

Annual Substation Inspections and Tests (based on ANSI/NETA MTS-2019)

Section	Description
7.1	Switchgear, Switchboard, and Panelboard Assemblies
A	Visual and Mechanical Inspection
	1 Inspect physical, electrical, and mechanical condition.
	2 Inspect anchorage, alignment, grounding, and required area clearances.
	14 Inspect mechanical indicating devices for correct operation.
	15 Verify that filters are in place and/or vents are clear.
7.2.1.2	Transformers, Dry-Type, Air-Cooled, Large
A	Visual and Mechanical Inspection
	1 Inspect physical and mechanical condition.
	2 Inspect anchorage, alignment, and grounding.
	***5 Verify that control and alarm settings on temperature indicators are as specified.
	6 Verify that cooling fans operate correctly.
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.
	9 Verify correct liquid level in tanks and bushings.
	10 Verify that positive pressure is maintained on gas-blanketed transformers.
B	Electrical Tests
	***10 Measure the percentage of oxygen in the gas blanket.
	11 <u>Remove a sample of insulating liquid in accordance with ASTM D923. The sample shall be tested for the following.</u>
	11.1 • Dielectric-breakdown voltage: ASTM D1816
	11.2 • Acid neutralization number: ASTM D974
	***11.3 • Specific gravity: ASTM D1298
	11.4 • Interfacial tension: ASTM D971
	11.5 • Color: ASTM D1500
	11.6 • Visual condition: ASTM D1524
	11.7 • Water in insulating liquids: ASTM D1533
	***11.8 • Measure power factor or dissipation factor in accordance with ASTM D924
	12 Remove a sample of insulating liquid in accordance with ASTM D3613 and perform dissolved-gas analysis (DGA) in accordance with IEEE C57.104 or ASTM D3612 .
7.3.3	Shielded Cables, Medium- and High-Voltage
A	Visual and Mechanical Inspection
	1 Inspect exposed sections of cables for physical damage and evidence of overheating and corona.

7.4	Metal-Enclosed Busways
A	Visual and Mechanical Inspection
	1 Inspect physical and mechanical condition.
	2 Inspect anchorage, alignment, and grounding.
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.
7.5.1.3	Switches, Air, Medium- and High-Voltage, Open
A	Visual and Mechanical Inspection
	1 Inspect physical and mechanical condition.
	2 Inspect anchorage, alignment, grounding, and required clearances.
7.5.4	Switches, SF₆, Medium-Voltage
A	Visual and Mechanical Inspection
	1 Inspect physical and mechanical condition.
	2 Inspect anchorage, alignment, grounding, and required clearances.
	13 Test for SF ₆ gas leaks in accordance with manufacturer's published data.
B	Electrical Tests
	***4 Remove a sample of SF ₆ gas and test in accordance with Table 100.13 .
7.5.5	Switches, Cutouts
A	Visual and Mechanical Inspection
	1 Inspect physical and mechanical condition.
	2 Inspect anchorage, alignment, and grounding.
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.
7.6.3	Circuit Breakers, Vacuum, Medium-Voltage
A	Visual and Mechanical Inspection
	1 Inspect physical and mechanical condition.
	2 Inspect anchorage, alignment, and grounding.
7.6.4	Circuit Breakers, SF₆
A	Visual and Mechanical Inspection
	1 Inspect physical and mechanical condition.
	2 Inspect anchorage, alignment, and grounding.
	9 Test for SF ₆ gas leaks in accordance with manufacturer's published data.
7.7	Circuit Switchers
A	Visual and Mechanical Inspection

	1	Inspect physical and mechanical condition.
	2	Inspect anchorage, alignment, and grounding.
7.9.1		Protective Relays, Electromechanical and Solid-State
A		Visual and Mechanical Inspection
	1	Inspect relays and cases for physical damage.
B		Electrical Tests
	2	<u>Test targets and indicators:</u>
	2.1	• Determine pickup and dropout of electromechanical targets.
	2.2	• Verify operation of all light-emitting diode indicators.
	2.3	• Set contrast for liquid-crystal display readouts.
	3	<u>Protection Elements (by ANSI device number)</u>
	3.1	• 2/62 Timing Relay
	3.1.1	▣ Determine time delay.
	3.1.2	▣ Verify operation of instantaneous contacts.
	3.2	• 21 Distance Relay
	3.2.1	▣ Determine maximum reach.
	3.2.2	▣ Determine maximum torque angle and directional characteristic.
	3.2.3	▣ Determine offset.
	***3.2.4	▣ Plot impedance circle.
	3.3	• 24 Volts/Hertz Relay
	3.3.1	▣ Determine pickup frequency at rated voltage.
	3.3.2	▣ Determine pickup frequency at a second voltage level.
	3.3.3	▣ Determine time delay.
	3.4	• 25 Sync Check Relay
	3.4.1	▣ Determine closing zone at rated voltage.
	3.4.2	▣ Determine maximum voltage differential that permits closing at zero degrees.
	3.4.3	▣ Determine live line, live bus, dead line, and dead bus set points.
	3.4.4	▣ Determine time delay.
	***3.4.5	▣ Determine advanced closing angle.
	3.4.6	▣ Verify dead bus/live line, dead line/live bus and dead bus/dead line control functions.
	3.5	• 27 Undervoltage Relay
	3.5.1	▣ Determine dropout voltage.
	3.5.2	▣ Determine time delay.
	3.5.3	▣ Determine the time delay at a second point on the timing curve for inverse time relays.
	3.6	• 32 Directional Power Relay
	3.6.1	▣ Determine minimum pickup at maximum torque angle.
	3.6.2	▣ Determine contact closing zone.
	3.6.3	▣ Determine maximum torque angle.
	3.6.4	▣ Determine time delay.
	3.6.5	▣ Verify the time delay at a second point on the timing curve for inverse time relays.

***3.6.6	▣ Plot the operating characteristic.
3.7	• 40 Loss of Field (Impedance) Relay
3.7.1	▣ Determine maximum reach.
3.7.2	▣ Determine maximum torque angle.
3.7.3	▣ Determine offset.
***3.7.4	▣ Plot impedance circle.
3.8	• 46 Current Balance Relay
3.8.1	▣ Determine pickup of each unit.
3.8.2	▣ Determine percent slope.
3.8.3	▣ Determine time delay.
3.9	• 46N Negative Sequence Current Relay
3.9.1	▣ Determine negative sequence alarm level.
3.9.2	▣ Determine negative sequence minimum trip level.
3.9.3	▣ Determine maximum time delay.
3.9.4	▣ Verify two points on the $(I_2)^2t$ curve.
3.10	• 47 Phase Sequence or Phase Balance Voltage Relay
3.10.1	▣ Determine positive sequence voltage to close the normally open contact.
3.10.2	▣ Determine positive sequence voltage to open the normally closed contact (undervoltage trip).
3.10.3	▣ Verify negative sequence trip.
3.10.4	▣ Determine time delay to close the normally open contact with sudden application of 120 percent of pickup.
3.10.5	▣ Determine time delay to close the normally closed contact upon removal of voltage when previously set to rated system voltage.
3.11	• 49R Thermal Replica Relay
3.11.1	▣ Determine time delay at 300 percent of setting.
3.11.2	▣ Determine a second point on the operating curve.
***3.11.3	▣ Determine minimum pickup.
3.12	• 49T Temperature (RTD) Relay
3.12.1	▣ Determine trip resistance.
3.12.2	▣ Determine reset resistance.
3.13	• 50 Instantaneous Overcurrent Relay
3.13.1	▣ Determine pickup.
3.13.2	▣ Determine dropout.
***3.13.3	▣ Determine time delay.
3.14	• 50BF Breaker Failure
3.14.1	▣ Determine current supervision pickup.
3.14.2	▣ Determine time delays.
3.14.3	▣ Test all used initiate inputs and all used outputs.
3.15	• 51 Time Overcurrent
3.15.1	▣ Determine minimum pickup.
3.15.2	▣ Determine time delay at two points on the time current curve.
3.16	• 55 Power Factor Relay

3.16.1	▣ Determine tripping lead and lag angles.
3.16.2	▣ Determine enable time delay.
3.16.3	▣ Determine operate time delay.
3.17	• 59 Overvoltage Relay
3.17.1	▣ Determine overvoltage pickup.
3.17.2	▣ Determine time delay to close the contact with sudden application of 120 percent of pickup.
3.18	• 60 Voltage Balance Relay
3.18.1	▣ Determine voltage difference to close the contacts with one source at rated voltage.
***3.18.2	▣ Plot the operating curve for the relay.
3.19	• 63 Transformer Sudden Pressure Relay
3.19.1	▣ Determine rate-of-rise or the pickup level of suddenly applied pressure in accordance with manufacturer's published data.
3.19.2	▣ Verify operation of the 63 FPX seal-in circuit.
3.19.3	▣ Verify trip circuit to remote operating device.
3.20	• 64 Ground Detector Relay
3.20.1	▣ Determine maximum impedance to ground causing relay pickup.
3.21	• 67 Directional Overcurrent Relay
3.21.1	▣ Determine directional unit minimum pickup at maximum torque angle.
3.21.2	▣ Determine contact closing zone.
***3.21.3	▣ Determine maximum torque angle.
***3.21.4	▣ Plot operating characteristics.
3.21.5	▣ Determine overcurrent unit pickup.
3.21.6	▣ Determine overcurrent unit time delay at two points on the time current curve.
3.22	• 79 Reclosing Relay
3.22.1	▣ Determine time delay for each programmed reclosing interval.
3.22.2	▣ Verify lockout for unsuccessful reclosing.
3.22.3	▣ Determine reset time.
***3.22.4	▣ Determine close pulse duration.
3.22.5	▣ Verify instantaneous overcurrent lockout.
3.23	• 81 Frequency Relay
3.23.1	▣ Verify frequency set points.
3.23.2	▣ Determine time delays.
3.23.3	▣ Determine undervoltage cutoff.
3.24	• 85 Pilot Wire Monitor
3.24.1	▣ Determine overcurrent pickup.
3.24.2	▣ Determine undercurrent pickup.
3.24.3	▣ Determine pilot wire ground pickup level.
3.25	• 87 Differential
3.25.1	▣ Determine operating unit pickup.
3.25.2	▣ Determine the operation of each restraint unit.
3.25.3	▣ Determine slope.
3.25.4	▣ Determine harmonic restraint.

3.25.5	<ul style="list-style-type: none"> ▣ Determine instantaneous pickup.
***3.25.6	<ul style="list-style-type: none"> ▣ Plot operating characteristics for each restraint.
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	Download all events from the event recorder in filtered and unfiltered mode before performing any tests on the relay.
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	Record passwords for all access levels.
6	Clean the front panel and remove foreign material from the case.
11	Check with owner for applicable firmware updates and product recalls.
7.10.1	Instrument Transformers, Current Transformers
A	Visual and Mechanical Inspection
1	Inspect physical and mechanical condition.
7.10.2	Instrument Transformers, Voltage Transformers
A	Visual and Mechanical Inspection
1	Inspect physical and mechanical condition.
7.11.1	Metering Devices, Electromechanical and Solid-State
A	Visual and Mechanical Inspection
1	Inspect physical and mechanical condition.
7.11.2	Metering Devices, Microprocessor-Based
A	Visual and Mechanical Inspection
1	Inspect meters and cases for physical damage.
7.13	Grounding Systems
A	Visual and Mechanical Inspection
1	Verify ground system is in compliance with NFPA 70, National Electrical Code, Article 250 .
2	Inspect physical and mechanical condition.
7.19.2	Surge Arresters, Medium- and High-Voltage Surge Protection Devices
A	Visual and Mechanical Inspection
1	Inspect physical and mechanical condition.
7.20.1	Capacitors and Reactors, Capacitors
A	Visual and Mechanical Inspection
1	Inspect physical and mechanical condition.
2	Inspect anchorage, alignment, grounding, and required clearances.
7.20.3.1	Capacitors and Reactors, Reactors (Shunt and Current-Limiting), Dry-Type

A	Visual and Mechanical Inspection
1	Inspect physical and mechanical condition.
2	Inspect anchorage, alignment, and grounding.
7.21	Outdoor Bus Structures
A	Visual and Mechanical Inspection
1	Inspect physical and mechanical condition.
2	Inspect anchorage, alignment, and grounding.
7.22.3	Emergency Systems, Automatic Transfer Switches
A	Visual and Mechanical Inspection
1	Inspect physical and mechanical condition.
2	Inspect anchorage, alignment, grounding, and required clearances.