# Switchboards
# Functional Performance Test

| | |
|---|---|
| Equipment ID | **[Equipment ID]** |
| Building | **[Building]** |
| Location | **[Room]** |

## System Description

**Description:**

**Operational Assumptions:**

| Initial Test | | Start Date | End Date | Initials |
|---|---|---|---|---|
| Results (Check one)<br>☐ Pass<br>☐ Fail<br>☐ Partial Test w/Corrective Actions<br>☐ Complete Test w/Corrective Actions<br>☐ Other | Explanation: | | | |

| Re-Test 1 | | Start Date | End Date | Initials |
|---|---|---|---|---|
| Results (Check one)<br>☐ Pass<br>☐ Fail<br>☐ Partial Test w/Corrective Actions<br>☐ Complete Test w/Corrective Actions<br>☐ Other | Explanation: | | | |

| Re-Test 2 | | Start Date | End Date | Initials |
|---|---|---|---|---|
| Results (Check one)<br>☐ Pass<br>☐ Fail<br>☐ Partial Test w/Corrective Actions<br>☐ Complete Test w/Corrective Actions<br>☐ Other | Explanation: | | | |

| Deferred/Seasonal Test | | Start Date | End Date | Initials |
|---|---|---|---|---|
| Results (Check one)<br>☐ Pass<br>☐ Fail<br>☐ Partial Test w/Corrective Actions<br>☐ Complete Test w/Corrective Actions<br>☐ Other | Explanation: | | | |

## Test Participants

| Organization | Required | Optional |
|---|---|---|
| General Contractor | ☐ | ☐ |
| Mechanical Contractor | ☐ | ☐ |
| Electrical Contractor | ☐ | ☐ |
| TAB Contractor | ☐ | ☐ |
| Controls Contractor | ☐ | ☐ |
| Owner's O&M Personnel | ☐ | ☐ |

## Pre-Functional Performance Test Summary

| Description | Yes | No | Date |
|---|---|---|---|
| System ready for test | ☐ | ☐ | |
| Required personnel available | ☐ | ☐ | |
| Required tools/test equipment/supplies available | ☐ | ☐ | |
| Required safety equipment available | ☐ | ☐ | |

## TEST INSTRUMENTS (to be provided by the Contractor)

## Test Equipment Required:

| Test Name | Equipment Description |
|---|---|
| Contact Resistance | Four-probe Digital Low Resistance Ohmmeter (DLRO) |
| Insulation Resistance | Megger-battery or line-powered (Hand-crank not acceptable) |
| DI Electric Withstand | High Potential Tester |
| Bolt Torque | Calibrated torque wrench |
| Relay Operation | Variable AC Voltage source |
| Voltage/Continuity | DVM |

## Functional Performance Test -- (Verify all components are ready before energizing or operating the system.)

The Commissioning Authority will make and document any changes/addition/deletions to this test procedure required by current system conditions (i.e. weather, system load, utility availability, etc.).

R = Retest (Check (✓) retest required)
C = Corrected (Check (✓) when correction verified)
Y= Checked and Passed
N = Not Passed

| ACTION | REQUIRED REACTION | Y (✓) | N (✓) | COMMENTS | R (✓) | C (✓) |
|---|---|---|---|---|---|---|
| **PRE-TEST VISUAL MECHANICAL INSPECTION** | | | | | | |
| 1. Safe conditions (protective gear in-place, available & procedures observed) | | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 2. Inspect the exterior of the switchgear | No evidence of damage. | ☐ | ☐ | | ☐ | ☐ |
| | Surfaces are clean. | ☐ | ☐ | | ☐ | ☐ |
| | All doors, panels, and hardware present. | ☐ | ☐ | | ☐ | ☐ |
| | All doors swing freely, latch in open and closed positions. | ☐ | ☐ | | ☐ | ☐ |
| | Feeder cable/bus routing doesn't obstruct access for operation or maintenance. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 3. Verify anchoring | Anchor bolts are provided in locations shown on manufacturer's drawings. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |

| ACTION | REQUIRED REACTION | Y (✓) | N (✓) | COMMENTS | R (✓) | C (✓) |
|---|---|---|---|---|---|---|
| 4. Verify ratings and configuration. Nameplate data match shop drawings and specifications | Volts: 480/277V. | ☐ | ☐ | | ☐ | ☐ |
| | Amps: 4000A. | ☐ | ☐ | | ☐ | ☐ |
| | 3ph, 4W. | ☐ | ☐ | | ☐ | ☐ |
| | Frequency: 60hZ. | ☐ | ☐ | | ☐ | ☐ |
| | Interrupting Rating: 65kAIC. | ☐ | ☐ | | ☐ | ☐ |
| | Enclosure: NEMA 1. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial / Date | | |
| 5. Verify permanent labels are installed | Equipment labeled with name plates which are black engraved surface on white core for normal power circuits and red engraved surface on white core for emergency power circuits. | ☐ | ☐ | | ☐ | ☐ |
| | Labels include unit number, voltage, and origin of service. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial / Date | | |
| 6. TVSS provided as required by drawings | Conductor length is as short as possible. | ☐ | ☐ | | ☐ | ☐ |
| | Conductor bends are minimized. | ☐ | ☐ | | ☐ | ☐ |
| | Conductors are no longer than 24 inches. | ☐ | ☐ | | ☐ | ☐ |
| | Installed on load side of main circuit breaker. | ☐ | ☐ | | ☐ | ☐ |
| | Indicator lights are functional. | ☐ | ☐ | | ☐ | ☐ |

| ACTION | REQUIRED REACTION | Y (✓) | N (✓) | COMMENTS | R (✓) | C (✓) |
|---|---|---|---|---|---|---|
| | Surge event operation counter reads zero. | ☐ | ☐ | | ☐ | ☐ |
| | TVSS is equipped with remote monitoring contacts. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 7. Inspect the control wiring for proper support, routing, protection | Control wires are supported well clear of the path of movement of breakers and auxiliary device trays. | ☐ | ☐ | | ☐ | ☐ |
| | All wires labeled both ends. | ☐ | ☐ | | ☐ | ☐ |
| | Control wire termination connections tight and cannot be pulled from connection. | ☐ | ☐ | | ☐ | ☐ |
| | The wire bundle at the door is supported clear of the hinge. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 8. Verify rating of all control circuit protective devices match shop drawings | Fuse and circuit breaker ratings match drawings. | ☐ | ☐ | | ☐ | ☐ |
| | Device labels match drawings. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 9. Verify control power transformer installation | Control power transformer installation per the schematic drawings. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |

| ACTION | REQUIRED REACTION | Y (✓) | N (✓) | COMMENTS | R (✓) | C (✓) |
|---|---|---|---|---|---|---|
| 10. Verify grounding | Connection from station ground grid to equipment ground bus. (possibly at multiple locations). | ☐ | ☐ | | ☐ | ☐ |
| | Frames and enclosures bolted to ground buss. | ☐ | ☐ | | ☐ | ☐ |
| | Breaker and feeder equipment grounding conductor/conduit are connected to the ground buss. | ☐ | ☐ | | ☐ | ☐ |
| | Measured diameter of bare copper conductor corresponds to diameter of specified conductors. | ☐ | ☐ | | ☐ | ☐ |
| | Neutral is bonded to ground at switchgear, not transformer. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 11. Verify provision and proper operation of integral rail mounted, breaker lifting device | Remove circuit breaker using device and confirm full operation. | ☐ | ☐ | | ☐ | ☐ |
| | Confirm that lifter travels entire length of switchgear smoothly to the end of travel. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 12. Operate each circuit breaker (5) times to ensure smooth operation | Breaker opens and closes in a smooth motion without binding. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |

| ACTION | REQUIRED REACTION | Y (✓) | N (✓) | COMMENTS | R (✓) | C (✓) |
|---|---|---|---|---|---|---|
| **ELECTRICAL INTEGRITY** | | | | | | |
| 13. Disconnect PTs, CPTs, surge arrestors, and circuit breakers | | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 14. Disconnect the main bonding jumpers at the switchgear | | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 15. Perform an insulation resistance test at 1000VDC on each bus section, phase-to-phase and phase to ground with the circuit breakers connected in the closed position | Minimum insulation resistance shall be 100 Megohms. | ☐ | ☐ | Record results in Insulation Resistance Data Table.<br><br>Test with all circuit breakers in the closed position<br><br>Test for one minute in accordance with NETA Table 100.1.<br><br>Feeder conductors should not be terminated | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 16. Perform an insulation resistance test at 1000 VDC on the neutral bus section to ground | Minimum insulation resistance shall be 100 Megohms. | ☐ | ☐ | Record results in Insulation Resistance Data Table<br><br>Test for one minute in accordance with NETA Table 100.1. | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |

| ACTION | REQUIRED REACTION | Y (✓) | N (✓) | COMMENTS | R (✓) | C (✓) |
|---|---|---|---|---|---|---|
| 17. With the breaker in the closed position, measure the contact resistance of each phase of circuit breakers rated 400A and greater | Readings are within 50% of the average value. | ☐ | ☐ | Record results in Contact Resistance Data Table. | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 18. Re-connect the main bonding jumpers and verify tightness with a calibrated torque wrench | | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 19. Reconnect surge, arrestors, TVSS, CPT's, and PTs | | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 20. Reconnect CT grounds | | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 21. After testing is performed on the switchboard, verify tightness of field | Primary connections properly torqued and marked. | ☐ | ☐ | Record results in Feeder Termination Torque Data Table. | ☐ | ☐ |
| | Bus-to-bus connections properly torqued and marked. | ☐ | ☐ | | ☐ | ☐ |

| ACTION | REQUIRED REACTION | Y (✓) | N (✓) | COMMENTS | R (✓) | C (✓) |
|---|---|---|---|---|---|---|
| landed feeder terminations and bus-to-bus connections | TVSS connections are properly torqued and marked. | ☐ | ☐ | Bolted torque should comply with NETA Table 100.12 unless manufacturer specified values are listed on the equipment.<br><br>Secondary distribution feeder connections are not included in the test.<br><br>Black marker marked across the head of the bolt and bus. | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial / Date | | |
| **FUNCTIONAL TRIP TESTS** | | | | | | |
| 22. Test the long time delay (seconds) and long time pickup current (amperes) setting on device breakers rated 400A and greater, by using primary current injection. | Long delay current pick up and time delay per coordination study. | ☐ | ☐ | Record results in Current Injection Data Table. | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial / Date | | |
| 23. Test the short time delay (seconds) and short time pickup current (amperes) setting on device breakers rated 400A and greater, by using primary current injection | Short delay current pick up and time delay per coordination study. | ☐ | ☐ | Record results in Current Injection Data Table. | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial / Date | | |

| ACTION | REQUIRED REACTION | Y (✓) | N (✓) | COMMENTS | R (✓) | C (✓) |
|---|---|---|---|---|---|---|
| 24. Test the instantaneous time delay (seconds) and instantaneous time pickup current (amperes) setting on device breakers rated 400A and greater, by using primary current injection | Instantaneous pick up per coordination study. | ☐ | ☐ | Record results in Current Injection Data Table. | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 25. Test the ground fault time delay (seconds) and ground fault time pickup current (amperes) setting on device breakers rated 400A and greater, by using primary current injection. | Ground fault pick up per coordination study. | ☐ | ☐ | Record results in Current Injection Data Table. | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| **METERING** | | | | | | |
| 26. Verify the nameplate matches the shop drawings | Model Number: ____. | ☐ | ☐ | | ☐ | ☐ |
| | Meter supply voltage matches the AC control power supply. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 27. Verify all metering circuits | Components and wire labels match the drawings. | ☐ | ☐ | | ☐ | ☐ |
| | Verify control power wiring to the meter. | ☐ | ☐ | | ☐ | ☐ |

| ACTION | REQUIRED REACTION | Y (✓) | N (✓) | COMMENTS | R (✓) | C (✓) |
|---|---|---|---|---|---|---|
| | CT and PT locations, polarity, fusing, and wiring match the drawings. | ☐ | ☐ | | ☐ | ☐ |
| | CT poles shall have shorting auxiliary contacts. Screws removed from CT shorting blocks. | ☐ | ☐ | | ☐ | ☐ |
| | Confirm tightness of all (100%) CT wiring with screwdriver. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |
| 28. Verify the correct parameters have been programmed into the meter | 3ph, 4w, 1000:5 CT, 480:277V PT configuration has been entered into the meter. | ☐ | ☐ | | ☐ | ☐ |
| | The correct PT ratio of 480:277 has been entered into the meter. | ☐ | ☐ | | ☐ | ☐ |
| | The correct secondary L-N voltage 120V has been entered into the meter. | ☐ | ☐ | | ☐ | ☐ |
| | The current transformer ratio 1000:5 has been correctly entered into the meter. | ☐ | ☐ | | ☐ | ☐ |
| | Phase rotation is ___. | ☐ | ☐ | | ☐ | ☐ |
| | The correct frequency 60 Hz has been entered into the meter. | ☐ | ☐ | | ☐ | ☐ |
| | Password is ____. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |

| ACTION | REQUIRED REACTION | Y (✓) | N (✓) | COMMENTS | R (✓) | C (✓) |
|---|---|---|---|---|---|---|
| **FINAL INSPECTION** | | | | | | |
| 29. At the conclusion of testing, inspect interior hardware and electrical terminations | All hardware in place and properly torqued. | ☐ | ☐ | | ☐ | ☐ |
| | Compartments clear of tools and hardware. | ☐ | ☐ | | ☐ | ☐ |
| Record issues | | | | Issue Log Item: | | |
| | | | | Initial | Date | |

## Test Equipment Used:

| Test Name | Manufacturer | Model Number | Serial Number | Calibration (Date) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**Temperature:** _____ **Relative Humidity:** _____

## Insulation Resistance (1000 VDC)

| Circuit Breaker (Closed) | A-B | B-C | C-A | A-G | B-G | C-G | N |
|---|---|---|---|---|---|---|---|
| 1 Minute (Meg Ohms) | | | | | | | |
| Circuit Breaker (open) | A-A | B-B | C-C | | | | |
| 1 Minute (Meg Ohms) | | | | | | | |

## Circuit Breaker Contact Resistance

| Phase | A | B | C |
|---|---|---|---|
| (Micro Ohms) | | | |

## Feeder Termination Torque (Newton Meters or Foot-Pounds)

| Bolt or Lug | A | B | C | N | G |
|---|---|---|---|---|---|
| **Feeder Lugs** | | | | | |
| **Feeder Lugs** | | | | | |
| | | | | | |
| | | | | | |

## Current Injection

| Function | Actual Set. | Test Setting | Test Point | Nominal Val. | A | B | C |
|---|---|---|---|---|---|---|---|
| **LTD** | | | | | | | |
| **LDPU** | | | | | | | |
| **STD** | | | | | | | |
| **SDPU** | | | | | | | |
| **INSTPU** | | | | | | | |
| **GFD** | | | | | | | |
| **GFPU** | | | | | | | |

# Final Sign-Off

| Commissioning Agent | Printed Name | Initials | Date |
|---|---|---|---|
| | | | |

| CONTRACTOR | PRINTED NAME | INITIALS | DATE |
|---|---|---|---|
| General Contractor (GC) | | | |
| Mechanical Contractor (MC) | | | |
| Electrical Contractor (EC) | | | |
| TAB Contractor (TAB) | | | |
| Controls Contractor (CC) | | | |
| Owner's O&M Personnel | | | |

**TABLE 100.1**

**Insulation Resistance Test Values**
**Electrical Apparatus and Systems**

| Nominal Rating Of Equipment in Volts | Minimum Test Voltage, DC | Recommended Minimum Insulation Resistance in Megohms |
|---|---|---|
| 250 | 500 | 25 |
| 600 | 1,000 | 100 |
| 1,000 | 1,000 | 100 |
| 2,500 | 1,000 | 500 |
| 5,000 | 2,500 | 1,000 |
| 8,000 | 2,500 | 2,000 |
| 15,000 | 2,500 | 5,000 |
| 25,000 | 5,000 | 20,000 |
| 34,500 and above | 15,000 | 100,000 |

In the absence of consensus standards dealing with insulation-resistance tests, the Standards Review Council suggests the above representative values.

See Table 100.10 for temperature correction factors.

Test results are dependent on the temperature of the insulating material and the humidity of the surrounding environment at the time of the test.

Insulation-resistance test data may be used to establish a trending pattern. Deviations from the baseline information permit evaluation of the insulation.

**TABLE 100.12.1**
**Bolt-Torque Values for Electrical Connections**

**US Standard Fasteners [a]**
**Heat-Treated Steel – Cadmium or Zinc Plated [b]**

| Grade | SAE 1&2 | SAE 5 | SAE 7 | SAE 8 |
|---|---|---|---|---|
| Head Marking | |  |  |  |
| Minimum Tensile (Strength) ($lbf/in^2$) | 64K | 105K | 133K | 150K |

| Bolt Diameter (Inches) | Torque (Pound-Feet) | | | |
|---|---|---|---|---|
| 1/4 | 4 | 6 | 8 | 8 |
| 5/16 | 7 | 11 | 15 | 18 |
| 3/8 | 12 | 20 | 27 | 30 |
| 7/16 | 19 | 32 | 44 | 48 |
| 1/2 | 30 | 48 | 68 | 74 |
| 9/16 | 42 | 70 | 96 | 105 |
| 5/8 | 59 | 96 | 135 | 145 |
| 3/4 | 96 | 160 | 225 | 235 |
| 7/8 | 150 | 240 | 350 | 380 |
| 1.0 | 225 | 370 | 530 | 570 |

a. Consult manufacturer for equipment supplied with metric fasteners.

b. Table is based on national coarse thread pitch.