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Work consists of complete preventive maintenance, repair, and replacement to include installation services as needed for electrical engineering testing services for all Pinellas County Utilities switchgear, automatic transfer switch (ATS), switchboard, and low voltage power circuit breakers maintenance, testing and calibration throughout Pinellas County. All repairs and adjustments must be made per National Electrical Testing Association (NETA) Acceptance / Maintenance and/or Project testing. Replacement of equipment shall be upon approval by the County representative prior to replacement.

For purposes of this Bid, "Owner" refers to Pinellas County Utilities (PCU) to include S.K. Keller Water Treatment Plant, William E. Dunn Water Reclamation Facility and South Cross Bayou Advanced Water Reclamation Facility.

A. **Purpose:**
Pinellas County Utilities seeks to obtain the services of a contractor to perform complete preventive maintenance and repair for electrical engineering testing services for all Pinellas County Utilities switchgear, automatic transfer switch (ATS), switchboard, and low voltage power circuit breakers maintenance, testing and calibration throughout Pinellas County. All repairs and adjustments must be made per National Electrical Testing Association (NETA) Acceptance / Maintenance and/or Project testing.

B. **Low-Voltage Power Circuit Breakers Maintenance and Testing Guideline Requirements. Report serious deficiencies immediately to the responsible PCU contact:**

a. Low-voltage power circuit breakers, covered by this scope of work, are comprised of various brands and types of circuit breakers installed at all areas of Pinellas County Utilities.

b. Always verify that no voltage is present before proceeding with testing. Assume all circuits are energized. Confirm primary sources of power are disconnected, tagged, and locked out. Always follow all local, state, and national regulations including Occupational Safety and Health Administration (OSHA) requirements and generally accepted safety procedures.

c. Contractor shall be responsible for all necessary equipment which shall include but not limited to:
   i. Project folder or notebook
   ii. Standard breaker accessories and maintenance tools
   iii. Approved lifting device
   iv. Low resistance digital ohmmeter 100 amp
   v. Personal protective equipment (PPE) to include arc flash
   vi. Insulation resistance tester set 1000 Volts Direct Current (VDC) minimum
   vii. AC high potential test set 60Hz
   viii. Root Mean Square (RMS) Multimeter
   ix. Secondary injection tester set Trip unit test set adaptor
   x. Primary Injection Tester as required.
   xi. Auxiliary power module
   xii. Specimen grounding jumpers
   xiii. Control power source
   xiv. Site safety rules and emergency procedures
   xv. Portable generator (if required)
   xvi. Lighting needed for inside switchgear
   xvii. Vacuum for cleaning

d. Prior to testing the contractor shall provide:
   i. Switchgear drawings associated with the device being tested
   ii. Instruction books
   iii. Schematic and wiring diagrams associated with the circuit breaker being tested.
   iv. Power-Test data forms
   v. Power system studies
   vi. Safe working procedures and Safety Data Sheet (SDS) forms that apply to this task
   vii. Site safety rules and emergency procedures

e. Contractor shall Verify:
   i. The device nameplate information is compatible with the switchgear drawings
   ii. Sensor Current Transfer (CT) polarity marking
   iii. Suitability and calibration dates of test equipment

f. Contractor shall record on the power-test form:
   i. Customer and job information
   ii. General order, item, and sequence number
   iii. Field data
      a) Rating (voltage, current, control voltage, and interrupting rating)
      b) Limiter information (when mounted)
      c) Trip unit information
      d) Trip settings - As Found
      e) Sensor tap range and tap setting
      f) Rating plug value

g. Counter – as found
   iv. As found conditions in the comment area
   v. Test equipment data
   vi. Service engineer/technician name

3. <u>Low- voltage maintenance and test procedures: report serious deficiencies immediately to the responsible PCU contact:</u>

a. Contractor shall examine breaker for:
   i. Loose or obviously damaged components
   ii. Application with the cell
   iii. Compliance to drawings

b. Contractor shall with breaker open, Inspect and make corrections as needed:
   i. Primary leads, insulators, current transformer mounting and terminations, and secondary disconnects
   ii. Trip unit mounting and connectors
   iii. Frame condition
   iv. Mechanical and safety interlocks
   v. Ground contact

c. Contractor shall verify the manual operation of the breaker:
   i. Charge closing spring using manual charge handle
   ii. Close breaker manually
   iii. Trip breaker manually

d. Contractor shall inspect and make corrections as needed arc chutes:
   i. Remove arc chutes
   ii. Inspect clean and make corrections as needed for cracks and defects
   iii. Set arc chutes aside

e. Contractor shall with the breaker closed:
   i. Inspect and make corrections as needed on main contact over travel
   ii. Inspect and make corrections as needed arcing contact engagement
   iii. Measure contact resistance
   iv. Measure limiter resistance
   v. Perform “CLOSED” portions of the insulation resistance test
   vi. Open breaker

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f. Contractor shall with the breaker open:
   i. Inspect and make corrections as needed on the condition of the main and arcing contacts
   ii. Inspect and make corrections as needed on insulating links/push rods and inter phase barriers for cracks and defects
   iii. Install arc chutes

g. Contractor shall with the breaker removed:
   i. Perform control wiring insulation resistance at 500 volts Direct Current (DC). Do not perform this test on wiring connected to solid state components without consulting the trip unit instruction book.
   ii. Clean, lubricate, adjust as needed and verify the proper operation of all breaker/cell accessories, auxiliary switches, cell Maintenance of Certification (MOC) and Table of Content (TOC) switches, and key interlocks
   iii. Clean, lubricate, adjust as needed and verify the proper operation of all breaker /cell safety interlocks:
   iv. Closed breaker insertion/withdrawal interlock
   v. Stored energy removal interlock
   vi. Breaker/cell rating code interlock
   vii. All other devices
   viii. Inspect and make corrections as needed on all grounding connections for cleanliness torque and alignment
   ix. Inspect and make corrections as needed on neutral current transformer (CT), connections, and mounting.
      a) Verify that all accessible moving components are adequately lubricated
      b) Verify proper operation of all status indicators.

h. Contractor shall preform functional tests with breaker in cell:
   i. Verify control power for close and trip functions prior to racking breaker into cell
   ii. Verify the electrical operation of each breaker
   iii. Perform trip/close and anti-pump tests
   iv. Verify operation of the breaker from all local and remote-control switches or terminal blocks
   v. Close and open the breaker from each controllable device in the circuit
   vi. Confirm if this test must be performed with the breaker in the “Test Position”
   vii. Verify the proper operation of any automatic or remote-control schemes, protective relays, and lock-out (86) devices which are integral to the breaker control circuit

i. Contractor shall with the Breaker removed:
   i. Clean, lubricate, adjust as needed and verify the proper operation of all breaker/cell accessories, auxiliary switches, cell MOC and TOC switches, and key interlocks
   ii. Clean, lubricate, adjust as needed and verify the proper operation of all breaker /cell safety interlocks:
   iii. Closed breaker insertion/withdrawal interlock
   iv. Stored energy removal interlock
   v. Breaker/cell rating code interlock
   vi. All other devices
   vii. Inspect and make corrections as needed on all grounding connections for cleanliness torque and alignment
   viii. Inspect and make corrections as needed on neutral CT, connections, and mounting

j. Contractor shall preform functional tests with breaker in cell:
   i. Verify control power for close and trip functions prior to racking breaker into cell
   ii. Verify the electrical operation of each breaker
   iii. Perform trip/close and anti-pump tests
   iv. Verify operation of the breaker from all local and remote-control switches or terminal blocks
   v. Close and open the breaker from each controllable device in the circuit
   vi. Confirm if this test must be performed with the breaker in the “Test Position”
   vii. Verify the proper operation of any automatic or remote-control schemes, protective relays, and lock-out (86) devices which are integral to the breaker control circuit

k. Contractor shall trip unit tests verify:
   i. The device nameplate information is compatible with the switchgear drawings
   ii. Suitability and calibration dates of test equipment
   iii. Examine trip unit for:
      a. Physical damage
      b. Loose or obviously damaged components
      c. Verify the settings for the trip unit in accordance with the coordination study supplied by the owner
      d. Check status of rating plug mounted battery
   iv. Verify the calibration of all functions of the trip unit by means of secondary current injection
   v. Test and record long - time pick up and delay
   vi. Test and record short – time pick up and delay
   vii. Test and record instantaneous pick up
   viii. Test and record ground - fault pick up and delay
   ix. Reset trip flags and restore all settings changed during testing

l. After testing the contractor shall:
   i. Record as left trip unit settings and compare to as found settings or coordination study settings
   ii. Record counter as left value
   iii. Finish recording data on the Power-Test data form, completely filling in all the appropriate blocks
   iv. Apply a test sticker to the equipment
   v. Remove and account for all test equipment, jumper wires, and tools used during testing
   vi. Reinstall all barriers and covers, close all doors, and secure all latches
   vii. Review and organize all test results and forms
   viii. Contact a customer representative to report results and follow-up actions by this scope of work, are comprised of various brands and types of circuit breakers installed at all areas of Pinellas County Utilities.
   ix. Always verify that no voltage is present before proceeding with testing. Assume all circuits are energized. Confirm primary sources of power are disconnected, tagged, and locked out. Always follow all local, state, and national regulations.

4. **<u>Medium- Voltage Maintenance and Test Procedures: Report Serious Deficiencies Immediately to the Responsible PCU Contact</u>**

a. Contractor shall examine breaker for:
   i. Loose or obviously damaged components
   ii. Application with the cell
   iii. Compliance to drawings

b. Contractor shall with breaker open, Inspect and make corrections as needed:
   i. Primary leads, insulators, current transformer mounting and terminations, and secondary disconnects
   ii. Trip unit mounting and connectors Frame condition
   iii. Mechanical and safety interlocks
   iv. Ground contact

c. Contractor shall verify the manual operation of the breaker:
   i. Charge closing spring using manual charge handle
   ii. Close breaker manually
   iii Trip breaker manually

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d. Contractor shall with the breaker closed:
   i. Inspect and make corrections as needed on main contact over travel
   ii. Inspect and make corrections as needed arcing contact engagement
   iii. Measure contact resistance
   iv. Measure limiter resistance
   v. Perform “CLOSED” portions of the insulation resistance test
   vi. Open breaker

e. Contractor shall with the breaker open:
   i. Inspect and make corrections as needed on the condition of the main and arcing contacts
   ii. Inspect and make corrections as needed on insulating links/push rods and inter phase barriers for cracks and defects
   iii. Install arc chutes

f. Contractor shall with the breaker removed:
   i. Perform control wiring insulation resistance at 500 volts Direct Current (DC). Do not perform this test on wiring connected to solid state components without consulting the trip unit instruction book.
   ii. Clean, lubricate, adjust as needed and verify the proper operation of all breaker/cell accessories, auxiliary switches, cell Maintenance of Certification (MOC) and Table of Content (TOC) switches, and key interlocks
   iii. Clean, lubricate, adjust as needed and verify the proper operation of all breaker /cell safety interlocks:
   iv. Closed breaker insertion/withdrawal interlock
   v. Stored energy removal interlock
   vi. Breaker/cell rating code interlock
   vii. All other devices
   viii. Inspect and make corrections as needed on all grounding connections for cleanliness torque and alignment
   ix. Inspect and make corrections as needed on neutral CT, connections, and mounting.

      a) Verify that all accessible moving components are adequately lubricated
      b) Verify proper operation of all status indicators.

g. Contractor shall preform functional tests with breaker in cell:
   i. Verify control power for close and trip functions prior to racking breaker into cell
   ii. Verify the electrical operation of each breaker
   iii. Perform trip/close and anti-pump tests
   iv. Verify operation of the breaker from all local and remote-control switches or terminal blocks
   v. Close and open the breaker from each controllable device in the circuit
   vi. Confirm if this test must be performed with the breaker in the “Test Position”
   vii. Verify the proper operation of any automatic or remote-control schemes, protective relays, and lock-out (86) devices which are integral to the breaker control circuit

h. Contractor shall with the Breaker removed:
   i. Clean, lubricate, adjust as needed and verify the proper operation of all breaker/cell accessories, auxiliary switches, cell MOC and TOC switches, and key interlocks
   ii. Clean, lubricate, adjust as needed and verify the proper operation of all breaker /cell safety interlocks:
   iii Closed breaker insertion/withdrawal interlock
   iv. Stored energy removal interlock
   v. Breaker/cell rating code interlock
   vi. All other devices
   viii. Inspect and make corrections as needed on all grounding connections for cleanliness torque and alignment

ix. Inspect and make corrections as needed on neutral CT, connections, and mounting
   a) Verify that all accessible moving components are adequately lubricated
   b) Verify proper operation of all status indicators.
   c) clean breaker area in switchgear of dust dirt or grime while breaker is out.

i. Contractor shall preform functional tests with breaker in cell:
   i. Verify control power for close and trip functions prior to racking breaker into cell
   ii. Verify the electrical operation of each breaker
   iii. Perform trip/close and anti-pump tests
   iv. Verify operation of the breaker from all local and remote-control switches or terminal blocks
   v. Close and open the breaker from each controllable device in the circuit
   vi. Confirm if this test must be performed with the breaker in the "Test Position"
   ix. Verify the proper operation of any automatic or remote-control schemes, protective relays, and lock-out (86) devices which are integral to the breaker control circuit

j. Contractor shall trip unit tests verify:
   i. The device nameplate information is compatible with the switchgear drawings
   ii. Suitability and calibration dates of test equipment
   iii. Examine trip unit for:
      a. Physical damage
      b. Loose or obviously damaged components
      c. Verify the settings for the trip unit in accordance with the coordination study supplied by the owner
      d. Check status of rating plug mounted battery
   iv. Verify the calibration of all functions of the trip unit by means of secondary current injection
   v. Test and record long - time pick up and delay
   vi. Test and record short – time pick up and delay
   vii. Test and record instantaneous pick up
   viii. Test and record ground - fault pick up and delay
   ix. Reset trip flags and restore all settings changed during testing

k. After testing the contractor shall:
   i. Record as left trip unit settings and compare to as found settings or coordination study settings
   ii. Record counter as left value
   iii. Finish recording data on the Power-Test data form, completely filling in all the appropriate blocks
   iv. Apply a test sticker to the equipment
   v. Remove and account for all test equipment, jumper wires, and tools used during testing
   vi. Reinstall all barriers and covers, close all doors, and secure all latches
   vii. Review and organize all test results and forms
   viii. Contact a customer representative to report results and follow-up actions

5. <u>Switchgear And Switchboard Maintenance and Testing Guideline:</u>

a. Switchgear and Switchboard covered by this Guideline are comprised of various brands and Types installed at areas in Pinellas County.
   i. Contractor shall provide necessary equipment (but not limited to)
   ii. Personal protective equipment (PPE)
   iii. Project folder or notebook
   iv. Standard accessories and maintenance tools
   v. Insulation resistance test set 1000 VDC min
   vi. Specimen grounding jumpers
   vii. Torque Wrench

viii. Phase rotation meter
ix. RMS Multimeter
x. Phase Angle Meter
xi. Secondary Injection Test Set
xii. Primary Injection Tester
xiii. AC/DC Power supply
xiv. Variable Current source
xv. Current Transformer test set
xvi. Arc flash PPE,
xvii. Lighting needed for inside switchgear
xviii. Vacuum for cleaning

b. Contractor shall provide prior to testing, procure and review:
   i. Equipment drawings associated with the device being tested
   ii. Instruction books
   iii. Power-Test data forms
   iv. Power system studies: The protective relay, metering, and control settings must be supplied by the customers' engineer or from a Power System Study performed prior to commissioning
   v. Safe working procedures and SDS forms that apply to this task
   vi. Site safety rules and emergency procedures
   vii. Install safety locks and tags and safety grounds as required to provide for a safe working environment

c. Contractor shall verify:
   i. The device nameplate information is compatible with the switchgear drawings
   ii. Suitability and calibration dates of test sets

d. Contractor shall record on the power-test form:
   i. Customer and job information
   ii. Field data
   iii. As found conditions in the comment area
   iv. Test equipment data
   v. Service engineer/technician name
   vi. Record on the appropriate forms: control, metering, breaker trip units, and protective relay adjustments (these settings are best determined as the result of an "Engineering Study" performed by an experienced system engineer)

e. Contractor shall preform maintenance and test procedures, examine the switchgear line-up, including breakers, and accessories for:

   i. Loose or obviously damaged components
   ii. Proper identification
   iii. Physical damage from installation
      a) Doors, panels, and sections for alignment, dents, scratches, fit, and missing hardware
      b) Maintenance accessories for servicing and operating all devices

f. Contractor shall clean, lubricate and adjust as necessary, inspect and make corrections as needed and verify the proper operation of all mechanisms.
   i. Inspect and make corrections as needed all grounding connections for cleanliness and alignment
   ii. Main Bonding Jumper for proper size and termination (Refer to NEC Article 250, Section 250-102, Equipment Bonding Jumpers)
   iii. Insulators for evidence of physical damage or contaminated surfaces
   iv. Surge Arrestor and/or Surge Suppression size, type, installation and connection to determine if they are in accordance with the drawings (Refer to NEC Article 280)
   v. Breaker Cell(s), Primary and Secondary Disconnects for physical condition, cleanliness and lubrication

vi. Alignment and penetration of instrument transformer withdrawal disconnects, current carrying, and grounding components
vii. Control power transformers
viii. Wiring for damaged insulation, broken leads, tightness of connections, proper crimping, and overall general condition

g. Contractor shall verify structure, grounding, cables and bus assembly:
   i. Verify the grounding electrode conductor is properly sized (in accordance with NEC Article 250, Table 250-66) and terminated
   ii. The proper grounding of instruments, panels and connections (Refer to NEC Article 250, Part J, Sections 250-170 through 250-178)
   iii. That conductors are properly identified
   iv. Cable termination tightness
   v. Tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturers published data or Table 1 found at the end of this document
   vi. Correct barrier and shutter installation and operation
   vii. That filters are in place and/or vents are clear from obstructions

h. Contractor shall verify control and instrumentation:
   i. That all VT and CT ratios properly correspond to drawings and that polarity is correct
   ii. That shorting screws and bars are removed from CT's and terminal blocks as required
   iii. That primary and secondary fuse ratings or circuit breakers match drawings
   iv. Meter scaling and type match drawings
   v. That circuit breaker and meter addresses are set for microprocessor-communication packages
   vi. That accessible moving components are adequately lubricated

i. Contractor shall verify key interlock system:
   i. Key number and exchange codes
   ii. Proper sequencing to comply with drawing notes
   iii. Attempt to close locked-open devices.
   iv. Attempt to open locked-closed devices
   v. Make key exchange with devices operated in off-normal positions
   vi. Disposition of duplicate keys per the owner's safety policy

j. The contractor shall preform electrical tests, insulation system:
   i. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground. Values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, refer to Table 2
   ii. Perform insulation-resistance tests at 500 volts DC on all control wiring
   iii. Do not perform this test on wiring connected to solid-state components.
   iv. To ensure proper connections of double ended style switchgear or switchboards, perform an insulation-resistance tests at the bus-tie breaker compartment(s) phase-to-phase, line-to-load and phase-to-ground. Values shall be in accordance with the manufacturer's published data. In the absence of manufacturer's published data, refer to Table 2. (Note: This test is to be performed inside the Tie Breaker compartment(s) at the line and load side bus connection points, with the bus de-energized. This procedure is to verify correct connection of the main bus system to assure the two bus systems were not inadvertently connected together)

k. Contractor shall perform the following tests on control power transformers
   i. Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with Table 3 unless otherwise specified by manufacturer
   ii. Verify correct secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with the secondary wiring connected
   iii. Perform secondary wiring integrity test. Confirm potential at all devices
      a) Verify correct function of control transfer relays locate in switchgear
      b) Verify operation of switchgear/switchboard heaters

l. Contractor shall perform the following tests on potential transformers
   i. Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with Table 3 unless otherwise specified by manufacturer
   ii. Verify correct secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with the secondary wiring connected
   iii. Perform secondary wiring integrity test. Confirm potential at all devices

m. Contractor shall perform the following tests on current transformers
   i. Ratio
   ii. Saturation

n. Contractor shall preform Ground fault system test:
   i. Perform ground-fault test in accordance with Ground Fault or Low Voltage Breaker: Maintenance Testing Guidelines (as appropriate). If ground fault relay is a stand-alone relay record results on the Ground Fault data form. If it is a function of the circuit breaker, record results on the Low Voltage Breaker data form.

o. Contractor shall preform test on protection devices:
   i. Circuit breakers
      a) Perform current injection tests on circuit breakers (200 amp and greater) in each section of the switchgear being commissioned (for low voltage assemblies only)
      b) Utilize Secondary Current Injection test method for maintenance testing
      c) Perform current tests by primary injection, when secondary injection testing can't be, or is specified to be, performed
      d) Test each device and record values on appropriate Power-Test data form

   ii. Determine accuracy of protective relays in accordance with the Protective Relay: Maintenance Testing Guidelines
   iii. Utilize appropriate Meter/Relay Power-Test data form to record values

p. Contractor shall preform test on metering and power monitoring devices:
   i. Set up if needed all meters and IQ or similar devices
   ii. Determine accuracy of meters, watt-hour meters in accordance with the Watt-hour Meter: Maintenance Testing Guidelines
   iii. Utilize appropriate Meter/Relay Power-Test data form to record values.

q. Contractor shall preform after testing:
   i. Before energizing:
      a) Remove metal shavings and thoroughly clean and vacuum the equipment before energizing
      b) Remove and account for all test equipment, jumper wires, and tools used during testing
      c) Remove and account for safety grounds and tools
      d) Replace all barriers and covers, close all doors, and secure all latches
      e) Remove safety locks and tags

   ii. Finish recording data on the Power-Test data form, completely filling in all the appropriate blocks
   iii. Note corrective actions taken, deficiencies and recommendations, and any general comments
   iv. Apply a test sticker to the equipment
   v. Review and organize all test results and forms
   vi. Contact a customer representative to report results and follow-up actions

6. <u>Automatic Transfer Scheme/Switch System: Maintenance & Testing Guideline</u>

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a. Contractor shall be responsible for all necessary equipment (but not limited to)
   i. Project folder or notebook
   ii. Standard ATS accessories and maintenance tools
   iii. AC/DC Power Supply
   iv. Insulation resistance test set 1000 VDC minimum
   v. Low resistance digital ohmmeter
   vi. Secondary injection test set
   vii. RMS Multimeter

b. Contractor shall prior to testing: procure and review
   i. ATS or switchgear drawings
   ii. Instruction books
   iii. Power-Test data forms
   iv. Power system studies
   v. Safe working procedures and MSDS forms that apply to this task
   vi. Site safety rules and emergency procedures
   vii. Install safety locks and tags and safety grounds as required to provide for a safe working environment

c. Contractor shall verify:
   i. The device nameplate information is compatible with the switchgear drawings
   ii. Suitability and calibration dates of test sets

d. Contractor shall record on the power-test form:
   i. Customer and job information
   ii. Field data
   iii. As found conditions in the comment area
   iv. Test equipment data
   v. Service engineer/technician name
   vi. Record on the appropriate forms: control, metering, breaker trip units, and protective relay adjustments (these settings are best determined as the result of an “Engineering Study” performed by an experienced system engineer)

e. Contractor shall preform maintenance and test procedures examine the ATS and accessories for.
   i. Loose or obviously damaged components
   ii. Proper identification
   iii. Physical damage from installation
   iv. Doors, panels, and sections for alignment, dents, scratches, fit, and missing hardware
   v. Maintenance accessories for servicing and operating all devices.

f. Contractor shall clean, lubricate and adjust as necessary, inspect and make corrections as needed and verify the proper operation of all mechanisms.
   i. Inspect and make corrections as needed all grounding connections
   ii. Insulators for evidence of physical damage or contaminated surfaces
   iii. Surge Arrestor and/or Surge Suppression size, type, installation and connection to determine if they are in accordance with the drawings (Refer to NEC Article 280)
   iv. Control power breaker or switch for physical condition and cleanliness
   v. Wiring for damaged insulation, broken leads, tightness of connections, proper crimping, and overall general condition

g. Contractor shall verify structure, grounding, cables and bus assembly:
   i. That the grounding electrode conductor is properly sized and connected in accordance with NEC Article 250, Table 250-66 and the OEM instruction book
   ii. That conductors are properly identified
   iii. Cable and control wire termination tightness
   iv. That all cables have been properly installed, routed and supported
   v. That conduits and conduit bushings are correctly installed

vi. Unused openings have been properly closed and secured
vii. Tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturers published data

h. Contractor shall preform electrical tests: metering and power monitoring devices.
   i. Inspect and make corrections as needed and test per OEM manuals
      a) Metering devices
      b) IQ or similar devices
   ii. Utilize appropriate Meter/Relay Power-Test data form to record values

i. Contractor shall examine utility and emergency breakers for:
   i. Loose or obviously damaged components
   ii. Proper operation enclosure mechanical interlocks
   iii. Proper operation of racking or draw-out mechanism

j. Contractor shall with breaker open, inspect and make corrections as needed:
   i. Primary leads, insulators, current transformer mounting and terminations, and secondary disconnects
   ii. Trip unit mounting and connectors
   iii. Frame condition
   iv. Mechanical and safety interlocks
   v. Ground contact

k. Contractor shall verify the manual operation of the breaker
   i. Charge closing spring using manual charge handle
   ii. Close breaker manually
   iii. Trip breaker manually

l. Contractor shall inspect and make corrections as needed arc chutes (if removable)
   i. Remove arc chutes
   ii. Inspect and make corrections as needed for cracks and defects
   iii. Set arc chutes aside

m. With the breaker closed contractor shall:
   i. Inspect and make corrections as needed main contact over-travel
   ii. Inspect and make corrections as needed arcing contact engagement
   iii. Measure contact resistance
   iv. Measure limiter resistance
   v. Perform “CLOSED” portions of the insulation resistance test
   vi. Verify operation of anti-single-phase device, if provided
   vii. Open breaker

n. With the breaker open contractor shall:
   i. Inspect and make corrections as needed the condition of the main and arcing contacts
   ii. Perform the “OPEN” portion of the insulation resistance test
   iii. Inspect and make corrections as needed insulating links/push rods and interphase barriers for cracks and defects
   iv. Install arc chutes

o. Contractor shall perform control wiring insulation resistance
   i. test at 500 volts DC. Do not perform this test on wiring connected to solid state components without consulting the trip unit instruction book

p. If draw out type breakers, rack the breaker into the cell contractor shall:
   i. (“Test Position” if applicable) using the standard breaker maintenance accessories and check for binding or hesitation and the movement of the breaker position indicator

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q. Contractor shall verify the proper operation of all breaker/cell accessories, auxiliary switches, cell MOC and TOC switches, and key interlocks

r. Contractor shall verify the proper operation of all breaker /cell safety interlocks:
   i. Closed breaker insertion/withdrawal interlock
   ii. Stored energy removal interlock
   iii. Breaker/cell rating code interlock
   iv. All other devices

s. Contractor shall Inspect and make corrections as needed all grounding connections for cleanliness and alignment
   i. Verify that all accessible moving components are adequately lubricated
   ii. Verify proper operation of all status indicators
   iii. Trip Unit Tests Verify:
      a. The device nameplate information is compatible with the ATS or switchgear drawings
      b. Suitability and calibration dates of test equipment

t. Contractor shall examine trip unit for:
   i. Shipping damage
   ii. Loose or obviously damaged components

u. Contractor shall select the final settings for the trip unit in accordance with the coordination study supplied by the owner

v. Contractor shall check status of rating plug mounted battery and replace as needed.

w. Contractor shall verify the calibration of all functions of the trip unit by means of secondary current injection
   i. Test and record long - time pick up and delay
   ii. Test and record short - time pick up and delay
   iii. Test and record instantaneous pick up
   iv. Test and record ground - fault pick up and delay

x. Contractor shall reset trip flags and restore all settings changed during testing

y. Contractor shall initial Energizing of Automatic Transfer System Before energizing
   ii. Remove metal shavings and thoroughly clean and vacuum the equipment before energizing
   iii. Remove and account for all test equipment, jumper wires, and tools used during testing
   iv. Remove and account for safety grounds and tools
   v. Replace barriers, covers, close doors removed during start-up
   vi. Verify no wires are pinched
   vii. Verify that all enclosure parts are properly aligned and tightened
   viii. Remove safety locks and tags
   ix. Turn all circuit breakers and fusible switches to the OFF position

z. Contractor shall on phasing note as required based on site specific conditions at the time of testing.
   i. Perform rotation check and verify correct motor rotation
   ii. For ATS equipment fed from two sources, verify the phase relationship and rotation of both sources before operating the system
   iii. Note: This check is for systems operating at 600 volts and below ONLY. For medium voltage system a safe working plan must be developed to address site and system conditions prior to performing a phasing check

aa. Contractor shall test Control Power Transformer:
   i. Verify correct secondary voltage by energizing primary winding with system voltage
      a) Measure secondary voltage with the secondary wiring connected
   ii. Perform secondary wiring integrity test
      a) Confirm potential at all devices

SECTION E – SPECIFICATIONS

bb. Contractor shall preform automatic transfer switch system function tests
- i. Perform system function tests upon completion of above listed items. The system function tests must prove the correct interaction of sensing, processing, protection, timing, control, and switching devices

cc. Contractor shall implement test plan:
- i. Develop parameters and procedures specific to the equipment design and control scheme for the purpose of evaluating the performance of components as a system
- ii. This can be accomplished using the “Function Testing” Power-Test data for

dd. Contractor shall Implement these items to be included and verified in the test plan
- i. The correct operation of all interlock’s safety devices for fail-safe functions in addition to design function
- ii. Power connections: Utility, Emergency, and Load
- iii. Engine start contacts and interface to engine
- iv. Under-voltage function on utility and generator sources
- v. Under-frequency function on generator
- vi. Time delays
    - a) Utility voltage sensing relay
    - b) Engine start sequence
    - c) Transfer time delay
    - d) Neutral transfer time delay
    - e) Retransfer time delay
    - f) Engine cool down and shutdown time delay
- vii. System operation:
    - a) Loss of utility
    - b) Return to utility
    - c) Loss of emergency
    - d) Single phase conditions
    - e) Over current (Bell Alarm) lockout
    - f) Verify the correct operation of all sensing devices, alarms, and indicating devices
- viii. Verify that ATS functions properly with associated control switches, both local and remote, as applicable
- ix. Verify that automatic control schemes operate per the design drawings and documents
- x. Record test results and values on the Function Testing data form

ee. Contractor shall after testing
- i. Finish recording data on the Pow-R-Test data form, completely filling in all the appropriate blocks
- ii. Note corrective actions taken, deficiencies and recommendations, and any general comments
- iii. Apply a test sticker to the equipment
- iv. Review and organize all test results and forms
    - a) Contact a customer representative to report results and follow-up actions

SECTION E – SPECIFICATIONS

TABLE 1

Metal Clad Switchgear

Bolt Torque's for Bus Connections					
Bolt Material	Torque in foot-pounds **for Bolt Size**				
High Strength Steel Silicon Bronze	.25-20	.31-18	.38-16	.50-13	.62-11
	5	12	20	50	95
	5	10	15	40	55

TABLE 1

Metal Enclosed Switchgear

Torque for Bolts in Bus Bar Joints (Using Grade 5 Steel Bolts)	
Bolt Size	Torque Ft/Lbs. **(Newton/Meters)**
3/8 - 16	20 (27)
½ - 13	50 (65)

Lug Bolting Torque's for Connection of Wire Connectors to Bus bars, etc.

Bolt Diameter – Inches	**Tightening Torque, Pound - Feet**
No. 8 or smaller	1.5
No. 10	2.0
¼ or less	6
5/16	11
3/8	19
7/16	30
½	40
9/16 or larger	55

Tightening Torque's for Screws*
In Pound-Inches

Wire Size (AWG or kcmil)	Slotted Head No. 10 and Larger		Hexagonal Head-External Drive Socket Wrench	
	Slot Width to 3/64 or Slot Length to ¼ in.**	Slot Width to 3/64 or Slot Length to ¼ in.**	Split-Bolt Connectors	Other Connectors
30 – 10	20	35	80	75
8	25	40	80	75
6	35	45	165	110
4	35	45	165	110
3	35	50	275	150
2	40	50	275	150
1	--	50	275	150
1/0	--	50	385	180
2/0	--	50	385	180
3/0	--	50	500	250
4/0	--	50	500	250
250	--	50	650	325
300	--	50	650	325
350	--	50	650	325
400	--	50	825	325
500	--	50	825	375
600	--	50	1000	375
700	--	50	1000	375
750	--	50	1000	375
800	--	50	1100	500
900	--	50	1100	500
1000	--	50	1100	500
1250	--	--	1100	600
1500	--	--	1100	600
1750	--	--	1100	600
2000	--	--	1100	600

* Clamping screws with multiple tightening means. For example, for a slotted hexagonal head screw, use the torque value associated with the tool used in the installation. UL uses both values when testing.
For values of slot width or length other than those specified, select the largest torque value associated with conductor size.
Note: This information should be used for guidance only if no tightening information on the specific wire connector is available. It should not be used to replace the manufacturer's instructions. This information was taken from the edition of UL Standard 486B. Similar information can be found in UL 486A and UL 486C.

SECTION E – SPECIFICATIONS

Tightening Torque's for Screws*
Smaller than #10, for use with No. 8 Smaller Conductors
In Pound-Inches

Screw-Slot Length – In.**	Screw-Slot Width Less than 3/64 in.	Screw-Slot Width 3/64in. and Larger
to 5/32	7	9
5/32	7	12
3/16	7	12
7/32	7	12
¼	9	12
9/32	--	15
above 9/32	--	20

* Clamping screws with multiple tightening means. For example, for a slotted hexagonal head screw, use the torque value associated with the tool used in the installation. UL uses both values when testing.
**For slot lengths of intermediate values, select torque's pertaining to next shorter slot length.

Torque's for Recessed Allen Head Screws

Socket Size Across Flats – in. Pound-Inches	Torque, Pound-Inches
1/8	45
5/32	100
3/16	120
7/32	150
¼	200
5/16	275
3/8	375
½	500
9/16	600

TABLE 2

Switchgear Insulation-Resistance Test Voltage

Voltage Rating	Minimum dc Test Voltage	Recommended Minimum Insulation Resistance In Megohms
0 - 250	500	50
251 - 600	1,000	100
601 - 5,000	2,500	1,000
5,001 - 15,000	2,500	5,000
15,001 - 25,000	5,000	20,000
25,001 - 35,000	15,000	100,000

In the absence of consensus standards dealing with insulation-resistance tests, use of the above representative values is suggested.

TABLE 3

Over-potential Test Voltages for Electrical Apparatus
Other than Inductive Equipment

• Nominal • System (Line) • Voltage* (kV)	Insulation Class	AC Factory Test (kV)	Maximum Field Applied AC Test (kV)	Maximum Field Applied DC Test (kV)
1.2	1.2	10	6.0	8.5
2.4	2.5	15	9.0	12.7
4.8	5.0	19	11.4	16.1
8.3	8.7	26	15.6	22.1
14.4	15.0	34	20.4	28.8
18.0	18.0	40	24.0	33.9
25.0	25.0	50	30.0	42.4
34.5	35.0	70	42.0	59.4
46.0	46.0	95	57.0	80.6
69.0	69.0	140	84.0	118.8

In the absence of consensus standards, use the above representative suggested values.
* Intermediate voltage ratings are placed in the next higher insulation class.

TABLE 4

Switchgear Low-Frequency Withstand Test Voltages

Type of Switchgear	Rated kV	Maximum Test Voltage kV	
		ac	dc
MC	4.76	14.0	20.0
(Metal-Clad Switchgear)	8.25	27.0	37.0
	15.0	27.0	37.0
	38.0	60.0	+
SC	15.5	37.0	+
(Station-Type Cubicle	38.0	60.0	+
Switchgear)	72.5	120.0	+
MEI	4.76	14.0	20.0
(Metal-Enclosed Interrupter	8.25	19.0	27.0
Switchgear)	15.0	27.0	37.0
	15.5	37.0	52.0
	25.8	45.0	+
	38.0	60.0	+

Derived from ANSI/IEEE C37.20.2-1987, Paragraph 5.5, *Metal-Clad and Station-Type Cubicle Switchgear* and C37.20.3-1987, Paragraph 5.5, *Metal-Enclosed Interrupter Switchgear*, and includes 0.75 multiplier with fraction rounded down.

The column headed "DC Withstand" is given as a reference only for those using dc tests to verify the integrity of connected cable installations without disconnecting the cables from the switchgear. It represents values believed to be appropriate and approximately equivalent to the corresponding power frequency withstand test values specified for voltage rating of switchgear. The presence of this column in no way implies any requirement for a dc withstand test on ac equipment or that a dc withstand test represents an acceptable alternative to the low-frequency withstand tests specified in this specification, either for design tests, production tests, conformance tests, or field tests. When making dc tests, the voltage should be raised to the test value in discrete steps and held for a period of one minute.

Because of the variable voltage distribution encountered, when making dc withstand tests, the manufacturer should be contacted for recommendations before applying dc withstand tests to the switchgear.