current and voltage transformer ratios correspond to drawings.
7. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.1.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
8. 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 all devices included in the interlock scheme as applicable.
9. Use appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
10. Verify correct barrier and shutter installation and operation.
11. Exercise all active components.
12. Inspect mechanical indicating devices for correct operation.
13. Verify that filters are in place and/or vents are clear.
14. Perform visual and mechanical inspection of instrument transformers in accordance with Section 7.10.

* Optional





7. INSPECTION AND TEST PROCEDURES

7.1 Switchgear and Switchboard Assemblies (*continued*)

15. Inspect control power transformers.
 1. Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
 2. Verify that primary and secondary fuse ratings or circuit breakers match drawings.
 3. Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.
16. Perform as-left tests.

B. Electrical Tests

1. Perform resistance measurements through bolted electrical connections with a low-resistance ohmmeter in accordance with Section 7.1.A.7.1.
2. Perform insulation-resistance tests for one minute on each bus section, phase-to-phase and phase-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1.
- *3. 
- *4. 
5. Perform electrical tests on instrument transformers in accordance with Section 7.10.
6. Perform ground-resistance tests in accordance with Section 7.13.
7. Determine accuracy of all meters and calibrate watt-hour meters in accordance with Section 7.11.
8. 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 manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.1 Switchgear and Switchboard Assemblies (*continued*)

2. Verify correct function of control transfer relays located in switchgear with multiple power sources.
9. Verify operation of switchgear/switchboard heaters and their controller.
10. Perform system function tests in accordance with Section 8.

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.1.A.7.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.1.A.7.2)
3. Results of the thermographic survey shall be in accordance with Section 9. (7.1.A.7.3)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Insulation-resistance values of bus insulation should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated. Dielectric withstand voltage tests should not proceed until insulation-resistance levels are raised above minimum values.
3. [REDACTED]
4. [REDACTED]
5. Results of electrical tests on instrument transformers should be in accordance with Section 7.10.
6. Results of ground resistance tests should be in accordance with Section 7.13.
7. Accuracy of meters should be in accordance with Section 7.11.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.1 Switchgear and Switchboard Assemblies (*continued*)

8. Control Power Transformers

1. Insulation-resistance values of control power transformers should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.
2. Control transfer relays should perform as designed.
9. Heaters should be operational.
10. Results of system function tests shall be in accordance with Section 8.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.2.1.1 Transformers, Dry Type, Air-Cooled, Low-Voltage, Small

NOTE: This category consists of power transformers with windings rated 600 volts or less and sizes equal to or less than 167 kVA single-phase or 500 kVA three-phase.

A. Visual and Mechanical Inspection.

1. Inspect physical and mechanical condition.
2. Inspect anchorage, alignment, and grounding.
3. Prior to cleaning the unit, perform as-found tests, if required.
4. Clean the unit.
5. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use a of low-resistance ohmmeter in accordance with Section 7.2.1.1.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
6. Perform as-left tests.
7. Verify that as-left tap connections are as specified.

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.2.1.1.A.5.1.
2. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.5. Calculate the dielectric absorption ratio or polarization index.
- *3. Perform turns-ratio tests at the designated tap position.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.2.1.1 Transformers, Dry Type, Air-Cooled, Low-Voltage, Small (*continued*)

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.2.1.1.A.5.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.2.1.1.A.5.2)
3. Results of the thermographic survey shall be in accordance with Section 9. (7.2.1.1.A.5.3)
4. Tap connections are left as found unless otherwise specified. (7.2.1.1.A.7)

D. Test Values – Electrical

1. Compare bolted electrical connection resistances to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Minimum insulation-resistance values of transformer insulation should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated. The dielectric absorption ratio or polarization index shall be compared to previously obtained results and should not be less than 1.0.
3. Turns-ratio test results should not deviate more than one-half percent from either the adjacent coils or the calculated ratio.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.2.1.2 Transformers, Dry Type, Air-Cooled, Large

NOTE: This category consists of power transformers with windings rated higher than 600 volts and low-voltage transformers larger than 167 kVA single-phase or 500 kVA three-phase.

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition including evidence of moisture and corona.
2. Inspect anchorage, alignment, and grounding.
3. Prior to cleaning the unit, perform as-found tests, if required.
4. Clean the unit.
- *5. [REDACTED]
6. Verify that cooling fans operate correctly.
7. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.2.1.2.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
8. Perform specific inspections and mechanical tests as recommended by the manufacturer.
9. Perform as-left tests.
10. Verify that as-left tap connections are as specified.
11. Verify the presence of surge arresters.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.2.1.2 Transformers, Dry Type, Air-Cooled, Large (*continued*)

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.2.1.2.A.7.1.
2. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.5. Calculate polarization index.
3. Perform insulation power-factor or dissipation-factor tests on all windings in accordance with the test equipment manufacturer's published data.
- *4. [REDACTED]
5. Perform turns-ratio tests at the designated tap position.
6. Perform an excitation-current test on each phase.
- *7. [REDACTED]
8. Measure core insulation resistance at 500 volts dc if the core is insulated and if the core ground strap is removable.
- *9. [REDACTED]
10. Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.
11. Test surge arresters in accordance with Section 7.19.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.2.1.2 Transformers, Dry Type, Air-Cooled, Large (*continued*)

C. Test Values – Visual and Mechanical

1. Control and alarm settings on temperature indicators should operate within manufacturer's recommendations for specified settings. (7.2.1.2.A.5)
2. Cooling fans should operate. (7.2.1.2.A.6)
3. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.2.1.2.A.7.1)
4. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.2.1.2.A.7.2)
5. Results of the thermographic survey shall be in accordance with Section 9. (7.2.1.2.A.7.3)
6. Tap connections shall be left as found unless otherwise specified. (7.2.1.2.A.10)

D. Test Values – Electrical


1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Minimum insulation-resistance values of transformer insulation should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated. The polarization index shall be compared to previously obtained results and should not be less than 1.0.
3. [REDACTED]
[REDACTED]
[REDACTED]
4. [REDACTED]
5. Turns-ratio test results should not deviate more than one-half percent from either the adjacent coils or the calculated ratio.
6. The typical excitation current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.2.1.2 Transformers, Dry Type, Air-Cooled, Large (*continued*)

7. Temperature-corrected winding-resistance values should compare within one percent of previously-obtained results.
8. Core insulation-resistance values should be comparable to previously-obtained results but not less than one megohm at 500 volts dc.
9. 
10. Phase-to-phase and phase-to-neutral secondary voltages should be in agreement with nameplate data.
11. Test results for surge arresters shall be in accordance with Section 7.19.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.2.2 Transformers, Liquid-Filled

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage, alignment, and grounding.
3. Verify the presence of PCB labeling.
4. Prior to cleaning the unit, perform as-found tests, if required.
5. Clean bushings and control cabinets.
- *6. Verify operation of alarm, control, and trip circuits from temperature and level indicators, pressure relief device, and fault pressure relay
7. Verify that cooling fans and/or pumps operate correctly.
8. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.2.2B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
9. Verify correct liquid level in tanks and bushings.
10. [REDACTED]
11. Perform inspections and mechanical tests as recommended by the manufacturer.
12. [REDACTED]
13. Verify the presence of transformer surge arresters.
14. Perform as-left tests.
15. [REDACTED]

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.2.2.A.8.1.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.2.2 Transformers, Liquid-Filled (*continued*)

2. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.5. Calculate polarization index.
3. Perform turns-ratio tests at the designated tap position.
4. [REDACTED]
5. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/ capacitance tap. In the absence of a power-factor/ capacitance tap, perform hot-collar tests. These tests shall be in accordance with the test equipment manufacturer's published data.
6. Perform excitation-current tests in accordance with the test equipment manufacturer's published data.
7. Measure the resistance of each winding at the designated tap position.
- *8. If the core ground strap is accessible, remove and measure the core insulation resistance at 500 volts dc.
- *9. [REDACTED]
10. Remove a sample of insulating liquid in accordance with ASTM D 923. The sample shall be tested for the following.
 1. Dielectric breakdown voltage: ASTM D 877 and/or ASTM D 1816
 2. Acid neutralization number: ANSI/ASTM D 974
 - *3. Specific gravity: ANSI/ASTM D 1298
 4. Interfacial tension: ANSI/ASTM D 971 or ANSI/ASTM D 2285
 5. Color: ANSI/ASTM D 1500
 6. Visual Condition: ASTM D 1524
 - *7. Water in insulating liquids: ASTM D 1533. (Required on 25 kV or higher voltages and on all silicone-filled units.)
 - *8. Measure power factor or dissipation factor in accordance with ASTM D 924.
11. Remove a sample of insulating liquid in accordance with ASTM D 3613 and perform dissolved-gas analysis (DGA) in accordance with ANSI/IEEE C57.104 or ASTM D3612.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.2.2 Transformers, Liquid-Filled (*continued*)

12. Test the instrument transformers in accordance with Section 7.10.
13. Test the surge arresters in accordance with Section 7.19.
14. Test the transformer neutral grounding impedance devices.

C. Test Values – Visual and Mechanical

1. Alarm, control, and trip circuits from temperature and level indicators as well as pressure relief device and fault pressure relay should operate within manufacturer's recommendations for their specified settings. (7.2.2.A.6)
2. Cooling fans and/or pumps should operate. (7.2.2.A.7)
3. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.2.2.A.8.1)
4. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.2.2.A.8.2)
5. Results of the thermographic survey shall be in accordance with Section 9. (7.2.2.A.8.3)
6. Liquid levels in the transformer tanks and bushings should be within indicated tolerances. (7.2.2.A.9)
7. [REDACTED]

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Minimum insulation-resistance values of transformer insulation should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated. The polarization index shall be compared to previously obtained results and should not be less than 1.0.
3. Turns-ratio test results should not deviate by more than one-half percent from either the adjacent coils or the calculated ratio.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.2.2 Transformers, Liquid-Filled (*continued*)

4. [REDACTED]
5. Investigate bushing power-factor and capacitance values that vary from nameplate values by more than ten percent. Hot-collar tests are evaluated on a milliampere/milliwatt loss basis, and the results should be compared to values of similar bushings.
6. Typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading.
7. Temperature corrected winding-resistance values should compare within one percent of previously obtained results.
8. Core insulation values should be comparable to previously obtained results but not less than one megohm at 500 volts dc.
9. [REDACTED]
10. Insulating liquid values should be in accordance with Table 100.4.
11. Evaluate results of dissolved-gas analysis in accordance with ANSI/IEEE Standard C57.104.
12. [REDACTED]
13. Results of surge arrester tests shall be in accordance with Section 7.19.
14. Compare grounding impedance device values to previously obtained results. In the absence of previously obtained values, compare obtained values to manufacturer's published data.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.4 Metal-Enclosed Busways

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage, alignment, and grounding.
3. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.4.B.1.
 2. Verify tightness of accessible bolted electrical connections and bus joints by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
4. Confirm physical orientation in accordance with manufacturer's labels to insure adequate cooling.
5. Examine outdoor busway for removal of "weep-hole" plugs and for the correct installation of joint shield.
6. Inspect and clean ventilating openings.

B. Electrical Tests

1. Perform resistance measurements through bolted connections and bus joints with a low-resistance ohmmeter in accordance with Section 7.4.A.3.1.
2. Perform insulation resistance tests on each busway for one minute, phase-to-phase and phase-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1.
3. [REDACTED]
- *4. [REDACTED]
5. Verify operation of busway space heaters.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.4 Metal-Enclosed Busways (*continued*)

C. Test Values – Visual and Mechanical


1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.4.A.3.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.4.A.3.2)
3. Results of the thermographic survey shall be in accordance with Section 9. (7.4.A.3.3)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Insulation-resistance test voltages and resistance values shall be in accordance with manufacturer's published data or Table 100.1. In the absence of manufacturer's published data, minimum resistance values are for a nominal 1000-foot busway run. Use the following formula to convert the measured resistance value to the 1000-foot nominal value:

$$R_{1000\text{ ft}} = \text{Measured Resistance} \times \frac{\text{Length of Run}}{1000}$$

Converted values of insulation resistance less than those in Table 100.1 or manufacturer's minimum should be investigated. Dielectric withstand voltage tests shall not proceed until insulation-resistance levels are raised above minimum values.

3. 
4. Microhm or dc millivolt drop values should not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate values which deviate from those of similar bus connections and sections by more than 50 percent of the lowest value.
5. Heaters should be operational.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.5.1.1 Switches, Air, Low-Voltage

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage, alignment, grounding, and required clearances.
3. Prior to cleaning the unit, perform as-found tests, if required.
4. Clean the unit.
5. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
6. Verify that fuse sizes and types are in accordance with drawings, short-circuit study, and coordination study.
7. Verify that each fuse has adequate mechanical support and contact integrity.
8. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.5.1.1.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
9. Verify operation and sequencing of interlocking systems.
10. Verify phase-barrier mounting is intact.
11. Verify correct operation of indicating and control devices.
12. Use appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
13. Perform as-left tests.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.5.1.1 Switches, Air, Low-Voltage (*continued*)

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.5.1.1.A.8.1.
2. Measure contact resistance across each switchblade and fuseholder.
3. 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 in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1.
4. Measure fuse resistance.
5. Verify cubicle space heater operation.
6. Perform a ground-fault test in accordance with Section 7.14.
7. Perform tests on other protective devices in accordance with Section 7.9.

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.5.1.1.A.8.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.1.1.A.8.2)
3. Results of the thermographic survey shall be in accordance with Section 9. (7.1.1.A.8.3)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Microhm or dc millivolt drop values should not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
3. Insulation-resistance values should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.5.1.1 Switches, Air, Low-Voltage (*continued*)

4. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
5. Heaters should be operational.
6. Ground fault tests should be in accordance with Section 7.14.
7. Results of protective device tests should be in accordance with Section 7.9.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.5.1.2 Switches, Air, Medium-Voltage, Metal-Enclosed

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage, alignment, grounding, and required clearances.
3. Prior to cleaning the unit, perform as-found tests, if required.
4. Clean the unit.
5. Verify correct blade alignment, blade penetration, travel stops, arc interrupter operation, and mechanical operation.
6. Verify that fuse sizes and types are in accordance with drawings, short-circuit studies, and coordination study.
7. Verify that expulsion-limiting devices are in place on all fuses having expulsion-type elements.
8. Verify that each fuseholder has adequate mechanical support and contact integrity.
9. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.5.1.2.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
10. Verify operation and sequencing of interlocking systems.
11. Verify that phase-barrier mounting is intact.
12. Verify correct operation of all indicating and control devices.
13. Use appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
14. Perform as-left tests.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.5.1.2 Switches, Air, Medium-Voltage, Metal-Enclosed (*continued*)

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.5.1.2.A.9.1.
2. Measure contact resistance across each switchblade assembly and fuseholder.
3. 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 in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1.
4. Perform a dielectric withstand voltage test on each pole with switch closed. Test each pole-to-ground with all other poles grounded. Test voltage shall be in accordance with manufacturer's published data or Table 100.2.
5. Measure fuse resistance.
6. Verify cubicle space heater operation.

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.5.1.2.A.9.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.5.1.2.A.9.2)
3. Results of the thermographic survey shall be in accordance with Section 9. (7.5.1.2.A.9.3)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Microhm or dc millivolt drop values should not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.5.1.2 Switches, Air, Medium-Voltage, Metal-Enclosed (*continued*)

3. Insulation-resistance values should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated. Dielectric withstand voltage tests shall not proceed until insulation-resistance levels are raised above minimum values.
4. 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 test specimen is considered to have passed the test.
5. Investigate fuse resistance values that deviate from each other by more than 15 percent.
6. Heaters should be operational.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.6.1.1 Circuit Breakers, Air, Insulated-Case/Molded-Case

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage and alignment.
3. Prior to cleaning the unit, perform as-found tests, if required.
4. Clean the unit.
5. Operate the circuit breaker to insure smooth operation.
6. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.6.1.1.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
7. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
8. Perform adjustments for final protective device settings in accordance with coordination study provided by end user.
9. Perform as-left tests.

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.1.1.A.6.1.
2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1.
3. Perform a contact/pole-resistance test.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.6.1.1 Circuit Breakers, Air, Insulated-Case/Molded-Case (*continued*)

*4.



5. Determine long-time pickup and delay by primary current injection.
6. Determine short-time pickup and delay by primary current injection.
7. Determine ground-fault pickup delay by primary current injection.
8. Determine instantaneous pickup current by primary injection.
- *9. Test functions of the trip unit by means of secondary injection.
10. Perform minimum pickup voltage test on shunt trip and close coils in accordance with Table 100.20.
11. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery condition.
12. Reset all trip logs and indicators.
13. Verify operation of charging mechanism.

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.6.1.1.A.6.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.6.1.1.A.6.2)
3. Results of the thermographic survey shall be in accordance with Section 9. (7.6.1.1.A.6.3)
4. Settings shall comply with coordination study recommendations. (7.6.1.1.A.8)

* Optional



7. INSPECTION AND TEST PROCEDURES

7.6.1.1 Circuit Breakers, Air, Insulated-Case/Molded-Case (*continued*)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Insulation-resistance values should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.
3. Microhm or dc millivolt drop values should not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate values that deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
4. Insulation-resistance values of control wiring should be comparable to previously obtained results but not less than two megohms.
5. Long-time pickup values should be as specified, and the trip characteristic should not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times should not exceed the value shown in Table 100.7.
6. Short-time pickup values should be as specified, and the trip characteristic should not exceed manufacturer's published time-current tolerance band.
7. Ground fault pickup values should be as specified, and the trip characteristic should not exceed manufacturer's published time-current tolerance band.
8. Instantaneous pickup values of molded-case circuit breakers should fall within manufacturer's published tolerances and/or Table 100.8.
9. Pickup values and trip characteristics should be within manufacturer's published tolerances.
10. Minimum pickup voltage on shunt trip and close coils should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, refer to Table 100.20.
11. Breaker open, close, trip, trip-free, antipump, and auxiliary features should function as designed.
12. Trip logs and indicators are reset.
13. The charging mechanism should operate in accordance with manufacturer's published data.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.6.1.2 Circuit Breakers, Air, Low-Voltage Power

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage, alignment, and grounding.
3. Verify that all maintenance devices are available for servicing and operating the breaker.
4. Prior to cleaning the unit, perform as-found tests, if required.
5. Clean the unit.
6. Inspect arc chutes.
7. Inspect moving and stationary contacts for condition, wear, and alignment.
8. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.
9. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturer's published data.
10. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.6.1.2.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
11. Verify cell fit and element alignment.
12. Verify racking mechanism operation.
13. Use appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
14. Perform adjustments for final protective device settings in accordance with coordination study provided by end user.
15. Perform as-left tests.
16. Record as-found and as-left operation counter readings.


* Optional



7. INSPECTION AND TEST PROCEDURES

7.6.1.2 Circuit Breakers, Air, Low-Voltage Power (*continued*)

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.1.2.A.10.1.
2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1.
3. Perform a contact/pole-resistance test.
- *4. 
5. Determine long-time pickup and 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 current by primary current injection.
- *9. Test functions of the trip unit by means of secondary injection.
10. Perform minimum pickup voltage test on shunt trip and close coils in accordance with Table 100.20.
11. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery condition.
12. Reset all trip logs and indicators.
13. Verify operation of charging mechanism.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.6.1.2 Circuit Breakers, Air, Low-Voltage Power (*continued*)

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.6.1.2.A.10.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.6.1.2.A.10.2)
3. Results of the thermographic survey shall be in accordance with Section 9. (7.6.1.2.A.10.3)
4. Settings shall comply with coordination study recommendations. (7.6.1.2.A.15)
5. Operations counter should advance one digit per close-open cycle. (7.6.1.2.A.16)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Insulation-resistance values of breakers should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.
3. Microhm or dc millivolt drop values should not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate values that deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
4. [REDACTED]
5. Long-time pickup values should be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band.
6. Short-time pickup values should be as specified, and the trip characteristic should not exceed manufacturer's published time-current tolerance band.
7. Ground fault pickup values should be as specified, and the trip characteristic should not exceed manufacturer's published time-current tolerance band.
8. Instantaneous pickup values should be within the tolerances of manufacturer's published data.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.6.1.2 Circuit Breakers, Air, Low-Voltage Power (*continued*)

9. Pickup values and trip characteristic should be as specified and within manufacturer's published tolerances.
10. Minimum pickup voltage on shunt trip and close coils should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, refer to Table 100.20.
11. Auxiliary features should operate in accordance with manufacturer's published data.
12. Trip logs and indicators are reset.
13. The charging mechanism should operate in accordance with manufacturer's published data.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.6.1.3 Circuit Breakers, Air, Medium-Voltage

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage, alignment, and grounding.
3. Verify that all maintenance devices are available for servicing and operating the breaker.
- *4. Perform operator analysis (first-trip) test.
5. Prior to cleaning the unit, perform as-found tests, if required.
6. Clean the unit.
7. Inspect arc chutes.
8. Inspect moving and stationary contacts for condition, wear, and alignment.
9. If recommended by manufacturer, slow close/open breaker and check for binding, friction, contact alignment, contact sequence, and penetration. Verify that contact sequence is in accordance with manufacturer's published data. In the absence of manufacturer's published data, refer to ANSI/IEEE C37.04.
10. Perform all mechanical operation tests on the operating mechanism in accordance with manufacturer's published data.
11. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.6.1.3.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
12. Verify cell fit and element alignment.
13. Verify racking mechanism operation.
14. Inspect puffer operation.
15. Use appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.6.1.3 Circuit Breakers, Air, Medium-Voltage (*continued*)

- *16. Perform time-travel analysis.
- 17. Perform as-left tests.
- 18. Record as-found and as-left operation-counter readings.

B. Electrical Tests

- 1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. See Section 7.6.1.3.A.11.1.
- 2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1.
- *3. [REDACTED]
- 4. Perform a contact/pole-resistance test.
- 5. With the breaker in a test position, perform the following tests:
 - 1. Trip and close breaker with the control switch.
 - 2. Trip breaker by operating each of its protective relays.
 - 3. Verify mechanism charge, trip-free, and antipump functions.
- *6. Perform minimum pickup voltage tests on trip and close coils in accordance with Table 100.20.
- *7. [REDACTED]
- *8. [REDACTED]
- *9. [REDACTED]

* Optional



7. INSPECTION AND TEST PROCEDURES

7.6.1.3 Circuit Breakers, Air, Medium-Voltage (*continued*)

10. Verify blowout coil circuit continuity.
11. Verify operation of cubicle space heaters.

*12. [REDACTED]

C. Test Values – Visual and Mechanical

1. Compare first-trip operation time and trip-coil current waveform to manufacturer's published data. In the absence of manufacturer's published data, compare first-trip operation time and trip-coil current waveform to previously obtained results. (7.6.1.3.A.4)
2. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.6.1.3.A.11.1)
3. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.6.1.3.A.11.2)
4. Results of the thermographic survey shall be in accordance with Section 9. (7.6.1.3.A.11.3)
5. Compare travel and velocity values to manufacturer's published data and previous test data. (7.6.1.3.A.16)
6. Operations counter should advance one digit per close-open cycle. (7.6.1.2.A.18)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Insulation-resistance values of circuit breakers should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.
3. Insulation-resistance values of control wiring should be comparable to previously obtained results but not less than two megohms.
4. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate values that deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.6.1.3 Circuit Breakers, Air, Medium-Voltage (*continued*)

5. Breaker mechanism charge, close, open, trip, trip-free, and antipump features shall function as designed.
6. Minimum pickup for trip and close coils shall be in accordance with manufacturer's published data. In the absence of manufacturer's data, refer to Table 100.20.
7. [REDACTED]
8. [REDACTED]
9. [REDACTED]
10. The blowout coil circuit should exhibit continuity.
11. Cubicle space heaters should be operational.
12. [REDACTED]

* Optional



7. INSPECTION AND TEST PROCEDURES

7.9.1 Protective Relays, Electromechanical and Solid-State

A. Visual and Mechanical Inspection

1. Inspect relays and cases for physical damage.
2. Prior to cleaning the unit, perform as-found tests, if required.
3. Clean and inspect the unit.
 1. Relay Case
 1. Tighten case connections.
 2. Inspect cover for correct gasket seal.
 3. Clean cover glass. Inspect shorting hardware, connection paddles, and/or knife switches.
 4. Remove any foreign material from the case.
 5. Verify target reset
 2. Relay
 1. Inspect relay for foreign material, particularly in disk slots of the damping and electromagnets.
 2. Verify disk clearance. Verify contact clearance and spring bias.
 3. Inspect spiral spring convolutions.
 4. Inspect disk and contacts for freedom of movement and correct travel. Verify tightness of mounting hardware and connections. Burnish contacts. Inspect bearings and/or pivots.
4. Verify that all settings are in accordance with coordination study or setting sheet supplied by owner.

B. Electrical Tests

1. Perform insulation-resistance test on each circuit-to-frame. Procedures for performing insulation-resistance tests on solid-state relays should be determined from the relay manufacturer's published data.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.9.1 Protective Relays, Electromechanical and Solid-State (*continued*)

2. Test targets and indicators.
 1. Determine pickup and dropout of electromechanical targets.
 2. Verify operation of all light-emitting diode indicators.
 3. Set contrast for liquid-crystal display readouts.
3. Protection Elements
 1. 2/62 Timing Relay
 1. Determine time delay.
 2. Verify operation of instantaneous contacts.
 2. 21 Distance Relay
 1. Determine maximum reach.
 2. Determine maximum torque angle and directional characteristic.
 3. Determine offset.
 - *4. [REDACTED]
 3. 24 Volts/Hertz Relay
 1. Determine pickup frequency at rated voltage.
 2. Determine pickup frequency at a second voltage level.
 3. Determine time delay.
 4. 25 Sync Check Relay
 1. Determine closing zone at rated voltage.
 2. Determine maximum voltage differential that permits closing at zero degrees.
 3. Determine live line, live bus, dead line, and dead bus set points.
 4. Determine time delay.
 - *5. Determine advanced closing angle.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.9.1 Protective Relays, Electromechanical and Solid-State (*continued*)

6. Verify dead bus/live line, dead line/live bus and dead bus/dead line control functions.
5. 27 Undervoltage Relay
 1. Determine dropout voltage.
 2. Determine time delay.
 3. Determine the time delay at a second point on the timing curve for inverse time relays.
6. 32 Directional Power Relay
 1. Determine minimum pickup at maximum torque angle.
 2. Determine closing zone.
 3. Determine maximum torque angle.
 4. Determine time delay.
 5. Verify the time delay at a second point on the timing curve for inverse time relays.
 - *6. [REDACTED]
7. 40 Loss of Field (Impedance) Relay
 1. Determine maximum reach.
 2. Determine maximum torque angle.
 3. Determine offset.
 - *4. [REDACTED]
8. 46 Current Balance Relay
 1. Determine pickup of each unit.
 2. Determine percent slope.
 3. Determine time delay.
9. 46N Negative Sequence Current Relay
 1. Determine negative sequence alarm level.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.9.1 Protective Relays, Electromechanical and Solid-State (*continued*)

2. Determine negative sequence minimum trip level.
 3. Determine maximum time delay.
 4. Verify two points on the $(I_2)^2t$ curve.
10. 47 Phase Sequence or Phase Balance Voltage Relay
 1. Determine positive sequence voltage to close the normally open contact.
 2. Determine positive sequence voltage to open the normally closed contact (undervoltage trip).
 3. Verify negative sequence trip.
 4. Determine time delay to close the normally open contact with sudden application of 120 percent of pickup.
 5. Determine time delay to close the normally closed contact upon removal of voltage when previously set to rated system voltage.
11. 49R Thermal Replica Relay
 1. Determine time delay at 300 percent of setting.
 2. Determine a second point on the operating curve.
 - *3. [REDACTED]
12. 49T Temperature (RTD) Relay
 1. Determine trip resistance.
 2. Determine reset resistance.
13. 50 Instantaneous Overcurrent Relay
 1. Determine pickup.
 2. Determine dropout.
 - *3. Determine time delay.
14. 50BF Breaker Failure

* Optional



7. INSPECTION AND TEST PROCEDURES

7.9.1 Protective Relays, Electromechanical and Solid-State (*continued*)

1. Determine current supervision pickup.
 2. Determine time delays.
 3. Test all used initiate inputs and all used outputs.
15. 51 Time Overcurrent
1. Determine minimum pickup.
 2. Determine time delay at two points on the time current curve.
16. 55 Power Factor Relay
1. Determine tripping angle.
 2. Determine time delay.
17. 59 Overvoltage Relay
1. Determine overvoltage pickup.
 2. Determine time delay to close the contact with sudden application of 120 percent of pickup.
18. 60 Voltage Balance Relay
1. Determine voltage difference to close the contacts with one source at rated voltage.
 - *2. [REDACTED]
19. 63 Transformer Sudden Pressure Relay
1. Determine rate-of-rise or the pickup level of suddenly applied pressure in accordance with manufacturer's published data.
 2. Verify operation of the 63 FPX seal-in circuit.
 3. Verify trip circuit to remote operating device.
20. 64 Ground Detector Relay
- Determine maximum impedance to ground causing relay pickup.
21. 67 Directional Overcurrent Relay

* Optional



7. INSPECTION AND TEST PROCEDURES

7.9.1 Protective Relays, Electromechanical and Solid-State (*continued*)

1. Determine directional unit minimum pickup at maximum torque angle.
 2. Determine closing zone.
 - *3. [REDACTED]
 - *4. [REDACTED]
 5. Determine overcurrent unit pickup.
 6. Determine overcurrent unit time delay at two points on the time current curve.
22. 79 Reclosing Relay
1. Determine time delay for each programmed reclosing interval.
 2. Verify lockout for unsuccessful reclosing.
 3. Determine reset time.
 - *4. [REDACTED]
 5. Verify instantaneous overcurrent lockout.
23. 81 Frequency Relay
1. Verify frequency set points.
 2. Determine time delay.
 3. Determine undervoltage cutoff.
24. 85 Pilot Wire Monitor
1. Determine overcurrent pickup.
 2. Determine undercurrent pickup.
 3. Determine pilot wire ground pickup level.
25. 87 Differential
1. Determine operating unit pickup.
 2. Determine the operation of each restraint unit.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.9.1 Protective Relays, Electromechanical and Solid-State (*continued*)

3. Determine slope.
4. Determine harmonic restraint.
5. Determine instantaneous pickup.
- *6. [REDACTED]

4. Control Verification

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

C. Test Values – Visual and Mechanical

1. Relay case

1. Case connections should be torqued in accordance with manufacturer's published data. (7.9.1.A.3.1.1)
2. Cover gasket should be intact and able to prevent foreign matter from entering the case. (7.9.1.A.3.1.2)
3. Cover glass, connection paddles, and/or knife switches should be clean. (7.9.1.A.3.1.3)
4. Case should be free of foreign material. (7.9.1.A.3.1.4)
5. The target reset should be operational. (7.9.1.A.3.1.5)

2. Relay

1. Relay should be free of foreign material. (7.9.1.A.3.2.1)
 2. Relay disc clearance, contact clearance, and spring bias should operate in accordance with manufacturer's published data. (7.9.1.A.3.2.2)
 3. Relay spiral spring should be concentric and should not show signs of overheating. (7.9.1.A.3.2.3)
 4. Relay discs and contacts should have freedom of movement and correct travel distance in accordance with manufacturer's published data. (7.9.1.A.3.2.4)
3. As-left relay settings should match the most recent coordination and arc-flash study or engineered setting files. (7.9.1.A.4)

* Optional



7. INSPECTION AND TEST PROCEDURES

7.9.1 Protective Relays, Electromechanical and Solid-State (*continued*)

D. Test Values – Electrical

1. Insulation-resistance values should be in accordance with manufacturer's published data. Values of insulation resistance less than the manufacturer's recommendations should be investigated.
2. Targets and Indicators
 1. Pickup and dropout of electromechanical targets should be in accordance with manufacturer's published data.
 2. Light-emitting diodes should illuminate.
3. Operation of protection elements for devices listed in section 7.9.1.B , one through 25, should be calibrated using manufacturer's recommended tolerances unless critical test points are specified by the setting engineer.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.9.2 Protective Relays, Microprocessor-Based

A. Visual and Mechanical Inspection

1. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
- *2. [REDACTED]
3. Download the sequence of events, maintenance data, and statistical data prior to testing the relay.
4. Verify operation of light-emitting diodes, display, and targets.
- *5. [REDACTED]
6. Clean the front panel and remove foreign material from the case.
7. Check tightness of connections.
8. Verify that the frame is grounded in accordance with manufacturer's instructions.
9. Download settings and logic from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.
10. Verify relay displays the correct date and time. Compare relay time to actual time and record the differential.
11. Check with owner for applicable firmware updates and product recalls.
12. Inspect, clean, and verify operation of shorting devices.

B. Electrical Tests

- *1. Perform insulation-resistance tests from each circuit to the grounded frame in accordance with manufacturer's published data.
2. Apply voltage or current to all analog inputs and verify correct registration of the relay meter functions.
- *3. [REDACTED]
- *4. Protection Elements

Check functional operation of each element used in the protection scheme as described for electromechanical and solid-state relays in 7.9.1.B.3.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.9.2 Protective Relays, Microprocessor-Based (*continued*)

5. Control Verification

1. Check operation of all active digital inputs.
2. Check all output contacts or SCRs, preferably by operating the controlled device such as circuit breaker, auxiliary relay, or alarm.
- *3. Check all internal logic functions used in the protection scheme.
4. For pilot schemes, perform a loop-back test to check the receive and transmit communication circuits.
5. Upon completion of testing, reset all min/max records and fault counters. Delete sequence-of-events records and all event records.
6. Verify trip and close coil monitoring functions.
- *7. [REDACTED]
- *8. [REDACTED]
- *9. [REDACTED]

C Test Values – Visual and Mechanical

1. As-left relay settings should match the most recent coordination and arc-flash study or engineered setting files. As-found relay settings that do not match the as-left settings should be reviewed. (7.9.2.A.9)
2. Relay should be clean and operational. (7.9.2.A.6)
3. Clear maintenance and statistical data. (7.9.2.A.3)
4. Light-emitting diodes, displays, and targets should illuminate. (7.9.2.A.4)
5. Downloaded settings and logic should agree with the most recent engineered setting files. (7.9.2.A.9)
6. Verify relay displays the correct date and time. (7.9.2.A.10)

D. Test Values – Electrical

1. Insulation-resistance values should be in accordance with manufacturer's published data. Values of insulation resistance less than manufacturer's recommendations should be investigated.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.9.2 Protective Relays, Microprocessor-Based (*continued*)

2. Voltage and current analog readings should be in accordance with manufacturer's published tolerances.
3. Operation of protection elements for devices as listed in 7.9.1.B, items 1 through 25, should be operational and within manufacturer's recommended tolerances.
4. Control verification of inputs, outputs, and protection schemes, as listed in 7.9.2.B.5, items 1 through 9, should operate as per the design. Results should be within the manufacturer's published tolerances.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.10.1 Instrument Transformers, Current Transformers

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Prior to cleaning the unit, perform as-found tests, if required.
3. Clean the unit.
4. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.10.1.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
5. Verify that all required grounding and shorting connections provide contact.
6. Use appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
7. Perform as-left tests.

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.10.1.A.4.1.
2. Perform insulation-resistance test of each current transformer and wiring-to-ground at 1000 volts dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations.
- *3. [REDACTED]
- *4. [REDACTED]
- *5. [REDACTED]
- *6. [REDACTED]

* Optional



7. INSPECTION AND TEST PROCEDURES

7.10.1 Instrument Transformers, Current Transformers (*continued*)

7. When applicable, perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages shall be in accordance with Table 100.5.
8. [REDACTED]
- *9. [REDACTED]
10. Verify that current circuits are grounded and have only one grounding point in accordance with ANSI/IEEE C57.13.3. (IEEE *Guide for the Grounding of Instrument Transformer Secondary Circuits and Cases*).

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.10.1.A.4.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.10.1.A.4.2)
3. Results of the thermographic survey shall be in accordance with Section 9. (7.10.1.A.4.3)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Insulation-resistance values of instrument transformers should not be less than values shown in Table 100.5.
3. [REDACTED]
4. [REDACTED]
5. Excitation results should match the curve supplied by the manufacturer or be in accordance with ANSI C57.13.1.
6. [REDACTED]
7. Insulation-resistance values of instrument transformers should not be less than values shown in Table 100.5.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.10.1 Instrument Transformers, Current Transformers (*continued*)

8.

[REDACTED]

9.

[REDACTED]

10. Test results should indicate that the circuits have only one grounding point.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.10.2 Instrument Transformers, Voltage Transformers

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Prior to cleaning the unit, perform as-found tests, if required.
3. Clean the unit.
4. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.10.2.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
5. Verify that all required grounding and connections provide contact.
6. Verify correct operation of transformer withdrawal mechanism and grounding operation.
7. Verify correct primary and secondary fuse sizes for voltage transformers.
8. Use appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
9. Perform as-left tests.

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.10.2.A.4.1
2. Perform insulation-resistance tests for one minute winding-to-winding and each winding-to-ground. Test voltages shall be applied in accordance with Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations.

*3. [REDACTED]

*4. [REDACTED]

*5. [REDACTED]

* Optional

7. INSPECTION AND TEST PROCEDURES

7.10.2 Instrument Transformers, Voltage Transformers (*continued*)

*6.

[REDACTED]

*7.

[REDACTED]

8. Verify that potential circuits are grounded and have only one grounding point in accordance with ANSI/IEEE C57.13.3.

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.10.2.A.4.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.10.2.A.4.2)

3.

[REDACTED]

D. Test Values – Voltage Transformers – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Insulation-resistance values of instrument transformers should not be less than values shown in Table 100.5.

3.

[REDACTED]

4.

[REDACTED]

1.

[REDACTED]

2.

[REDACTED]

5.

[REDACTED]

6.


[REDACTED]

* Optional



7. INSPECTION AND TEST PROCEDURES

7.10.2 Instrument Transformers, Voltage Transformers (*continued*)

7. 
8. Test results should indicate that the circuits have only one grounding point.

* Optional




7. INSPECTION AND TEST PROCEDURES

7.10.3 Instrument Transformers, Coupling-Capacitor Voltage Transformers

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Prior to cleaning the unit, perform as-found tests, if required.
3. Clean the unit.
4. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.10.3.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
5. Verify that all required grounding and connections provide contact.
6. Verify correct operation of transformer withdrawal mechanism and grounding operation.
7. Verify correct primary and secondary fuse sizes for voltage transformers.
8. Use appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
9. Perform as-left tests.

B. Electrical Tests – Coupling-Capacitor Voltage Transformers

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.10.3.A.4.1.
2. Perform insulation-resistance tests for one minute, winding-to-winding and each winding-to-ground. Test voltages shall be applied in accordance with Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations.
- *3. 
4. Perform a turns ratio test on the as-found tap position.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.10.3 Instrument Transformers, Coupling-Capacitor Voltage Transformers (continued)

- *5. [REDACTED]
- *6. [REDACTED]
- 7. Measure capacitance of capacitor sections.
- 8. [REDACTED]
- 9. Verify that potential circuits are grounded and have only one grounding point in accordance with ANSI/IEEE C57.13.3.

C. Test Values – Visual and Mechanical

- 1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.10.3.A.4.1)
- 2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.10.3.A.4.2)
- 3. Results of the thermographic survey shall be in accordance with Section 9. (7.10.3.A.4.3)

D. Test Values – Coupling Capacitor Voltage Transformers

- 1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
- 2. Insulation-resistance values of instrument transformers should not be less than values shown in Table 100.5.
- 3. [REDACTED]
- 4. [REDACTED]
 - 1. [REDACTED]
 - 2. [REDACTED]

* Optional

7. INSPECTION AND TEST PROCEDURES

7.10.3 Instrument Transformers, Coupling-Capacitor Voltage Transformers (continued)

5. [REDACTED]
6. [REDACTED]
7. Capacitance of capacitor sections of coupling-capacitance voltage transformers should be in accordance with manufacturer's published data.
8. [REDACTED]
9. Test results should indicate that the circuits have only one grounding point

* Optional



7. INSPECTION AND TEST PROCEDURES

7.11.1 Metering Devices, Electromechanical and Solid-State

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.11.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12.
 3. Perform a thermographic survey in accordance with Section 9.
3. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case-shorting contacts, as applicable.
4. Prior to cleaning the unit, perform as-found tests, if required.
5. Clean the unit.
6. Verify freedom of movement, end play, and alignment of rotating disk(s).
7. Perform as-left tests.

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.11.A.2.1.
2. Verify accuracy of meters at all cardinal points.
3. Calibrate meters in accordance with manufacturer's published data.
- *4. [REDACTED]

* Optional



7. INSPECTION AND TEST PROCEDURES

7.11.1 Metering Devices, Electromechanical and Solid-State (*continued*)

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.11.1.A.2.2)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.11.1.A.2.2)
3. Results of the thermographic survey shall be in accordance with Section 9. (7.11.1.A.2.3)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Meter accuracy should be in accordance with manufacturer's published data.
3. Calibration results should be within manufacturer's specified tolerances.
4. Instrument multipliers should be in accordance with specified system design.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.13 Grounding Systems

A. Visual and Mechanical Inspection

1. Verify ground system is in compliance with ANSI/NFPA 70, *National Electrical Code*, Article 250.
2. Inspect physical and mechanical condition.
3. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of low-resistance ohmmeter in accordance with Section 7.13.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
4. Inspect anchorage.

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with section 7.13.A.3.1.
2. Perform fall-of-potential or alternative test in accordance with IEEE Standard 81 on the main grounding electrode or system.
3. 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 – Visual and Mechanical

1. Grounding system electrical and mechanical connections should be free of corrosion. (7.13.A.2)
2. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.13.A.3.1)
3. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.13.A.3.2)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.13 Grounding Systems (*continued*)

2. The resistance between the main grounding electrode and ground should be no greater than five ohms for large commercial or industrial systems and 1.0 ohm or less for generating or transmission station grounds unless otherwise specified by the owner. (Reference ANSI/IEEE Standard 142)
3. Investigate point-to-point resistance values which exceed 0.5 ohm.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.14 Ground-Fault Protection Systems, Low-Voltage

A. Visual and Mechanical Inspection

1. Inspect the components for damage and errors in polarity or conductor routing.
 1. Verify that the ground connection is made on the source side of the neutral disconnect link and also on the source side of any ground fault sensor.
 2. Verify that the neutral sensors are connected with correct polarity on both primary and secondary.
 3. Verify that all phase conductors and the neutral pass through the sensor in the same direction for zero sequence systems.
 4. Verify that grounding conductors do not pass through zero sequence sensors.
 5. Verify that the grounded conductor is solidly grounded.
2. Prior to cleaning the unit, perform as-found tests.
3. Clean the unit.
4. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.14.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12.
5. Verify correct operation of all functions of the self-test panel.
6. Verify 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 ANSI/NFPA 70 *National Electrical Code*, Article 230.95.
7. Perform as-left tests.

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.14.A.4.1.
2. Measure the system neutral-to-ground insulation resistance with the neutral disconnect link temporarily removed. Replace neutral disconnect link after testing.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.14 Ground-Fault Protection Systems, Low-Voltage (*continued*)

*3.

[REDACTED]

4. Perform ground fault protective device pickup tests using primary current injection.
5. 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.
6. Measure time delay of the ground fault protective device at a value equal to or greater than 150 percent of the pickup value.
7. Verify that reduced control voltage tripping capability is 55 percent for ac systems and 80 percent for dc systems.
8. Verify blocking capability of zone interlock systems.

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.14.A.4.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.14.A.4.2)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. System neutral-to-ground insulation resistance should be a minimum of one megohm.
3. [REDACTED]
4. Results of pickup test should be greater than 90 percent of the ground fault protection device pickup setting and less than 1200 amperes or 125 percent of the pickup setting, whichever is smaller.
5. The ground fault protective device should operate when current direction is the same relative to polarity marks in the two current transformers. The ground fault protective device should not

* Optional



7. INSPECTION AND TEST PROCEDURES

7.14 Ground-Fault Protection Systems, Low-Voltage (*continued*)

operate when current direction is opposite relative to polarity marks in the two current transformers.

6. Relay timing should be in accordance with manufacturer's specifications but must be no longer than one second at 3000 amperes in accordance with ANSI/NFPA 70, *National Electrical Code*, Article 230.95.
7. The circuit interrupting device should operate when control voltage is 55 percent of nominal voltage for ac circuits and 80 percent of nominal voltage for dc circuits.
8. Results of zone-blocking tests should be in accordance with manufacturer's published data and/or design specifications.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.16.1.1 Motor Control, Motor Starters, Low-Voltage

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage, alignment, and grounding.
3. Prior to cleaning the unit, perform as-found tests, if required.
4. Clean the unit.
5. Inspect contactors.
 1. Verify mechanical operation.
 2. Inspect and adjust contact gap, wipe, alignment, and pressure in accordance with manufacturer's published data.

*6.

1.

2.

7. Inspect bolted electrical connections for high resistance using one or more of the following methods:

1. Use of a low-resistance ohmmeter in accordance with Section 7.16.1.1.B.1.
2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12.
3. Perform a thermographic survey in accordance with Section 9.
8. Use appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
9. Perform as-left tests.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.16.1.1 Motor Control, Motor Starters, Low-Voltage (*continued*)

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.16.1.1.A.7.1.
2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with starter closed, and across each open pole. Test voltage shall be in accordance with manufacturer's published data or Table 100.1.
- *3. [REDACTED]
4. Test motor protection devices in accordance with manufacturer's published data. In the absence of manufacturer's data, use Section 7.9.
5. Test circuit breakers in accordance with Section 7.6.1.1.
6. Perform operational tests by initiating control devices.

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.16.1.1.A.7.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.16.1.1.A.7.2)
3. Results of the thermographic survey shall be in accordance with Section 9. (7.16.1.1.A.7.3)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Insulation-resistance values should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.
3. [REDACTED]

* Optional



7. INSPECTION AND TEST PROCEDURES

7.16.1.1 Motor Control, Motor Starters, Low-Voltage (*continued*)

4. Motor protection parameters shall be in accordance with manufacturer's published data or Section 7.9.
5. Circuit breaker test results shall be in accordance with Section 7.6.1.1.
6. Control devices should perform in accordance with system design and/or requirements.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.16.2.1 Motor Control, Motor Control Centers, Low-Voltage

1. Refer to Section 7.1 for appropriate inspections and tests of the motor control center bus.
2. Refer to Section 7.5.1.1 for appropriate inspections and tests of the motor control center switches.
3. Refer to Section 7.6 for appropriate inspections and tests of the motor control center circuit breakers.
4. Refer to Section 7.16.1.1 for appropriate inspections and tests of the motor control center starters.

7.16.2.2

1. [REDACTED]
2. [REDACTED]
3. [REDACTED]
4. [REDACTED]

* Optional



7. INSPECTION AND TEST PROCEDURES

7.19.1 Surge Arresters, Low-Voltage Surge Protection Devices

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage, alignment, and grounding.
3. Prior to cleaning the unit, perform as-found tests.
4. Clean the unit.
5. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.19.1.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
6. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
7. Perform as-left tests.

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.19.1.A.5.1.
2. Perform insulation-resistance test on each arrester, from the phase terminal to ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1.
3. Test grounding connection in accordance with Section 7.13.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.19.1 Surge Arresters, Low-Voltage Surge Protection Devices (*continued*)

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.19.1.A.5.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.19.1.A.5.2)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Insulation-resistance values should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.
3. Resistance between the arrester ground terminal and the ground system should be less than 0.5 ohm and in accordance with Section 7.13.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.19.2 Surge Arresters, Medium- and High-Voltage Surge Protection Devices

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage, alignment, and grounding.
3. Prior to cleaning the unit, perform as-found tests.
4. Clean the unit.
5. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 1. Use of a low-resistance ohmmeter in accordance with Section 7.19.2.B.1.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
6. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
7. Verify that stroke counter, if present, is correctly mounted and electrically connected.
8. Perform as-left tests.

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.19.2.A.5.1.
2. Perform insulation-resistance tests from phase terminal(s) to case for one minute. Test voltage and minimum resistance shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, refer to Table 100.1.
3. Test the grounding connection in accordance with Section 7.13.

*4.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.19.2 Surge Arresters, Medium- and High-Voltage Surge Protection Devices (continued)

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.19.2.A.5.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.19.2.A.5.2)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Insulation-resistance values should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated
3. Resistance between the arrester ground terminal and the ground system should be less than 0.5 ohm and in accordance with Section 7.13.
4. [REDACTED]

* Optional



7. INSPECTION AND TEST PROCEDURES

7.22.1 Emergency Systems, Engine Generator

NOTE: The prime mover is not addressed in these specifications.

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage, alignment, and grounding.
3. Prior to cleaning the unit, perform as-found tests.
4. Clean the unit.
5. Perform as-left tests.

B. Electrical and Mechanical Tests

1. Perform an insulation-resistance test on the generator winding-to-ground in accordance with ANSI/IEEE Standard 43. Calculate the polarization index.
2. Test protective relay devices in accordance with Section 7.9.
3. Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
- *4. [REDACTED]
5. Conduct performance test in accordance with ANSI/NFPA Standard 110.
6. Verify correct functioning of governor and regulator.

C. Test Values – Visual and Mechanical

1. Anchorage, alignment, and grounding should be in accordance with manufacturer's published data and system design.

* Optional



7. INSPECTION AND TEST PROCEDURES

7.22.1 Emergency Systems, Engine Generator (*continued*)

D. Test Values – Electrical

1. Insulation resistance values should be in accordance with ANSI/IEEE Standard 43.
2. The dielectric absorption ratio or polarization shall be compared to previously obtained results and should not be less than 1.0. The recommended minimum insulation resistance ($IR_{1 \text{ min}}$) test results in megohms should be corrected to 40° C and read as follows:

1. $IR_{1 \text{ min}} = kV + 1$ for most windings made before 1970, all field windings, and others not described in 2.2 and 2.3.

(kV is the rated machine terminal-to-terminal voltage, in rms kV)

2. $IR_{1 \text{ min}} = 100$ megohms for most dc armature and ac windings built after 1970 (form-wound coils).
3. $IR_{1 \text{ min}} = 5$ megohms for most machines and random-wound stator coils and form-wound coils rated below 1 kV.

NOTE: Dielectric withstand voltage high-potential, and surge comparison tests shall not be performed on machines having values lower than those indicated above.

3. Protective relay device test results shall be in accordance with Section 7.9.
4. Low oil pressure, overtemperature, overspeed, and other protection features should operate in accordance with manufacturer's and system design requirements.
5. Vibration levels should be in accordance with manufacturer's published data and shall be compared to baseline data.
6. Performance tests should conform to manufacturer's published data and ANSI/NFPA Standard 110.
7. Governor and regulator should operate in accordance with manufacturer's and system design requirements.

* Optional



8. SYSTEM FUNCTION TESTS

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

Perform system function tests upon completion of the maintenance tests defined, as system conditions allow.

1. Develop test parameters and perform tests for the purpose of evaluating performance of all integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of all interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of all sensing devices, alarms, and indicating devices.
4. Verify communication assisted protection schemes via end-to-end testing.
5. Measure latency of communication lines for pilot wire, line differential and transfer trip protection schemes.
6. Function test lock-out relay and block close circuits.
7. Function test relay self-test, power supply failure, and trip coil monitor alarms to SCADA system.
8. Function test bus restoration and/or transfer switches.
9. Verify correct metering on protective relays and meters.
10. Verify control circuits and current transfer circuits are restored to normal operation.
11. Verify communication lines are operational for local and remote devices.
12. Verify control annunciation systems are left with no alarms and any alarms present shall be investigated.
13. Verify systems are left in normal operating mode or position, transfer and restoration schemes are enabled, and monitoring and protection devices are operational.

9. THERMOGRAPHIC SURVEY

1. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Remove panel covers or view the equipment through viewing ports designed to transmit applicable signals being measured.

2. Thermographic Survey Report

Provide a report which includes the following:

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/or unobservable areas and/or equipment.
6. Identify load conditions at time of inspection.
7. Provide photographs and/or thermograms of the deficient area.
8. Provide recommended action for repair.

3. Test Parameters

1. Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1° C at 30° C.
2. Equipment shall detect emitted radiation and convert detected radiation to visual signal.
3. Thermographic surveys should be performed during periods of maximum possible loading. Refer to ANSI/NFPA 70B 2013 edition, Section 11.17

4. Test Results

Suggested actions based on temperature rise can be found in Table 100.18.

