

SUBSTATION TESTING SPECIFICATION

Kootenai Electric Cooperative, Inc.

**Rev B
11/15/2023**



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1.0 GENERAL REQUIREMENTS

- 1.1 The Testing Contractor shall furnish qualified personnel, all testing equipment, man-lifts, generators, materials, taxes, any specialized craft labor, full-time supervision, tools, freight, safety equipment, insurance, special equipment instruction manuals, and software necessary for testing of all protective relays and other electrical equipment described in this specification.
- 1.2 The Testing contractor safety practices shall include, but are not limited to, the following requirements:
 - 1.2.1 Occupational Safety and Health Act (OSHA)
 - 1.2.2 ANSI/NFPA 70E Electrical Safety Requirements for Employee Work Places
 - 1.2.3 Applicable state and local safety operating procedures.
 - 1.2.4 Institute and maintain rigorous precautions for all test procedures requiring application of potentials above 30 volts, erect barricades around danger areas, post suitable warning signs, and station watchers as necessary to ensure that unauthorized persons do not approach energized conductors or equipment. Workers shall use proper Personal Protective Equipment (PPE) around energized conductors and equipment, or in other areas as required.
 - 1.2.5 Any wiring in energized control circuits shall be done under the supervision of the Owner. Relay disabling that is required for wiring activities on existing panels will be done under the approval of the Owner. Any control circuit wiring modified shall be checked out and commissioned under the approval of the Owner before relays or control circuits are returned or put into service.
- 1.3 All other materials used in the installation of the equipment shall be new, unused, non-surplus materials of current design, and shall include all required accessories. Design, detail, material, fabrication, assembly, testing, and delivery should comply with the latest revisions of ANSI, NEMA, and IEEE standards

2.0 TESTING REQUIREMENTS

2.1 The Testing Contractor will conduct test in accordance with manufacturer recommendations, and applicable IEEE, ANSI, ASTM, and NETA standards. Test as defined within this section shall be performed on equipment as listed in the scope of work prior to the equipment being energized.

2.2 115/24.9kV Transformer

2.2.1 Inspection: The following visual and mechanical inspections shall be performed.

2.2.1.1 Verify equipment ground installed.

2.2.1.2 Visually check bushing designation and circuit switcher orientation with respect to one-line and three-line diagrams.

2.2.1.3 Positive pressure verification.

2.2.2 Electrical Tests: The following electrical tests shall be performed.

2.2.2.1 Insulation resistance Megger test on all windings.

2.2.2.2 Insulation power factor and capacitance tests on all windings and bushings.

2.2.2.3 Leakage reactance measurements.

2.2.2.4 Transformer turns ratio (TTR) on rated voltage connection and all available taps.

2.2.2.5 Excitation current tests on rated voltage connection

2.2.2.6 Polarity and phase relationship test.

2.2.2.7 Low frequency dielectric test.

2.2.2.8 Pulse, polarity, ratio, and excitation tests on all CTs

2.2.2.9 All functional test for transformer cooling group operation, and Calisto oil monitor.

2.2.2.10 Calibration check of temperature probes and operational check of gauges and alarm circuit verification.

2.2.2.11 Operational check of sudden pressure relay.

2.3 115 kV Circuit Switcher

2.3.1 Inspection: The following visual and mechanical inspections shall be performed.

2.3.1.1 Verify equipment ground installed.

2.3.1.2 Visually check bushing designation and circuit switcher orientation with respect to one-line and three-line diagrams.

2.3.2 Electrical Tests: The following electrical tests shall be performed.

2.3.2.1 Megger test.

2.3.2.2 Contact resistance test on interrupters.

2.3.2.3 Hi-Pot test of interrupters.

2.3.2.4 Verify proper operation of all trip and close control circuits and speed tests.

2.3.2.5 Check all auxiliary switch and alarm contact connections utilized for proper functionality.

2.3.2.6 Check proper operation of all cabinet heaters, lights, and receptacles.

2.3.2.7 Mechanical operation tests.

2.3.2.8 Record reading of operation counter at completion of testing.

2.4 27 kV Vacuum Circuit Breaker

2.4.1 Inspection: The following visual and mechanical inspections shall be performed.

2.4.1.1 Verify equipment ground installed.

2.4.1.2 Visually check bushing designation and breaker orientation on each breaker with respect to one-line and three-line diagrams.

2.4.2 Electrical Tests: The following electrical tests shall be performed.

2.4.2.1 Megger test.

2.4.2.2 Contact resistance test on vacuum bottles.

2.4.2.3 Hi-Pot test of vacuum bottles.

- 2.4.2.4 Ratio, excitation, and polarity tests on all current transformers.
- 2.4.2.5 Verify proper operation of all trip and close control circuits and speed tests.
- 2.4.2.6 Check all auxiliary switch and alarm contact connections utilized for proper functionality.
- 2.4.2.7 Check proper operation of all cabinet heaters, lights, and receptacles.
- 2.4.2.8 Mechanical operation tests.
- 2.4.2.9 Record reading of operation counter at completion of testing.

2.5 Batteries and Battery Charger

2.5.1 Inspection: The following visual and mechanical inspections shall be performed.

- 2.5.1.1 Verify equipment ground installed.
- 2.5.1.2 Check all wiring connections for tightness and continuity.
- 2.5.1.3 Verify charger settings have been made and check operation including all alarm contact circuits.

2.5.2 Electrical Tests: The following electrical tests shall be performed.

- 2.5.2.1 Battery load test including cell readings before, during, and after tests.

2.6 Single Phase Regulators

2.6.1 Inspection: The following visual and mechanical inspections shall be performed.

- 2.6.1.1 Verify equipment ground installed.
- 2.6.1.2 Visually check bushing designation and regulator orientation on each regulator with respect to one-line and three-line diagrams.
- 2.6.1.3 Verify shunt and series arrester ratings and installation per manufacturer's drawings and specifications.

2.6.2 Electrical Tests: The following electrical tests shall be performed.

2.6.2.1 Megger test.

2.6.2.2 TTR ratio test on all steps.

2.6.2.3 Verify reversing switch and limit switch operation at full buck and full boost.

2.6.2.4 Verify proper operation of remote / local switches, raise / lower switches, drag hand reset switches, and other switches provided in the control cabinet.

2.6.2.5 Perform an oil dielectric test in accordance with ASTM D877 prior to energization.

2.6.2.6 Record reading of operation counter at completion of testing.

2.7 GOAB and Hookstick Switches

2.7.1 Inspection: The following visual and mechanical inspections shall be performed.

2.7.1.1 Verify equipment ground installed.

2.7.1.2 Visually check all mounting hardware and control mechanism hardware is tight. Final piercing of control mechanism to be done after acceptance from Owner.

2.7.2 Electrical Tests: The following electrical tests shall be performed.

2.7.2.1 Contact resistance test.

2.8 Fuses

2.8.1 Inspection: The following visual and mechanical inspections shall be performed.

2.8.1.1 Verify equipment ground installed.

2.8.1.2 Visually check all mounting hardware is tight.

2.8.2 Electrical Tests: The following electrical tests shall be performed.

2.8.2.1 Contact resistance test across assembled fuses.

2.9 Potential Transformers

2.9.1 Inspection: The following visual and mechanical inspections shall be performed.

2.9.1.1 Verify equipment grounds installed.

2.9.1.2 Visually check polarity mark orientation on all potential transformers with respect to one-line and three-line diagrams.

2.9.2 Electrical Tests: The following electrical test shall be performed.

2.9.2.1 Verify proper continuity and polarity for each potential transformer according to manufacturer's specifications.

2.9.2.2 Verify proper continuity, polarity, and phase relationship is maintained from the potential transformer through the cable circuit to each protective relay or instrument. Voltage applied as the CT secondary cable shall be verified as received in the connected device.

2.9.2.3 Perform a TTR ratio test on each potential transformer on all available taps.

2.9.2.4 Perform a polarity test.

2.9.2.5 Perform a megger test on all potential transformers to ground.

2.10 Current Transformers

2.10.1 Inspection: The following visual and mechanical inspections shall be performed.

2.10.1.1 Verify equipment grounds installed.

2.10.1.2 Visually check polarity mark orientation on all current transformers with respect to one-line and three-line diagrams.

2.10.2 Electrical Tests: The following electrical tests shall be performed.

2.10.2.1 Verify proper continuity and polarity for each current transformer according to manufacturer's specifications.

- 2.10.2.2 Verify proper continuity, polarity, and phase relationship is maintained from the current transformer through the cable circuit to each protective relay or instrument. Current applied as the CT secondary cable shall be verified as received in the connected device.
- 2.10.2.3 Perform a ratio test on each current transformer on all available taps.
- 2.10.2.4 Perform a polarity test.
- 2.10.2.5 Perform a megger test on all current transformers to ground.
- 2.10.2.6 Check excitation test data against available current transformer excitation curves.
- 2.10.2.7 Verify current transformer ratios and polarity on connected cabling to ensure they match the settings in protective relays and meters. All current transformers to remain shorted until testing has proven they are properly configured and wired, and the Owner is ready to proceed with Commissioning.

2.11 Protective Relays and Meters

- 2.11.1 Inspection: The following visual and mechanical inspections shall be performed.
 - 2.11.1.1 Verify nameplate data against drawings and setting sheets.
 - 2.11.1.2 Check for physical damage or evidence of moisture or dirt.
 - 2.11.1.3 Check all wiring connections for tightness and continuity.
 - 2.11.1.4 All relay and meter power supply circuits shall be checked for shorts and grounds and then each device shall be powered up to verify proper operation.
- 2.11.2 Settings: All relays and meters requiring electronic settings shall be loaded by the Contractor with setting files supplied by the Owner prior to electricpal tests being performed.
- 2.11.3 Electrical Tests: The following electrical tests shall be performed in conjunction with the Owner.
 - 2.11.3.1 All protective relay and meter testing should be done using secondary injection of three phase voltages and currents.

2.11.3.2 Prior to relay or meter testing, a metering function test should be performed on all relays and meters by three phase voltage current injection.

2.11.3.3 All enabled relay setting TRIP elements, along with over current or differential trip, close, reclose, and alarm functions of the relay shall be tested for proper operation.

2.12 Miscellaneous

2.12.1 Test for proper operation of all annunciator alarms.

2.12.2 Test for proper operation of station lighting.

2.12.3 Test smoke detector alarm.

2.12.4 Complete wiring point to point check of the system.

2.12.5 The Contractor shall review the installation manual for each piece of equipment and consult with the Owner concerning any other tests and or adjustment verifications recommended by the manufacturer or any other testing deemed appropriate for commissioning a new substation.

3.0 COMMISSIONING

3.1 The Erection Contractor will provide resources to the Owner as specified in the Erection Specification for commissioning activities.

3.2 It will be the responsibility of the Erection Contractor to terminate all cables from the yard on terminal blocks in the relay panels within the control house and terminate all cables on equipment in the yard.

3.3 The Erection Contractor shall provide a minimum of one (1) week advance notice to the Owner for the Owner led commissioning process to begin.

4.0 CONFLICTING INFORMATION

4.1 In the event of conflicts in the materials provided to the Contractor, either drawings or hardware, it will be the responsibility of the Contractor to contact the Owner to clarify the concerns.

5.0 DOCUMENTATION

5.1 The Contractor shall submit all test reports in PDF format for all tests and control circuit verification performed to the Owner for review and acceptance.

5.2 The Owner will provide the following to the Testing Contractor.

5.2.1 Substation wiring diagrams and schematics

5.2.2 Equipment Instruction Manuals and Manufacturer Drawings.

5.2.3 Two technicians to assist with the commissioning and testing of the substation.

APPENDIX A – SIEMENS SDV7 BREAKER MANUAL
SEPARATE ATTACHMENT

APPENDIX B – HAZARD INFORMATION

APPENDIX B. HAZARD INFORMATION

Contractor acknowledges that work performed on Kootenai Electric Cooperative, Inc.’s (KEC or Owner) electrical distribution system may involve hazards. This document details characteristics of KEC’s installation that are related to the safety of the work to be performed and are listed in OSHA regulation 1910.269(a)(4)(i) through (a)(4)(v).

Minimum Clearance Distances of energized lines or equipment from conductive equipment or materials for non-qualified electric workers performing work near energized lines or equipment.

**Safe working distances when working near energized lines or equipment
(for non-qualified electrical workers)**

Line or Substation Voltages (kV)	Minimum clearance distances non-qualified electric workers. (from OSHA crane standard tables)
15 kV (AC) 25 kV (AC)	10 feet (up to 50kV)
115 kV (AC)	15 feet (50 – 200 kV)

Induced Voltage/Accidental Energization Potential: Prior to commencing Work, Contractor and KEC will meet to review current infrastructure as well as adjacent energized circuits parallel to the line under construction (i.e., double circuit distribution lines/overbuild/underbuild) and any other energized lines crossing the line under construction.

Maximum Per-Unit Transient Over Voltages: No later than April 1, 2015, for voltages over 72.5 kilovolts, the employer shall, through an engineering analysis or assume a maximum anticipated per-unit transient voltage, phase-to-ground, in accordance with Table R-9.

Table R-9 – Assumed Maximum Per-Unit Transient Overvoltage

Voltage range (kV)	Type of current (ac or dc)	Assumed maximum per-unit transient overvoltage
72.6 to 420.0	ac	3.5
420.1 to 550.0	ac	3.0
550.1 to 800.0	ac	2.5
250 to 750	dc	1.8

Minimum Approach Distances of energized lines or equipment from conductive equipment or materials for qualified electrical workers.

- KEC uses WAC 296-45-325 table 2 for AC live work minimum approach distance.

AC Live Work Minimum Approach Distance

Voltage	Phase-to-Ground Exposure	Phase-to-Phase Exposure
15.1- 36 kV	2.7 feet	3.0 feet
72.6 – 121 kV	3.9 feet	4.8 feet

Condition of Protective Grounds and Equipment Grounding Conductors - Minimum Requirements:

- Protective ground sizing for line or substation:
 - 1/0 protective grounds for underground distribution
 - 2/0 protective grounds for distribution
 - 2/0 protective grounds for transmission
 - 2/0 protective grounds for all substations

Protective Clothing Requirements - Minimum Requirements:

- Arc flash incident energy rating: 8 calorie/cm² rated clothing

Contractor and KEC will also review relevant conditions that could affect work safety, including:

- Condition of protective grounds (if applicable).
- Are equipment grounds intact?
- Rejected poles or poles believed unsafe to climb (if known).
- Potential landowner concerns (if known).

KEC discloses the following common hazards that may be present on its system. Contractor acknowledges these are common hazards and list is not all-inclusive:

- Two-piece insulators
- Chance cutouts
- Woodpecker holes
- Poles damaged by ants
- Bad wood pole markings
- 6 Position mod cabinets with potential bad bus work
- Locations with copper weld wire
- Locations with #6 Copper
- 25 KV non Posi load break caps
- 10 kV & 18 kV Lightning arrestors

Contractor Requirements: Contractor shall advise KEC of any unique or unanticipated hazardous conditions found during the Work that KEC did not disclose and/or any other information regarding work safety. Reports shall be made in writing to KEC's contract representative within 2 working days following discovery

CONTRACTOR CERTIFICATION

Contractor certifies all of Contractor's employees, sub-contractors and others under its management or supervision have been appropriately trained prior to reporting to work and that Contractor is in compliance with regulatory and utility safety and health requirements. Contractor certifies it has received and understood this hazard information.

Contractor Name

Signature

Printed Name

Title

Date

This information is provided in accordance with OSHA's information sharing provision under the 1926 Subpart V and 1910.269 regulations for electric generation, transmission & distribution regulations.