

Technical Specification for Start-up and Commissioning of New Products

Specification Number: 26 08 00.10

Product Name: Start-up and Commissioning of New Products

PART 1: GENERAL

1.01 OVERVIEW

1. As part of this project, start-up services will be performed on the electrical distribution and control equipment as specified. This specification is intended as a part of the electrical portion of this project.
2. The start-up service company must follow job site electrical safety requirements, installation standards and electrical testing standards per NEMA[®], ASTM[®], IEEE[®], ANSI[®] C2, OSHA[®], ANSI/NFPA[®] 70, ANSI/NFPA 70B, NFPA 70E, ANSI/NFPA 78, and ANSI/NFPA 101 guidelines.
3. Documentation of all procedures performed shall be provided. [] copies shall be provided and forwarded to the [owner] [engineer] [architect]. Written documentation must contain recorded test values of all electrical tests performed per the individual product specification.
4. Individual product start-up procedures must be submitted and on file with start-up service company office 10 days prior to the specified bid date.
5. Start up of panelboards, lighting transformers, safety switches, enclosed circuit breakers, and lighting contactors will not be part of this specification.
6. Start-up service scheduling must be available through a 24-hour, toll-free national dispatch system.
7. The start-up service company [shall][may] be present during energization of the primary distribution equipment. Job site and equipment access must be provided by the electrical contractor. De-energization of equipment, when required for testing, must be available within 15 minutes of the start-up service company arrival at the job site.
8. The [owner] [contractor] shall supply a power source, specified by the start-up service company, for on-site test equipment.
9. Start-up service shall be performed by [authorized employee(s) of the equipment manufacturer] [Square D[®]/Schneider Electric].

PART 2: PRODUCT -- INSPECTION AND TEST PROCEDURES

2.01 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES

1. Visual and Mechanical Inspection
 - (a) Equipment nameplate data shall be documented.
 - (b) Verify the presence of all the manufacturers intended Documentation.
 - (c) Inspect physical, electrical, and mechanical condition of switchboard/switchgear and all components.
 - (d) Confirm correct application of lubricants at manufacturer's recommended locations.
 - (e) Verify that fuse and/or circuit breaker sizes and types correspond to drawings and coordination study.
 - (f) Verify drawings for correct revision and date in accordance with customer and supplier records.
 - (g) Verify that current and potential transformer ratios correspond to drawings.
 - (h) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench.

- (i) Confirm correct operation and sequencing of electrical and mechanical interlock systems.
 - (j) Verify correct barrier and shutter installation and operation.
 - (k) Inspect all mechanical indicating devices for correct operation.
 - (l) Verify that filters are in place and/or vents are clear.
 - (m) Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.
2. Electrical Tests
 - (a) Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground.
 - (b) Perform secondary current injection tests on the entire current circuit in each section.
 - (c) Perform control wiring performance test.
 - (d) Determine accuracy of all {analog} meters.
 - (e) Perform phasing check on double-ended switchgear to insure correct bus phasing from each source.
 - (f) Verify correct function of control transfer relays located in switchgear with multiple power sources.
 - (g) Verify operation of switchgear/switchboard heaters.
 3. Optional Tests
 - Perform tests on all instrument transformers.
 - Perform insulation-resistance tests at 1000 Vdc on all control wiring.
 - Perform ground-resistance tests.
 - Perform a power frequency test (High Pot) on each bus section, each phase to ground.
 - Perform current tests by primary injection.
 - Perform electrical performance test on control power transformer circuits.
 - Perform electrical performance tests on potential transformer circuits.
 4. Test Value
 - (a) Bolt torque levels are checked in accordance with U.S. Standards or manufacturer's specifications.
 - (b) Insulation resistance testing is to be performed in accordance with the following guidelines:
 Minimum Voltage Rating Test Voltage
 250 V 500 Vdc
 6000 V 1000 Vdc
 5000 V 2500 Vdc
 39000 V 5000 Vdc
 - (c) Overpotential testing will not proceed until insulation resistance testing is completed.
 - (d) Overpotential test voltages are applied in accordance with the following guidelines*.

Test Voltage kV	Rated kVac	dc
5	14.3	20.2
15	27.0	37.5
25	45.0	+
35	60.0	+

 Final test voltages will be applied for one (1) minute.
 * Derived from ANSI/IEEE C37.20.2 and C37.20.3.
 + Consult manufacturer

2.02 CIRCUIT BREAKERS - MEDIUM VOLTAGE (VACUUM)

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Confirm correct application of lubricants at manufacturer's recommended locations.

- (e) Inspect anchorage, alignment, and grounding.
 - (f) Perform all mechanical operational tests on both the circuit breaker and its operating mechanism.
 - (g) Measure critical distances such as contact gap as recommended by manufacturer.
 - (h) Verify tightness of accessible bolted connections by calibrated torque-wrench method.
 - (i) Record as-found and as-left operation counter readings.
2. Electrical Tests
- (a) Perform a contact-resistance test in accordance with manufacturer's recommended procedure.
 - (b) Verify trip, close, trip-free, and anti-pump function.
 - (c) Perform minimum pick-up voltage test on trip and close coils.
 - (d) Trip circuit breaker by operation of each protective device.
 - (e) Perform insulation-resistance tests pole-to-pole, pole-to-ground, and across open poles.
 - (f) Perform vacuum bottle integrity (overpotential) test across each vacuum bottle with the circuit breaker in the open position in strict accordance with manufacturer's instructions.
 - (g) Perform power frequency withstand test in accordance with manufacturer's instructions.
3. Optional Testing
- Perform insulation-resistance test on all control wiring at 500 Vdc except on wiring connected to solid-state relays.
 - Perform circuit breaker travel and velocity analysis.
 - Perform minimum pickup voltage tests on trip and close coils.
 - Perform dissipation-factor/power-factor tests on each pole with the circuit breaker open and each phase with the circuit breaker closed.
 - Perform dissipation-factor/power-factor tests on each bushing.

2.03 CIRCUIT BREAKERS - MEDIUM VOLTAGE (SF6)

1. Visual and Mechanical Inspection
- (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Confirm correct application of lubricants at manufacturer's recommended locations.
 - (e) Inspect anchorage and grounding.
 - (f) Inspect and verify adjustments of mechanism in accordance with manufacturer's instructions.
 - (g) Check indicators for gas leaks in accordance with manufacturer's instructions.
 - (h) Verify correct operation of all air and SF₆ gas pressure switches, alarms and cutouts.
 - (i) Slow close/open circuit breaker and check for binding.
 - (j) Verify tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method.
 - (k) Record as-found and as-left counter operations.
2. Electrical Tests
- (a) Measure contact resistances in accordance with manufacturer's recommended procedures.
 - (b) Perform insulation-resistance tests pole-to-pole, pole-to-ground, and across open poles.
 - (c) Perform power frequency withstand test in accordance with manufacturer's instructions.
 - (d) Perform minimum pick-up voltage test on trip and close coils.
 - (e) Verify trip, close, trip-free, and anti-pump functions.
 - (f) Trip circuit breaker by operation of each protective device.

3. Optional Tests
 - [] Perform insulation-resistance test on all control wiring at 500 Vdc except on wiring connected to solid-state relays.
 - [] Perform time-travel analysis.
 - [] Perform dissipation-factor/power-factor tests on circuit breaker and bushings.

2.04 CIRCUIT BREAKERS - LOW VOLTAGE (POWER)

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Confirm correct application of lubricants at manufacturer's recommended locations.
 - (e) Inspect anchorage, alignment, and grounding.
 - (f) Inspect arc chutes.
 - (g) Verify that all maintenance devices are available for servicing and operating the circuit breaker.
 - (h) Perform all mechanical operator and contact alignment tests on both the circuit breaker and its operating mechanism.
 - (i) Verify tightness of accessible bolted bus connections by calibrated torque-wrench method.
 - (j) Check cell fit and element alignment.
 - (k) Check racking mechanism.
 - (l) Verify that the circuit breaker is equipped with the correct rating plugs and current sensors.
 - (m) Verify that the circuit breaker has the specified trip unit, LI, LIS, LISG, etc.
 - (n) Verify that the circuit breaker has the specified accessories, auxiliary contacts, cell switches, shunt trip devices, undervoltage release, and etc.
 - (o) Verify that the ground fault system has been wired in accordance with the specified wiring diagram and that the sensor grounds are either present or not present as specified.
 - (p) Verify that the secondary control plug/connections are in accordance with the wiring diagram and specifications.
2. Electrical Tests
 - (a) Perform a contact-resistance test in accordance with manufacturer's recommended procedure.
 - (b) Perform an insulation-resistance test at 1000 Vdc from pole-to-pole and from each pole-to-ground with circuit breaker closed and across open contacts of each phase.
 - (c) Make adjustments for the final settings in accordance with the coordination study supplied by owner.
 - (d) Determine the following using secondary current injection:
 - Minimum pickup current by
 - Long-time delay
 - Short-time pickup and delay
 - Ground-fault pickup and delay
 - Instantaneous pickup value
 - (e) Activate auxiliary protective devices such as undervoltage relays, to insure operation of shunt trip devices.
 - (f) Check the operation of electrically operated circuit breakers in their cubicles.
 - (g) Verify correct operation of any auxiliary features such as trip and pickup indicator, electrical close and trip operation, trip-free, and anti-pump function.
 - (h) Check electric charging mechanism, if applicable.
3. Optional Testing
 - [] Perform an insulation-resistance test at 500 Vdc on all control wiring except on wiring connected to solid state components.

- [] Determine the following using primary current injection:
 - Minimum pickup current
 - Long-time delay
 - Short-time pickup and delay
 - Ground-fault pickup and delay
 - Instantaneous pickup value

2.05 CIRCUIT BREAKERS - LOW VOLTAGE (MOLDED CASE/INSULATED CASE)

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect circuit breaker for correct mounting.
 - (d) Operate circuit breaker to insure smooth operation.
 - (e) Inspect case for cracks or other defects.
 - (f) Verify tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method.
 - (g) Verify that trip units, shunt trip coils, auxiliary contacts and all other accessories are in accordance with the job specifications.
2. Electrical Tests
 - (a) Perform a contact-resistance test in accordance with manufacturer's recommended procedure.
 - (b) Perform an insulation-resistance test at 1000 Vdc from pole-to-pole and from each pole-to-ground with circuit breaker closed and across open contacts of each phase.
 - (c) Perform adjustments for final settings in accordance with coordination study supplied by owner, if available.
 - (d) Verify correct operation of any auxiliary features such as trip and pickup indicators, electrical close and trip operation, trip-free, and anti-pump function.
 - (e) Verify the calibration of all functions of the trip unit by means of secondary injection.
3. Optional Tests
 - [] Perform insulation-resistance tests at 1000 Vdc on all control wiring except wiring connected to solid-state components.
 - [] Perform long-time delay time-current characteristic tests by passing 300% rated current through each pole separately unless series testing is required to defeat ground fault functions.
 - [] Determine short-time pickup and delay by primary current injection.
 - [] Determine ground-fault pickup and time delay by primary current injection.
 - [] Determine instantaneous pickup current by primary injection using run-up or pulse method.

2.06 AIR SWITCHES - LOW VOLTAGE (BOLTED PRESSURE, QMB, OR EQUAL)

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Confirm correct application of lubricants at manufacturer's recommended locations.
 - (e) Verify appropriate anchorage and required area clearances.
 - (f) Verify appropriate equipment grounding.
 - (g) Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
 - (h) Verify and record fuse sizes and types are in accordance with drawings and short-circuit and coordination studies, if available.
 - (i) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

- (j) Check all interlocking systems for correct operation and sequencing, and key distribution, if applicable.
 - (k) Verify correct phase barrier materials and installation.
 - (l) Inspect all indicating and control devices for correct operation.
2. Electrical Tests
- (a) Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground with switch closed and across each open pole for one minute.
 - (b) Switches equipped with solenoid trip, blown main fuse detector, etc, test each feature for proper operation To test blown fuse detector, activate it and confirm by attempting to close the circuit breaker without reset.
 - (c) Square D/Schneider Electric BP switches:
 - (d) Perform Blade Contact Resistance Test with the device de-energized, operate the device closed and open several times using either manual or electrical means. Apply a minimum current of 100 A dc through the closed contacts. Measure the contact resistance of each pole and compare with the following values:
- | <u>BP Switch Rating</u> | <u>Resistance (Maximum)</u> |
|-------------------------|-----------------------------|
| 800 A | 13 Micro-Ohms |
| 1200 A | 13 Micro-Ohms |
| 1600 A | 11 Micro-Ohms |
| 2000 A | 8 Micro-Ohms |
| 2500 A | 7 Micro-Ohms |
| 3000 A | 6 Micro-Ohms |
| 4000 A | 7 Micro-Ohms |

2.07 AIR SWITCHES - MEDIUM VOLTAGE (METAL ENCLOSED)

- 1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Confirm correct application of lubricants at manufacturer's recommended locations.
 - (e) Verify appropriate anchorage and required area clearances.
 - (f) Verify appropriate equipment grounding.
 - (g) Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
 - (h) Verify that fuse sizes and types are in accordance with drawings and short-circuit and coordination studies, if available.
 - (i) Verify that expulsion-limiting devices are in place on all holders having expulsion-type elements.
 - (j) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - (k) Check all interlocking systems for correct operation and sequencing, and key distribution, if applicable.
 - (l) Verify correct phase-barrier materials and installation.
 - (m) Inspect all indicating and control devices for correct operation.
 - (n) Verify that the lightning arresters have been connected.
- 2. Electrical Tests
 - (a) Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground with switch closed and across each open pole for one minute.
 - (b) Perform a power frequency test (High Pot) on each pole with switch closed.
 - (c) Verify heater operation.
 - (d) Perform a contact-resistance test for HVL/cc and VISI-VAC® devices manufactured by Square D/Schneider Electric. Use the following procedure:
 - (e) With the device de-energized, operate the device closed and open several time using either manual or electrical means. Apply a minimum current of 100 A dc through the closed contacts.

- (f) Measure the contact resistance of each pole and compare with the following values:
VISI-VAC: 85 Micro-Ohms
HVL/cc: 75 Micro-Ohms

2.08 AIR SWITCHES - HIGH AND MEDIUM VOLTAGE (OPEN STYLE)

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Confirm correct application of lubricants at manufacturer's recommended locations.
 - (e) Verify that grounding is in accordance with industry standards and project specifications.
 - (f) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - (g) Perform mechanical operator tests in accordance with manufacturer's instructions.
 - (h) Verify correct operation and adjustment of motor operator limit-switches and mechanical interlocks.
 - (i) Verify correct blade alignment, blade penetration, travel stops, arc interrupter operation, and mechanical operation.
2. Electrical Tests
 - (a) Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground with switch closed and across each open pole for one minute.
 - (b) Perform a power frequency test (High Pot) on each pole with switch closed.
 - (c) Perform contact-resistance test across each switchblade and fuse holder.

2.09 ANALOG METERING

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Verify tightness of electrical connections.
 - (e) Inspect cover gasket, cover glass, condition of spiral spring, disc clearance, contacts, and case-shorting contacts, as applicable.
 - (f) Verify mechanically for freedom of movement, correct travel and alignment, and tightness of mounting hardware.
2. Electrical Tests
 - (a) Check calibration of meters at all cardinal points.
 - (b) Electrically confirm that current transformer and voltage transformer secondary circuits are intact.
3. Optional Tests
 - [] Calibrate watt-hour meters according to manufacturer's published data.
 - [] Verify all instrument multipliers.

2.10 BUSWAY - METAL ENCLOSED

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify busway nameplate ratings in accordance with customer drawings and specifications.
 - (c) Inspect busway for physical damage and correct connection in accordance with single-line diagram.

- (d) Inspect for appropriate bracing, suspension, alignment, and enclosure ground.
 - (e) Verify tightness of accessible bolted electrical connections by confirming that the outer head has been broken off and check torque to 70 lb-ft +/- 10 lb-ft (95 N•m +/- 13.5 N•m). Verify the removal of the red plastic disk (VISI-TITE®) at each bus joint that should automatically occur when the head is broken off.
 - (f) Confirm physical orientation in accordance with manufacturer's labels to insure adequate cooling.
 - (g) Examine outdoor busway for removal of "weep-hole" plugs, if applicable, and the correct installation of joint shield.
 - (h) Visually confirm correct phasing on each busway tie section energized by separate sources. (De-energized)
2. Electrical Tests
 - (a) Measure insulation resistance of each busway, phase-to-phase and phase-to-ground for one minute.
 3. Optional Tests
 - [] Perform contact-resistance test on each connection point of noninsulated busway. On insulated busway, perform contact resistance of assembled busway sections and compare values with adjacent phases on insulated busway.
 - [] Perform a power frequency test (High Pot) on each busway, phase-to-ground.

2.11 CABLES - LOW VOLTAGE (600 VOLTS MAXIMUM)

1. Visual and Mechanical Inspection
 - (a) Verify cable sizing and insulation temperature rating in accordance with customer's drawings.
 - (b) Inspect exposed sections of cables for physical damage and correct connection in accordance with single-line diagrams.
 - (c) Verify tightness of accessible bolted connections by calibrated torque wrench.
 - (d) Inspect compression-applied connectors for correct cable match and indentation.
 - (e) Verify cable color coding with applicable engineer's specifications.
2. Electrical Tests
 - (a) Test cables and leads for continuity to ensure correct cable connection and phasing rotation.
 - (b) Perform an insulation resistance test on each conductor between one conductor and ground with the other conductors grounded.
 - (c) Each 480 V feeder cable shall be tested with the cable connected to the racked-in but open circuit breaker at the equipment. Connection at the other end of each of these cables shall be as follows:
 - Cables to motor control centers shall be connected to the bus with the switches or circuit breakers in the starters open.
 - Cables to motors and other equipment shall be connected to the motors and equipment with feeder switches open.

2.12 DIRECT CURRENT SYSTEMS: BATTERIES

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - (e) Measure electrolyte specific gravity and temperature and visually check fill level.
 - (f) Verify adequacy of battery support racks, mounting, anchorage, and clearances.

- (g) Verify ventilation of battery room or enclosure.
- (h) Verify existence of suitable eyewash equipment.
- 2. Electrical Tests
 - (a) Verify all charger functions and alarms.
 - (b) Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
- 3. Optional Tests
 - [] Verify presence of flame arresters.
 - [] Set charger float and equalizing voltage levels.
 - [] Perform a capacity load test in accordance with manufacturer's specifications and ANSI/IEEE standards.

2.13 VARIABLE FREQUENCY DRIVES - AC

- 1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect controller for physical and mechanical condition.
 - (d) Inspect for proper grounding.
 - (e) Check customer cables, power wiring, and control wiring to insure correct installation.
 - (f) Check for proper heaters used in ISO/bypass unit.
 - (g) Check transformer taps for proper connection.
 - (h) Check all terminal wiring.
 - (i) Verify motor and drive sizing.
- 2. Electrical Test
 - (a) Verify the proper selection and operation of the electrical test equipment and record the date of the last calibration date and the date due re-calibration.
 - (b) Verify input voltages.
 - (c) Verify all transformer output voltages.
 - (d) Test all pilot devices, e.g., lights, speed pots, meters.
 - (e) Check D.I.P. switches for proper setup.
 - (f) Calibrate max speed.
 - (g) Setup acceleration and deceleration potentiometers to application.
 - (h) Setup hand minimum speed.
 - (i) Calibrate all meters.
 - (j) Align drive to customer's automatic control signal.
 - (k) Verify proper connection of alarm, smoke detectors, and remote devices.
 - (l) Check for proper motor rotation.
 - (m) Setup all option cards.
 - (n) Operate drive at all allowable speed and load conditions.
 - (o) Confirm ISO/bypass unit operation.

2.14 GROUNDING SYSTEMS

- 1. Visual and Mechanical Inspection
 - (a) Verify ground system is in compliance with drawings and specifications.
- 2. Electrical Tests
 - (a) Verify the proper selection and operation of the electrical test equipment and record the date of the last calibration date and the date due re-calibration.
 - (b) Perform fall-of-potential test or alternative in accordance with IEEE Standard 81-1991 on the main grounding electrode or system.
 - (c) 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.

2.15 GROUND FAULT PROTECTION SYSTEMS

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Visually inspect the components for damage and errors in polarity or conductor routing.
 - (d) Verify that ground connection is made ahead of neutral disconnect link and on the line side of any ground fault sensor.
 - (e) Verify that neutral sensors are connected with correct polarity on both primary and secondary.
 - (f) Verify that all phase conductors and the neutral pass through the sensor in the same direction for zero sequence systems.
 - (g) Verify that grounding conductors do not pass through zero sequence sensors.
 - (h) Verify that the grounded conductor (usually neutral) is bonded to ground in accordance with the power system specifications.
 - (i) Verify tightness of all electrical connections including control circuits.
 - (j) Verify correct operation of all functions of the self-test panel.
 - (k) Verify that the control power transformer has adequate capacity for the system.
 - (l) Set pickup and time-delay settings in accordance with the settings provided in the owner's specifications.
2. Electrical Tests
 - (a) Perform the following pickup tests using primary injection.
 - (b) Verify that the relay does not operate at 90% of the pickup setting.
 - (c) Verify pickup is less than 125% of setting or 1200 A, whichever is smaller.
 - (d) For summation type systems utilizing phase and neutral current transformers, verify correct polarities by applying current to each phase-neutral current transformer pair.
 - (e) Relay should operate when current direction is the same relative to polarity marks in the two current transformers.
 - (f) Relay should not operate when current direction is opposite relative to polarity marks in the two current transformers.
 - (g) Measure time delay of the relay at 150% or greater of pickup. Verify operability of I^2t function, if being used, of ground fault trip device.
 - (h) Verify reduced control voltage tripping capability: 55% for ac systems and 80% for dc systems.
 - (i) Verify blocking capability of zone interlock systems.
3. Optional Tests
 - [] Measure insulation resistance of the control wiring at 500 Vdc for one minute.

2.16 INSTRUMENT TRANSFORMERS - CURRENT TRANSFORMERS

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Verify correct connection of transformers with system requirements.
 - (e) Verify that adequate clearances exist between primary and secondary circuit wiring.
 - (f) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - (g) Verify that all required grounding and shorting connections provide contact.
 - (h) Verify that all shorting blocks are in the correct position, either grounding or open, as required.
 - (i) Verify correct operation of transformer withdrawal mechanism and grounding operation.
 - (j) Verify correct primary and secondary fuse sizes for potential transformers.
2. Electrical Tests - Current Transformers

- (a) Perform insulation-resistance test of the current transformer and wiring-to-ground at 500 Vdc.
 - (b) Perform a polarity test of each current transformer.
 - (c) Perform a ratio-verification test using the voltage or current method in accordance with ANSI C5XVIII.1.
3. Optional Tests – Current Transformers
- [] Perform an excitation test on transformers used for relaying applications in accordance with ANSI C5XVIII.1.
 - [] Measure current circuit burdens at transformer terminals and determine the total burden.
 - [] When applicable, perform insulation-resistance and dielectric withstand tests on the primary winding with secondary grounded.

2.17 INSTRUMENT TRANSFORMERS - POTENTIAL TRANSFORMERS

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Verify correct connection of transformers with system requirements.
 - (e) Verify that adequate clearances exist between primary and secondary circuit wiring.
 - (f) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - (g) Verify that all required grounding and shorting connections provide contact.
 - (h) Verify that all shorting blocks are in the correct position, either grounding or open, as required.
 - (i) Verify correct operation of transformer withdrawal mechanism and grounding operation.
 - (j) Verify correct primary and secondary fuse sizes for potential transformers.
2. Electrical Tests
 - (a) Perform insulation-resistance tests winding-to-winding and each winding-to-ground.
 - (b) Perform a polarity test on each transformer to verify the polarity marks or H1-X1 relationship as applicable.
3. Optional Tests
 - [] Measure potential circuit burdens at transformer terminals and determine the total burden.
 - [] Perform a dielectric withstand test on the primary windings with the secondary windings connected to ground.

2.18 MOTOR CONTROL CENTERS: LOW AND MEDIUM VOLTAGE

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical, electrical, and mechanical condition.
 - (d) Confirm correct application of lubricants at manufacturer's recommended locations.
 - (e) Verify appropriate anchorage, required area clearances, physical damage, and correct alignment and cleanliness.
 - (f) Verify that fuse and/or circuit breaker sizes and types correspond to drawings and coordination study, if available, as well as to the circuit breaker's address for microprocessor-communication packages.
 - (g) Verify that current and potential transformer ratios correspond to drawings.
 - (h) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

- (i) Confirm correct operation and sequencing of electrical and mechanical interlock systems.
 - (j) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
 - (k) Make key exchange with devices operated in off-normal positions.
 - (l) Inspect insulators for evidence of physical damage or contaminated surfaces.
 - (m) Verify correct barrier and shutter installation and operation.
 - (n) Exercise all active components.
 - (o) Verify that filters are in place and/or vents are clear.
 - (p) Test operation, alignment, and penetration of instrument transformer withdrawal disconnects, current carrying and grounding.
 - (q) Inspect control power transformers.
 - (r) Inspect physical damage, cracked insulation, broken leads, tightness of connections, defective wiring and overall general condition.
 - (s) Verify that primary and secondary fuse ratings or circuit breakers match drawings.
2. Electrical Tests
- (a) Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground at the minimum dc Test voltage appropriate for the equipment.
 - (b) Perform control wiring performance test.
 - (c) Verify operation of motor control center (MCC) heaters.
 - (d) Determine accuracy of all meters.
3. Optional Tests
- Perform insulation-resistance tests at 500 Vdc on all control wiring except on wiring connected to solid-state components.
 - Perform tests on all instrument transformers.
 - Perform the following tests on control power transformers:
 - Perform insulation-resistance tests.
 - Perform secondary wiring integrity test.
 - Verify correct secondary voltage by energizing primary winding with system voltage.
 - Perform the following tests on potential transformers:
 - Perform secondary wiring integrity test.
 - Verify secondary voltage by energizing primary winding with system voltage.
 - Perform a power frequency test (High Pot) on each bus section, each phase to ground with phases not under test grounded.
 - Perform ground-resistance tests.

2.19 MOTOR STARTERS - LOW VOLTAGE

1. Visual and Mechanical Inspection
- (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications. This to include: contactor, fuses, overloads, circuit breakers, overload relay heaters power factor correction capacitors and control power transformer.
 - (c) Inspect physical and mechanical condition.
 - (d) Motor-Running Protection:
 - Compare overload element rating with motor full-load current rating to verify correct sizing.
 - If power-factor correction capacitors are connected on the load side of the overload protection, include the effect of the capacitive reactance in determining appropriate overload element size.
 - If fuses provide motor-running protection, verify correct rating considering motor characteristics and power-factor correction capacitors, if applicable.
 - (e) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

2. Electrical Tests
 - (a) Verify the proper selection and operation of the electrical test equipment and record the date of the last calibration date and the date due re-calibration.
 - (b) Measure insulation resistance of each combination starter, phase-to-phase and phase-to-ground, with the starter contacts closed and the protective device open.
 - (c) Perform operational tests by initiating control devices.
3. Optional Tests
 - Measure insulation resistance of each control circuit-to-ground.
 - Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
 - Test circuit breakers in accordance with specified procedures.

2.20 MOTOR STARTERS - MEDIUM VOLTAGE

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical, electrical, and mechanical condition.
 - (d) Confirm correct application of lubricants at manufacturer's recommended locations.
 - (e) Test all electrical and mechanical interlock systems for correct operation and sequencing.
 - (f) Inspect insulators for evidence of damage or contaminated surfaces.
 - (g) Verify correct barrier and shutter installation and operation.
 - (h) Exercise all active components and confirm correct operation of all indicating devices.
 - (i) Inspect and adjust contact gap, wipe and alignment in accordance with manufacturer's published data.
 - (j) Verify tightness of all connections by using calibrated torque wrench method.
 - (k) Compare overload protection rating with motor nameplate to verify correct size. Set adjustable or programmable devices according to the protective device coordination study, if available.
2. Electrical Tests
 - (a) Verify the proper selection and operation of the electrical test equipment and record the date of the last calibration date and the date due re-calibration.
 - (b) Perform control wiring performance test. Use the elementary diagrams to identify each remote control and protective device. Verify satisfactory performance of each control feature.
 - (c) Perform insulation-resistance tests on contactor, phase-to-ground, phase-to-phase, and across the open contacts for one minute.
 - (d) Perform vacuum bottle integrity test (overpotential), if applicable, across each vacuum bottle with the contacts in the open position.
 - (e) Test ground-fault protection by injecting primary current through sensor. Confirm pickup level and timing.
 - (f) Perform setup and testing on protective relaying in accordance with manufacturer's published data.
 - (g) Verify operation of cubicle space heater.
3. Optional Tests
 - Perform insulation-resistance test at 500 Vdc on control wiring.
 - Perform ratio and polarity tests on all current and voltage transformers.
 - Test control power transformers.
 - Energize contactor using an auxiliary source. Adjust armature to minimize operating vibration where applicable.
 - Test circuit breakers.
 - Perform an overpotential test. The test voltage shall be applied for one minute.

2.21 OIL SWITCHES - MEDIUM VOLTAGE

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Inspect anchorage, alignment, and grounding.
 - (e) Perform all mechanical operation and contact alignment tests on both the switch and its operating mechanism.
 - (f) Test all electrical and mechanical interlock systems for correct operation and sequencing.
 - (g) Verify tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method.
 - (h) Verify that insulating oil level is correct.
2. Electrical Tests
 - (a) Remove a sample of insulating liquid in accordance with ASTM D-923. Sample shall be tested for the following:
 - Dielectric breakdown voltage: ASTM D-877.
 - Color: ASTM D-1500.
 - Visual condition: ASTM D-1524.
 - (b) Perform insulation-resistance tests pole-to-pole, pole-to-ground, and across open poles for one minute.
3. Optional Tests
 - [] Perform insulation-resistance tests at 1000 Vdc on all control wiring except wiring connected to solid-state components.

2.22 PROTECTIVE RELAYS

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect relays and cases for physical damage. If appropriate, remove shipping restraint material. Relay inspections and testing shall be performed in strict compliance with the manufacturer instructions.
 - (d) Tighten case connections.
 - (e) Inspect cover for correct gasket seal.
 - (f) Clean cover glass.
 - (g) Inspect shorting hardware, connection paddles, and/or knife switches. Remove any foreign material from the case.
 - (h) Verify target reset.
 - (i) Inspect relay for foreign material, particularly in disc slots of the damping and electromagnets.
 - (j) Verify disk clearance. Inspect disk and contacts for freedom of movement and correct travel.
 - (k) Inspect spiral spring convolutions. Verify tightness of mounting hardware and connections.
 - (l) Mechanically test the operation of relays.
 - (m) Set relays in accordance with coordination study supplied by owner, if available.
2. Electrical Tests
 - (a) Perform insulation-resistance test on each circuit-to-frame. Determine from the manufacturer's instructions the allowable procedures for this test for solid-state and microprocessor-based relays.
 - (b) Inspect targets and indicators.
 - (c) Determine pickup and dropout of electromechanical targets.
 - (d) Verify operation of all light-emitting diode indicators.
 - (e) Set contrast for liquid-crystal display readouts.

- (f) Control Verification
 - Verify that each of the relay contacts performs its intended function in the control scheme including circuit breaker trip tests, close inhibit tests, 86 lockout tests, and alarm functions.
- 3. Optional Tests
 - [] System Test: After the equipment is initially energized, measure magnitude and phase angle of all inputs and compare to expected values.

2.23 STEP VOLTAGE REGULATORS

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Inspect impact recorder prior to unloading regulator, if applicable.
 - (e) Verify removal of any shipping bracing and vent plugs after final placement.
 - (f) Verify auxiliary device operation.
 - (g) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - (h) Verify motor and drive train for correct operation and automatic motor cut-off at maximum lower and maximum raise.
 - (i) Verify appropriate liquid level in all tanks and bushings.
 - (j) Verify equipment grounding.
2. Electrical Tests
 - (a) Verify the proper selection and operation of the electrical test equipment and record the date of the last calibration date and the date due re-calibration.
 - (b) Perform insulation-resistance tests on each winding-to-ground in the neutral position.
 - (c) Perform special tests and adjustments as recommended by manufacturer.
 - (d) Perform turns ratio test on each voltage step position. Verify that the indicator correctly identifies all tap positions.
 - (e) Verify accurate operation of voltage range limiter.
 - (f) Verify functioning and accuracy of bandwidth, time delay, voltage and line-drop compensation adjustments.
 - (g) Remove a sample of insulating liquid in the main tank or common tank in accordance with ASTM D-923. Sample shall be tested for the following:
 - Dielectric breakdown voltage: ASTM D-877 and/or ASTM D-1816.
 - Acid neutralization number: ASTM D-974.
 - Specific gravity: ASTM D-1298.
 - Interfacial tension: ASTM D-971 or ASTM D-2285.
 - Color: ASTM D-1500.
 - Visual condition: ASTM D-1524.
 - (h) Remove a sample of insulating liquid in the tap-changer tank in accordance with ASTM D-923. Sample shall be tested for the following:
 - Dielectric breakdown voltage: ASTM D-877.
 - Color: ASTM D-1500.
 - Visual condition: ASTM D-1524.

2.24 SURGE PROTECTION DEVICES - LOW VOLTAGE

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Inspect for correct mounting and adequate clearances.
 - (e) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

- (f) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

2.25 SURGE PROTECTION DEVICES - HIGH AND MEDIUM VOLTAGE

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify equipment nameplate ratings are in accordance with the customer's drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Inspect for correct mounting and adequate clearances.
 - (e) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - (f) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
 - (g) Verify that stroke counter, if present, is correctly mounted and electrically connected.

2.26 TRANSFORMERS - SMALL DRY TYPE (167KVA SINGLE PHASE, 500KVA THREE PHASE, AND SMALLER)

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify Transformer nameplate ratings in accordance with customer drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Verify that resilient mounts are free and that any shipping brackets have been removed.
2. Electrical Tests
 - (a) Perform insulation-resistance test from winding-to-winding and each winding-to-ground.
 - (b) Calculate polarization index.
 - (c) Verify that winding turns-ratio measurements and polarities are in accordance with nameplate.
 - (d) Verify that as-left tap connections are as specified.

2.27 TRANSFORMERS - LARGE DRY TYPE (GREATER THAN 167KVA SINGLE PHASE AND 500KVA THREE PHASE)

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify transformer nameplate ratings in accordance with customer drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Verify that control and alarm settings on temperature indicators are as specified.
 - (e) Verify that cooling fans operate correctly and that fan motors have correct overcurrent protection.
 - (f) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - (g) Verify that shipping brackets or fixtures have been removed.
 - (h) Insure that resilient mounts are free.
 - (i) Verify that winding core, frame, and enclosure groundings are correct.
 - (j) Verify that as-left tap connections are as specified.
2. Electrical Tests
 - (a) Perform insulation-resistance tests winding-to-winding and each winding-to-ground.
 - (b) Calculate polarization index.
 - (c) Perform a turns-ratio test on all tap connections. Verify that winding polarities are in accordance with nameplate.

- (d) Verify that core is solidly grounded.
- 3. Optional Tests
 - For 5 kV and above, perform power-factor or dissipation-factor (excitation-current) tests.
 - Measure the resistance of each winding at each tap connection.

2.28 TRANSFORMERS - LIQUID FILLED

1. Visual and Mechanical Inspection
 - (a) Document equipment nameplate data on test report.
 - (b) Verify transformer nameplate ratings in accordance with customer drawings and specifications.
 - (c) Inspect physical and mechanical condition.
 - (d) Inspect impact recorder prior to unloading, if applicable.
 - (e) Verify that alarm, control, and trip settings on temperature indicators are as specified.
 - (f) Verify that cooling fans and pumps operate correctly and that fan and pump motors have correct overcurrent protection.
 - (g) Verify operation of all alarm, control, and trip circuits from temperature and level indicators, pressure relief device, and fault pressure relay.
 - (h) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench.
 - (i) Verify correct liquid level in all tanks and bushings.
 - (j) Verify that positive pressure is maintained on nitrogen-blanketed transformers.
 - (k) Verify correct equipment grounding.
 - (l) Test load tap-changer.
2. Electrical Tests
 - (a) Perform insulation-resistance tests, winding-to-winding and each winding-to-ground.
 - (b) Calculate polarization index.
 - (c) Perform a turns-ratio test on all no-load tap-changer positions and all load tap-changer positions. Verify that tap setting is as specified. Verify that winding polarities are in accordance with nameplate.
3. Optional Tests
 - Perform insulation power-factor/dissipation-factor tests on all windings and correct to 20 °C.
 - Perform power-factor/dissipation-factor tests (or hot collar watts-loss tests) on bushings and correct for 20 °C.
 - Perform excitation-current tests.
 - Measure resistance of each high-voltage winding in each no-load tap-changer position. Measure resistance of each low-voltage winding in each load tap-changer position, if applicable.
 - Remove a sample of insulating liquid in accordance with ASTM D-923 and be test for the following:
 - Dielectric breakdown voltage: ASTM D-877 and/or ASTM D-1816.
 - Acid neutralization number: ASTM D-974.
 - Specific gravity: ASTM D-1298.
 - Interfacial tension: ASTM D-971 or ASTM D-2285.
 - Color: ASTM D-1500.
 - Visual Condition: ASTM D-1524.
 - Parts per million water: ASTM D-1533. Required on 25 kV or higher voltages and on all silicone-filled units.
 - Measure dissipation factor or power factor in accordance with ASTM D-924.
 - Remove a sample of insulating liquid in accordance with ASTM D-3613 and perform dissolved gas analysis (DGA) in accordance with ANSI/IEEE C5XVI4 or ASTM D-3612.