SECTION 16080

SITE ACCEPTANCE TESTING

# GENERAL

## SCOPE

### The Contractor shall engage an independent testing agency that is acceptable to the DISTRICT.

## APPLICABLE CODES, STANDARDS AND REFERENCES

### All inspections and tests shall be in accordance with the following applicable codes and standards except as provided otherwise herein.

#### National Electrical Manufacturer’s Association – NEMA

#### American National Standards Institute – ANSI

#### Institute of Electrical and Electronic Engineers – IEEE

#### National Electrical Code – NEC

#### National Fire Protection Association – NFPA

#### American Society for Testing and Materials – ASTM

#### Insulated Power Cable Engineers Association – IPCEA

#### Association of Edison Illuminating Companies – AEIC

#### Occupational Safety and Health Administration – OSHA

#### State and local codes and ordinances

#### National Electrical Testing Association (NETA)

### All inspections and tests shall utilize the following references:

#### Project design specifications

#### Project design drawings

#### NFPA 70B -

#### Manufacturer’s instruction manuals applicable to each particular apparatus.

## QUALIFICATIONS OF SITE ACCEPTANCE TESTING COMPANY

### The testing company site lead engineer or project manager shall be a degreed engineer, who is a full-time employee, with at least 10 years of experience testing electrical apparatus. All other employees working on this project shall have had specific factory and/or field training in accordance with the equipment they are testing. All electrical equipment requiring field testing, shall be tested per NETA ATS requirements by a NETA certified 3rd Party Technician.

### To ensure compliance with quality control standards, the testing company shall conduct periodic audits of test procedures and test record forms to ensure compliance with industry standards. A Quality Assurance Manager, not reporting to the operation center of the testing company, must complete such audits.

### Tools, equipment and personal protective equipment utilized by the testing company shall comply with the requirements of OSHA Standard 29 CFR 1910, Subpart I, and NFPA 70E.

### The instruments and test equipment utilized by the testing company shall be calibrated by an accredited ISO/IEC 17025 laboratory. This laboratory shall be audited regularly by the National Voluntary Laboratory Accreditation Program (NVLAP).

#### The accuracy shall be traceable to the National Bureau of Standards in an unbroken chain.

#### Instruments shall be calibrated in accordance with the following frequency schedule:

##### Field instruments – six to twelve months

##### Laboratory instruments – twelve months

#### Dated calibration labels shall be visible on all instruments and test equipment.

## SUBMITTALS

### The test report shall include the following:

#### Summary of project

#### Description of equipment tested

#### Description of test

#### Test results

#### Conclusions and recommendations

#### Appendix, including appropriate test forms for

#### List of test equipment used and calibration date

#### Conditions for future access to secured computer database of all Test Data.

### Furnish three copies of the completed report to the DISTRICT’s Representative no later than 30 days after completion of the project, unless directed otherwise.

## SAFETY AND PRECAUTIONS

### Safety practices shall include, but are not limited to, the following requirements:

#### Occupational Safety and Health Act of 1970 – OSHA 29CFR 1910.269

#### National Fire Protection Association – NFPA 70E

#### Applicable state and local safety operating procedures.

### All tests shall be performed with apparatus de-energized except where otherwise specified.

### The independent testing agency’s lead test engineer for the project shall be a designated safety representative and shall be present on the project and supervise testing operations and safety requirements.

### Power circuits shall have conductors shorted to ground by a hotline grounded device approved for the purpose in accordance with the appropriate test procedures.

### In all cases, work shall not proceed until the safety representative has determined that it is safe to do so.

### The independent testing agency shall have available sufficient protective barriers and warning signs, where necessary, to conduct specified tests safely.

### The owner’s / DISTRICT’s safety procedures shall be reviewed and understood by the testing company personnel.

## EQUIPMENT EVALUATION PREPARATION

### The electrical contractor shall torque down all accessible bolts; perform continuity checks on all branch and control wiring; and perform rotational tests for all motors prior to and in addition to tests performed by the testing company, specified herein. Contractor shall thoroughly clean and vacuum equipment before testing or energizing electrical equipment.

### The electrical contractor shall supply a suitable and stable source of test power for testing at each test site. The testing company shall specify requirements.

### The electrical contractor shall notify the testing company when equipment becomes available for electrical tests. Work shall be coordinated to expedite project scheduling.

### The Contractor shall be responsible for supplying a complete set of as-built electrical plans, specifications and any pertinent change orders to the testing company prior to commencement of testing.

### The independent testing agency shall notify the Owner’s / DISTRICT’s representative prior to commencement of any testing.

### The independent testing agency shall be responsible for implementing all final settings and adjustments on protective devices and electrical equipment in accordance with the Short Circuit / Coordination / Arc Flash study performed by the third party hired by the Contractor in accordance with requirements set forth in the construction documents.

### Any system, material or workmanship which is found defective on the basis of electrical tests shall be reported directly to the Owners’s / DISTRICT’s representative.

### The testing company shall maintain a written record of all tests and upon completion of the project, assemble and certify a final test report.

### All test records shall be recorded onto standardized test forms. All data shall be uploaded to a central computer in a data-secured environment; therefore, ensuring no changes can be incorporated into the final test records. These records shall be retrievable for a period of not less than five years, based on a mutually agreed periodic maintenance plan, separate from this contract.

# PRODUCTS (nOT USED)

# EXECUTION

## GENERAL REQUIREMENTS

### For each Manufacture, the associated field engineering service group shall provide all material, equipment, labor and technical supervision to perform electrical equipment tests and inspections as listed in the applicable section below. The field engineering service division of the equipment manufacturer shall administer all site acceptance and power system studies, as referenced in other specification sections.

### Equipment warranty shall be extended to two years from date of acceptance when service representatives employed by the equipment manufacturer perform testing.

### The intent of these tests is to assure that all electrical equipment is operational within industry standards and manufacturer’s tolerances and that equipment is installed and functioning in the system in the manner intended by the engineer. The warranty start time is to reflect when the DISTRICT accepted the site.

### Upon completion of the tests and inspections noted in these specifications, a label shall be attached to all serviced devices. These labels will indicate date serviced and the testing company responsible.

### The tests and inspections shall determine suitability for initial continued reliable operation and provide a baseline for future maintenance testing.

## AC INDUCTION MOTOR

### Mechanical and Visual Inspection

#### Examine motor for:

##### Shipped loose and shipped short components

##### Shipping damage

##### Loose or obviously damaged

##### Termination box

##### Shaft

##### Tachometer

##### Brake

##### Zero speed switch

##### Mounting feet or flange

##### Proper motor lubrication

##### Coupling alignment and lubrication

##### Proper identification

##### Compliance to drawings

##### Customer field connections and signals

##### Remove temporary heater wiring and shipping braces

#### Inspect:

##### All grounding connections

##### Insulators for evidence of physical damage or contaminated surfaces

##### 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)

##### Wiring for damaged insulation, broken leads, tightness of connections, proper crimping, and overall general condition

#### Verify structure, grounding, cables and bus assembly for:

##### Anchorage (per local codes, wind and seismic considerations)

##### Required area clearances, correct alignment and cleanliness.

##### That the grounding electrode conductor is properly sized.

##### That conductors are properly identified

##### Cable and control wire termination tightness

##### That all cables have been properly installed, routed and supported

##### That conduits and conduit bushings are correctly installed

##### Unused openings have been properly closed and secured

##### Tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturers published data

##### That blocks or other temporary holding means used for shipment have been removed from the motor

##### That filters are in place and/or vents are clear from obstructions

#### Inspect and test the motor stator circuit:

##### Prior to disconnecting motor leads, verify, note, and mark the motor’s direction of rotation

##### Mark and disconnect the motor stator leads

##### Perform an insulation resistance test

##### Reconnect all leads removed during this check

### Electrical Tests

#### Perform an insulation resistance test on the motor leads to ground at 1000 VDC and calculate the polarization index of the motor windings

#### Recent current and voltage of each phase

## CABLES – LOW VOLTAGE (600V OR LESS)

### Mechanical and Visual Inspection

#### Examine the cables for:

##### Physical damage or deformities to exposed portions of cable

##### That compression-applied connectors are correct for cable and are compressed correctly

##### Jacket and insulation condition

##### Correct identification and arrangements

#### Inspect:

##### Cable termination or load break elbows

##### For proper shield grounding, cable support, and termination

#### Verify:

##### That visible cable bends meet or exceed manufacturer’s minimum allowable bending radius.

##### Adequate fireproofing in common cable areas, if specified

##### Cables terminated through window-type current transformers

##### Inspect to verify the neutral and ground conductors are correctly placed and that shields are correctly terminated for operation of protective devices

##### That conduits and conduit bushings are correctly installed

##### Unused openings have been properly closed and secured

##### Tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturers published data.

##### Cables are properly routed through current transformers and shields are properly terminated.

##### Both ends of cables are properly barricaded off for personnel protection

##### Cable ends are properly isolated from environmental conditions that would affect test results

### Electrical Tests

#### Perform a shield-continuity test on each power cable with an ohmmeter

#### Perform an insulation-resistance test using a megohmmeter with a voltage output of 500Vdc for 300V rated cable and 1000Vdc for 600V rated cable. Insulation testing is required for power conductors #4 AWG and larger.

##### Individually test each conductor with all other conductors and shields grounded

##### Test duration shall be one minute

##### Remove test lead with high voltage gloves

##### Apply grounds for a time period adequate to drain all insulation stored charge using high voltage gloves

## ELECTRONIC METERS

### Mechanical and Visual Inspection

#### Examine meter and accessories for:

##### Shipped loose and shipped short components

##### Shipping damage

##### Loose or obviously damaged components

##### Proper identification

##### Physical damage from installation

##### Alignment, dents, scratches, fit, and missing hardware

#### Inspect:

##### All connections for tightness

##### Current transformers for proper rating, polarity and wiring

#### Verify:

##### Proper operation of indicators and displays

##### Meter is correct for application

##### Grounding

### Electrical Tests

#### Apply the appropriate AC control power to the meter.

#### Set the basic programming parameters for the system:

##### Instrument transformer ratios

##### System configuration

#### Frequency

#### Perform simulation tests to verify proper response of Voltage, Current, Harmonics, Frequency, Power Factor, kW, kVA, and kVAR functions.

## GROUND FAULT PROTECTIONS SYSTEMS – LOW VOLTAGE

### Mechanical and Visual Inspection

#### Examine the Ground Fault System and accessories for:

##### Shipped loose and shipped short components

##### Physical damage from shipping or installation

##### Loose components

##### Proper identification

##### Maintenance accessories for servicing and operating all devices, as required.

#### Inspect:

##### Grounding electrode conductor to assure proper size and correct switchboard termination.

##### Switchboard main bonding jumper for:

###### Proper size

###### Termination on the source side of the neutral disconnect link

###### Termination on the source side of the zero sequence sensor or residual system neutral sensor

##### Switchboard neutral bus downstream of the neutral disconnect link to verify the absence of ground connections

##### Neutral scheme is correct to the provided prints, where applicable

#### Verify:

##### The ground sensor(s) are properly located around appropriate conductors

###### Zero sequence systems require that all phase conductors and the neutral pass through the sensor in the same direction

###### The grounding conductors do not pass through zero sequence sensors

###### Residual systems require that all phase and neutral conductors incorporate a sensor

###### That the neutral sensor is connected with the correct polarity on both the primary and secondary for residual systems and is the correct type / size.

###### Inspect wiring per manufacturer provided drawings for proper termination and that shipping split wiring (if applicable) has been connected.

### Electrical Tests

#### Settings:

##### Pickup and time-delay settings in accordance with the settings provided by the Power System Study i.e. coordination study and short circuit analysis. If no settings are present the breaker, or relay, will be left at minimum pickup values.

#### Verify Ground Fault System Performance for:

##### Correct response of the circuit-interrupting device by primary ground sensor current injection. Secondary injection can be performed if the device is capable of being tested by a secondary injection test set.

##### Measure and record ground fault relay pickup current and confirm timing to manufacturer’s curves at two separate points greater than 125%

#### Test reduced control voltage tripping operation at 57 percent of the rated voltage for zero sequence systems, where applicable.:

##### Verify correct Control Power Transformer secondary voltage by energizing primary winding at rated voltage with temporary test power.

###### Measure secondary voltage with the secondary wiring connected

##### Proper operation of ground fault indicator for correct indication of the ground fault trip

##### Proper sensor polarity of phase and neutral sensors for residual systems

###### Trip test

###### No trip test

###### Non-automatic operation

###### Neutral-To-Ground Insulation Resistance Measurement:

Remove the neutral disconnect link and measure the insulation resistance between the neutral to ground to verify the absence of grounds downstream of the neutral disconnect link. Test voltage shall be 1000V DC for one minute.

## GROUND RESISTANCE

### Testing Method

#### Test ground resistance using one of the following two methods:

##### Direct Method, or Two-Terminal Test

##### Fall-of-Potential Method, or Three-Terminal Test

### Direct Method Limitations

#### With this method, resistance of two electrodes is series is measured – the driven rod and the water system. But there are three important limitations:

##### The water-pipe system must be extensive enough to have a negligible resistance

##### The water-pipe system must be metallic throughout, without any insulating couplings or flanges

##### The earth electrode under test must be far enough away from the water-pipe system to be outside is sphere of influence

#### In some locations, your earth electrode may be so close to the water-pipe system that you cannot separate the two by the required distance for measurement by the two-terminal method. Under these circumstances, if condition 1 and 2 above are met, you can connect to the water-pipe system and obtain a suitable earth electrode.

### Ground Resistance Values

#### Maximum ground resistance shall be 10 ohms or less. For lightning protection, the arresters should be coupled with a maximum ground resistance of 1 ohm.

## INSTRUMENT TRANSFORMERS

### Mechanical and Visual Inspection

#### Inspect enclosure for structural integrity (if applicable).

#### Verify proper door latching, interlocking and grounding operation for draw-out types.

#### Inspect for loose, broken or missing hardware or components.

#### Inspect the electrical connections and perform a pull test on all customer and factory connections by giving a firm tug on all the connections.

#### Check tightness of bolted connections.

#### Inspect cable for tightness (if accessible), insulation fraying and clearances.

#### Verify proper location and configuration of current transformers.

#### Confirm all voltage and current ratios properly correspond to drawings and that polarity is correct

#### Remove shorting screws and bars are from current transformers and terminal blocks as required

#### Verify primary and secondary fuse ratings or circuit breakers match drawings

#### Verify current transformer secondary circuits are grounded in accordance with ANSI/IEEE C57.13.3 and correspond to locations on engineer drawings.

### Electrical Tests

#### Perform the following tests on control power transformers

##### Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground.

##### Perform the following tests on potential and voltage transformers

###### Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground.

###### Polarity

#### Perform the following tests on current transformers in accordance with the testing methods in ANSI/IEEE C57.13.1

##### Ratio

##### Polarity

## MOLDED CASE CIRCUIT BREAKER (480 VOLT)

### Mechanical and Visual Inspection

#### Examine breaker for:

##### Shipping damage

##### Loose or obviously damaged components

##### Primary lead connection tightness

##### Limiter fuses rating (as applicable)

##### Compliance to drawings

#### With breaker open, inspect:

##### Primary leads

##### Insulators

##### Trip unit mounting and connectors

##### Frame condition

##### Mechanical and safety interlocks (as applicable)

#### Inspect circuit breaker mounting hardware and connections.

#### Inspect neutral CT polarity, connections, and mounting (as applicable).

#### Verify the proper operation of all breaker accessories, auxiliary switches, and key interlocks (as applicable).

#### Operate the circuit breaker ON and OFF (3) three times to verify the breaker mechanism operates smoothly without binding.

### Electrical Tests

#### Test the insulation resistance on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed.

#### Test the insulation resistance across each pole, with the circuit breaker open.

#### Measure contact resistance using a digital low-resistance ohmmeter.

#### Test limiter resistance (as applicable).

#### Verify proper operation of all status indicators.

#### Trip Unit Tests

##### Program trip unit settings per manufacturer’s instructions and in accordance with settings provided by the DISTRICT approved coordination study device setting table otherwise test on default / minimum settings.

##### Check status of rating plug mounted battery (as applicable).

##### Verify all functions of the trip unit utilizing the manufacturer’s specified trip unit test device and record results.

##### Reset trip flags and restore all settings changed during testing.

##### Note: Discrete test values may not be obtainable for all types of trip units. For these units, function testing is required only.

## MOTOR CIRCUIT PROTECTOR

### Mechanical and Visual Inspection

#### Examine motor circuit protector for:

##### Shipping damage

##### Loose or obviously damaged components

##### Primary lead connection tightness

##### Compliance to drawings

#### With motor circuit protector open, inspect:

##### Primary leads

##### Insulators

##### Frame condition

##### Mechanical and safety interlocks (as applicable)

##### Mounting

#### Verify the proper operation of all motor circuit protector accessories, auxiliary motor switches, and key interlocks (as applicable).

### Electrical Tests

#### Test the insulation resistance on each pole, phase-to-phase and phase-to-ground with the motor circuit protector closed.

#### Test the insulation resistance across each pole, with the motor circuit protector open.

#### Measure contact resistance using a digital low-resistance ohmmeter.

## MOTOR CONTROL CENTERS – LOW VOLTAGE

### Mechanical and Visual Inspection

#### Examine the motor control center and accessories for:

##### Shipped loose and shipped short components

##### Shipping damage

##### Loose or obviously damaged components

##### Proper identification

##### Physical damage from installation

##### Doors, panels, and sections for alignment, dents, scratches, fit, and missing hardware.

##### Maintenance accessories for servicing and operating all devices

##### Check MCC nameplate and data such as voltage, ampere rating, short circuit rating

#### Inspect:

##### Shipping Splits to ensure that all bus connections were properly connected and torqued.

##### Verify all control wiring splits have been properly terminated by contractor.

##### Remove all temporary wiring for heaters if equipped

##### Remove all blocks or other temporary holding means used for shipment from all component devices in the MCC interior.

##### Grounding connections

##### Insulators for evidence of physical damage or contaminated surfaces

##### Surge Arrester and/or Surge Protective Devices (as applicable)

##### Circuit breaker and Secondary Disconnects for physical condition, cleanliness and lubrication (as applicable)

##### Alignment and penetration of instrument transformer withdrawal disconnects, current carrying, and grounding components (as applicable)

##### Control power transformers (as applicable)

##### Wiring for damaged insulation, broken leads, proper crimping, and overall general condition

##### Fuse clip contact pressure and contact means (as applicable)

##### Verify proper installation of isolation barriers and door latches for arc resistant models.

##### Check arc flash warning labels and arc flash labels required by NFPA 70E

#### Verify structure, grounding, cables and bus assembly:

##### Anchorage (per local codes, wind and seismic considerations)

##### Required area clearances, correct alignment and cleanliness.

##### Verify the grounding electrode conductor is properly sized and terminated.

##### The proper grounding of instruments, panels and connections.

##### That conductors are properly identified (as applicable).

##### Cable termination tightness

##### That all cables have been properly installed routed and supported and are clear of energized parts. Check power cables’ color code per the DISTRICT’s standards

##### That conduits and conduit bushings are correctly installed

##### Unused openings have been properly closed and secured

##### Verify factory connections by checking at least 10% of the total factory connections for tightness. If this spot check reveals loose connections, proceed to check all factory connections. These connections include bus hardware connections, circuit breaker and switch terminals, contactors, metering, and other connections, including the incoming terminals.

##### That filters are in place and/or vents are clear from obstructions

#### Verify control and instrumentation (as applicable):

##### All VT and CT ratios properly correspond to drawings and that polarity is correct

##### Shorting screws and bars are removed from CT’s and terminal blocks as required

##### Each current transformer is connected to a load, or a secondary shorting bar is installed.

##### Primary and secondary fuse ratings or circuit breakers match drawings

##### Meter scaling and type match drawings

##### All control wirings are properly identified with tags as per the Design Documents

#### Verify Key Interlock System (as applicable):

##### Key number and exchange codes

##### Proper sequencing to comply with drawing notes

##### Attempt to close locked-open devices

##### Attempt to open locked-closed devices

##### Make key exchange with devices operated in off-normal positions

##### Disposition of duplicate keys per the owner’s safety policy

#### Motor starter units:

##### Compare power and control circuits for agreement with the MCC wiring diagrams

##### Verify proper operating handle adjustment and safety interlock.

##### Verify tightness of power and control connections.

##### Inspect switches and indicating lights for proper operation.

##### Verify proper insertion alignment of starter buckets and operation of safety interlocks and position indicators (Flashgard).

##### Verify the operation of the automatic shutters (labyrinth vertical barrier system).

##### Manually exercise switches, circuit breakers, motor circuit protectors, and other operating mechanisms to verify they are properly aligned and operate freely

##### Set and adjust current and voltage trip mechanisms to the value specified by the DISTRICT. If no values are specified default settings will be applied.

##### Verify overload heater elements are installed and selected per the FLA shown on the nameplate of each motor.

### Electrical Tests

#### Insulation system:

##### Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground.

#### Control and Instrumentation (as applicable):

##### Perform the following tests on control power transformers:

###### Insulation-resistance measurements from winding-to-winding and each winding-to-ground.

###### Turns ratio test

##### Perform the following tests on voltage transformers:

###### Insulation-resistance measurements from winding-to-winding and each winding-to-ground.

###### Polarity

##### Verify correct function of control power transfer relays.

##### Verify operation of heaters.

##### Perform the following tests on current transformers in accordance with the testing methods in ANSI/IEEE C57.13.1:

###### Ratio

###### Polarity

#### Test protective devices in accordance with applicable specification section.

#### Test switches in accordance with applicable specification section.

#### Ground fault system (as applicable):

##### Perform ground-fault test in accordance with Ground Fault or Circuit Breaker testing specification.

#### Set up all metering and power monitoring devices in accordance with applicable specification section.

#### Motor Control Buckets

##### Test motor starters, variable frequency drives and reduced voltage starters in accordance with applicable specification section.

#### Test all integrated power distribution products in accordance with the applicable specification section.

## MOTOR STARTERS – LOW VOLTAGE

### Mechanical and Visual Inspection

#### Motor starter units:

##### Compare power and control circuits for agreement with the MCC wiring diagrams

##### Verify proper operating handle adjustment.

##### Verify tightness of power and control connections.

##### Inspect switches and indicating lights for proper operation.

##### Verify proper insertion alignment of starter buckets and operation of safety interlocks and position indicators (Flashgard).

##### Verify the operation of the automatic shutters (labyrinth vertical barrier system).

##### Manually exercise switches, circuit breakers, motor circuit protectors, and other operating mechanisms to verify they are properly aligned and operate freely

##### Set and adjust current and voltage trip mechanisms to the value specified by the DISTRICT. If no values are specified default settings will be applied.

### Electrical Tests

#### Insulation system:

##### Perform insulation-resistance tests on each starter, phase-to-phase and phase-to-ground with the starter “closed” and across each pole with the starter “open”. Values shall be in accordance with manufacturer's published data.

#### Test motor protection devices in accordance with the manufacturer instruction book.

#### Measure and record the contact resistance of the disconnect for the motor starter.

## PANELBOARDS

### Mechanical and Visual Inspection

#### Examine the panelboard, including breakers, and accessories for:

##### Shipped loose and shipped short components

##### Shipping damage

##### Loose or obviously damaged components

##### Proper identification of the panel and the individual loads served.

##### Physical damage from installation

##### Doors, panels, and sections for alignment, dents, scratches, fit, and missing hardware

##### Maintenance accessories for servicing and operating all devices

##### Ensue any packing material used for shipment have been removed

#### Inspect:

##### Insulators for evidence of physical damage or contaminated surfaces

##### Surge Arrester and/or Surge Suppression (as applicable)

##### Alignment and penetration of instrument transformer withdrawal disconnects, current carrying, and grounding components (as applicable)

##### Control power transformers (as applicable)

##### Wiring for damaged insulation, broken leads, proper crimping, and overall general condition

##### Fuse clip contact pressure and contact means (as applicable)

#### Verify structure, grounding, cables and bus assembly:

##### Cable termination tightness

##### That all cables have been properly installed, routed and supported and are clear of energized parts

##### That conduits and conduit bushings are correctly installed

##### Unused openings have been properly closed and secured

##### Verify factory connections by checking at least 10% of the total factory connections for tightness. If this spot check reveals loose connections, proceed to check all factory connections. These connections include bus hardware connections, circuit breaker and switch terminals, contactors, metering, and other connections, including the incoming terminals.

##### That filters are in place and/or vents are clear from obstructions

##### Verify all ground connections have been made properly

#### Verify control and instrumentation (as applicable):

##### All VT and CT ratios properly correspond to drawings and that polarity is correct

##### Shorting screws and bars are removed from CT’s and terminal blocks as required

##### Primary and secondary fuse ratings or circuit breakers match drawings

##### Meter scaling and type match drawings

##### Verify Key Interlock System (as applicable):

##### Key number and exchange codes

##### Proper sequencing to comply with drawing notes

##### Attempt to close locked-open devices

##### Attempt to open locked-closed devices

##### Make key exchange with devices operated in off-normal positions

##### Disposition of duplicate keys per the owner’s safety policy

### ELECTRICAL TESTS

#### Insulation system:

##### Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground.

#### Control and Instrumentation (as applicable):

##### Perform the following tests on control power transformers:

###### Insulation-resistance measurements from winding-to-winding and each winding-to-ground.

###### Turns ratio test

##### Perform the following tests on voltage transformers:

###### Insulation-resistance measurements from winding-to-winding and each winding-to-ground.

###### Polarity

#### Verify correct function of control power transfer relays.

#### Verify operation of heaters.

#### Perform the following tests on current transformers in accordance with the testing methods in ANSI/IEEE C57.13.1

##### Ratio

##### Polarity

#### Verify operation of all overcurrent protective devices equal to and greater than 200A per the appropriate specification section.

#### Test switches in accordance with applicable specification section.

#### Test surge arresters in accordance with applicable specification section.

#### Ground fault system (as applicable):

##### Perform ground-fault test in accordance with Ground Fault or Circuit Breaker testing specification (as applicable).

#### Set up all metering and power monitoring devices in accordance with applicable specification section. Check devices’ communication for devices provided with digital link such as ETHERNET communication port.

## SOLID-STATE REDUCED VOLTAGE STARTER - LOW VOLTAGE

### Mechanical and Visual Inspection

#### Examine the solid-state reduced voltage starter installation

* + - * 1. Shipped loose and shipped short components
        2. Shipping damage
        3. Loose or obviously damaged components
        4. Proper identification
        5. Physical damage from installation

#### Inspect:

##### Inspect grounding connections

##### Insulators for evidence of physical damage or contaminated surfaces.

##### Wiring for damaged insulation, broken leads, proper crimping, and overall general condition

#### Review the solid-state reduced voltage starter sizing with the motor sizing and application requirements.

#### Review automation system to be used (as applicable) with solid-state reduced voltage starter

#### Perform safety inspection of the solid-state reduced voltage starter installation and its associated equipment.

##### Tag and lock out all power sources to the solid-state reduced voltage starter according to the end users and commissioner’s policies until the commissioner is prepared to energize the solid-state reduced voltage starter.

##### Perform a walk around of the application and equipment to determine level of preparedness for operation.

##### Survey the installation environment to ensure it is safe and is within Electrical solid-state reduced voltage starter ambient specifications for operation.

##### Establish whether solid-state reduced voltage starter testing will be performed with or without its load attached.

##### Have end user representative prepare equipment if necessary.

#### Review solid-state reduced voltage starter and its connected load for proper installation.

##### Incoming power, outgoing motor, and control wiring are each in their own conduit.

##### All wiring has been accomplished to manufacturer’s specifications for the size of the solid-state reduced voltage starter and its connected load.

##### The solid-state reduced voltage starter is clean and free of installation debris, equipment, or tools.

### Initial Energization

#### Perform Pre-Power meter checks.

##### Compare power and RVSS control circuits for agreement with the factory wiring diagrams

##### Verify that each motor is connected to the correct starter

##### Manually exercise switches, circuit breakers, and other operating mechanisms to verify they are properly aligned and operate freely

##### Set all parameter values and DIP Switches on IT

##### Record As-Found and As-Left settings

##### Verify that power circuit fuses in fusible switches are in accordance to NEC application requirements

#### Perform initial power on safety checks.

##### Confirm that all power is still tagged and locked out to the solid-state reduced voltage starter.

##### If disconnected, reconnect the line and/or motor leads.

##### Ensure all appropriate control wiring has been reconnected.

##### Conduct a walk around of the solid-state reduced voltage starter and its connected load.

##### Remove tags and locks for the disconnect supplying power to the solid-state reduced voltage starter disconnect.

##### When safe, energize the disconnect that supplies power to the solid-state reduced voltage starter disconnect.

#### Setting the solid-state reduced voltage starter parameters

##### Program solid-state reduced voltage starter parameters as specified by the DISTRICT and in accordance manufacturer’s model-specific instructions. Record all settings.

##### Typical parameters would include

###### Motor name plate information

###### Solid-state reduced voltage starter controls

###### Motor protections

###### Check motor direction of rotation

Have customer / DISTRICT representative confirm that the motor is ready to rotate.

Bump the motor to check its direction of rotation in the following order:

Check rotation from the solid-state reduced voltage starter.

After checking solid-state reduced voltage starter rotation if a bypass is used, check rotation from the bypass.

###### Operation of the RVSS and Motor

It is preferred that the testing from this point on be done with the motor coupled to the normal operating load.

Testing of an unload application or just a motor is valid but should be noted in the commissioning documentation.

Perform operational checks in accordance with manufacturer’s model-specific instructions

Record settings and submit in report

## disconnect SWITCH – LOW VOLTAGE

### Mechanical and Visual Inspection

#### Examine switch for:

##### Shipping damage

##### Loose or obviously damaged components

##### Primary lead connection tightness

##### Fuses rating and type (as applicable)

##### Compliance to design drawings such as voltage, current ratings, NEMA Type

##### Correct blade alignment and penetration

##### Proper installation of line and load conductors

##### Correct operation of indicating and control devices.

##### Proper lubrication on moving parts

##### Safety interlocks and padlockable mechanism

##### Arc flash label

#### With switch open, inspect:

##### Fuse clips

##### Insulators

##### Mechanical and safety interlocks (as applicable)

##### Mounting

##### Cable terminations with color codes and tags

### Electrical Tests

#### Measure contact resistance across each switchblade and fuse holder.

#### Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground for one minute with switch closed, and across each open pole.

#### Test fuse resistance (if applicable)

#### Verify proper operation of all status indicators

#### Functional Tests only for switches with Motor Operator

##### Verify control power for close and trip functions

##### Verify the electrical operation of each electrically operated breaker

###### Perform trip and close tests

##### Verify operation of the switch from local switches or terminal blocks

## SWITCHBOARDS – LOW VOLTAGE (600v or less)

### Mechanical and Visual Inspection

#### Examine the switchboard line-up, including breakers, and accessories for:

##### Shipped loose and shipped short components

##### Shipping damage

##### Loose or obviously damaged components

##### Proper identification

##### Physical damage from installation

##### Doors, panels, and sections for alignment, dents, scratches, fit, and missing hardware

##### Maintenance accessories for servicing and operating all devices

##### Ensure any packing material used for shipment have been removed

#### Inspect:

##### Shipping Splits to ensure that all bus connections were properly connected and all control wiring splits have been properly terminated by contractor.

##### Remove all temporary wiring for heaters if equipped

##### Inspect grounding connections

##### Insulators for evidence of physical damage or contaminated surfaces

##### Surge Arrester and/or Surge Suppression (as applicable)

##### Breaker Cell(s), Primary and Secondary Disconnects for physical condition, cleanliness and lubrication (as applicable)

##### Alignment and penetration of instrument transformer withdrawal disconnects, current carrying, and grounding components (as applicable)

##### Control power transformers (as applicable)

##### Wiring for damaged insulation, broken leads, proper crimping, and overall general condition

##### Fuse clip contact pressure and contact means (as applicable)

#### Verify structure, grounding, cables and bus assembly:

##### Anchorage (per local codes, wind and seismic considerations)

##### Required area clearances, correct alignment and cleanliness.

##### Verify the grounding electrode conductor is properly sized.

##### The proper grounding of instruments, panels and connections.

##### That conductors are properly identified (as applicable)

##### Cable termination tightness

##### That all cables have been properly installed, routed and supported and are clear of energized parts

##### That conduits and conduit bushings are correctly installed

##### Unused openings have been properly closed and secured

##### Verify factory connections by checking at least 10% of the total factory connections for tightness. If this spot check reveals loose connections, proceed to check all factory connections. These connections include bus hardware connections, circuit breaker and switch terminals, contactors, metering, and other connections, including the incoming terminals.

##### Correct barrier and shutter installation and operation

##### That filters are in place and/or vents are clear from obstructions

#### Verify control and instrumentation (as applicable):

##### All VT and CT ratios properly correspond to drawings and that polarity is correct

##### Shorting screws and bars are removed from CT’s and terminal blocks as required

##### Primary and secondary fuse ratings or circuit breakers match drawings

##### Meter scaling and type match drawings

#### Verify the proper operation of all circuit breaker cell and safety interlocks operation for fail-safe function.

##### Verify cell rejection plates are properly aligned and draw-out circuit breakers cannot be inserted into cells with the circuit breakers in the “closed” position.

##### Verify Key Interlock System (as applicable):

##### Key number and exchange codes

##### Proper sequencing to comply with drawing notes

##### Attempt to close locked-open devices

##### Attempt to open locked-closed devices

##### Make key exchange with devices operated in off-normal positions

##### Disposition of duplicate keys per the DISTRICT’s safety policy

### Electrical Tests

#### Insulation system:

##### Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground.

#### Control and Instrumentation (as applicable):

##### Perform the following tests on control power transformers:

###### Insulation-resistance measurements from winding-to-winding and each winding-to-ground.

###### Turns ratio test

##### Perform the following tests on voltage transformers:

###### Insulation-resistance measurements from winding-to-winding and each winding-to-ground.

###### Polarity

##### Verify correct function of control power transfer relays.

##### Verify operation of heaters.

##### Perform the following tests on current transformers in accordance with the testing methods in ANSI/IEEE C57.13.1:

###### Ratio

###### Polarity

###### Ground fault system (as applicable):

Perform ground-fault test in accordance with Ground Fault or applicable circuit breaker specification section.

###### Verify operation of all protective devices equal to and greater than 200A per the appropriate specification section.

###### Test switches in accordance with applicable specification section.

###### Test surge arresters in accordance with applicable specification section

###### Set up all metering and power monitoring devices in accordance with applicable specification section.

###### Test all integrated power distribution products in accordance with the applicable specification section.

##### Check and test electronic metering installed in the switchboard as per design documents.

## SYNCHRONOUS GENERATOR

### Mechanical and Visual Inspection

#### Examine generator for:

##### Shipped loose and shipped short components

##### Shipping damage

##### Loose or obviously damaged

###### Frame

###### Termination box

###### Shaft

###### Tachometer

###### Brake

###### Zero speed switch

###### Mounting feet or flange

##### Proper generator lubrication

##### Coupling alignment and lubrication

##### Proper identification

##### Compliance to drawings

##### Customer field connections and signals

##### Remove temporary heater wiring and shipping braces

#### Inspect:

##### All grounding connections

##### Insulators for evidence of physical damage or contaminated surfaces

##### Surge Arrestor and/or Surge Suppression size, type, installation and connection to determine if they are in accordance with the drawings.

##### Wiring for damaged insulation, broken leads, tightness of connections, proper crimping, and overall general condition

#### Verify structure, grounding, cables and bus assembly for:

##### Anchorage (per local codes, wind and seismic considerations)

##### Required area clearances, correct alignment and cleanliness.

##### That the grounding electrode conductor is properly sized and connected.

##### That conductors are properly identified.

##### Cable and control wire termination tightness

##### That all cables have been properly installed, routed and supported

##### That conduits and conduit bushings are correctly installed

##### Unused openings have been properly closed and secured

##### Tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturers published data

##### That blocks or other temporary holding means used for shipment have been removed from the generator

##### That filters are in place and/or vents are clear from obstructions

#### Inspect and test the generator field and resistor circuit:

##### Disconnect the generator field leads from terminals

##### Generator collector rings must be clean and concentric

##### Generator brushes must be new, seated, free in the brush holders with the proper spring tension, and all brush lead connections clean and tight

##### Generator field lead terminations must be clean and tight

### Electrical Tests

#### Perform an insulation resistance test in accordance with ANSI/IEEE Standard 43

#### Perform dielectric absorption tests on each phase separately for 10 minutes. Calculate polarization index.

#### Measure resistance of Wye connections.

## automatic TRANSFER SWITCHES – LOW VOLTAGE

### Mechanical and Visual Inspection

#### Examine controller and accessories for:

##### Shipped loose and shipped short components

##### Shipping damage

##### Loose or obviously damaged components

##### Proper identification

##### Physical damage from installation

##### Alignment, dents, scratches, fit, and missing hardware

##### Arc flash label and labels as per Power System Study

#### Inspect:

##### All connections for tightness

##### Potential transformers for proper rating, polarity and wiring for all power sources

##### For multi-tap potential transformers check that connections match applied system voltage

##### Make sure a copy of the as-built is readily available in the inside pocket holder

##### Check power cables’ color codes and make sure phase rotation is correct

#### Perform the mechanical and visual inspections in the appropriate Site Acceptance Testing & Start-up Guideline for circuit breaker and contactor components.

### ELECTRICAL AND FUNCTION TESTS

#### Verifying equipment is ready for electrical testing:

##### Remove and account for all test equipment, jumper wires, and tools used during installation

##### Replace all barriers and covers

#### Simulate control power to the Automatic Transfer Controller (ATC)

#### Program settings per manufacturer’s instructions and setting provided by the DISTRICT to configure the ATC (Note: DISTRICT to provide settings prior to commencement of acceptance testing.)

#### Apply simulated source voltages to the ATC

#### Ensure that all operational LED indicators on the front of the display are as described in the IB for the system conditions

#### Perform a functional test of the manual operation

#### Perform a functional test of the Engine start contact using the test button on the front of the controller

#### Perform a functional test of the automatic transfer switch in accordance with the specific ATC instruction book.

## EVALUATION OF TEST DATA

### Test results should be evaluated in accordance with the manufacturer’s published data.

## RESTORATION OF EQUIPMENT AND REPORTS

### Before energizing:

#### Remove and account for all test equipment, jumper wires, and tools used during testing.

#### Remove and account for safety grounds and tools.

#### Replace all barriers and covers, close all doors, and secure all latches.

#### Remove safety locks and tags.

#### Ensure all adjustable meters, relays and trip devices are properly set in accordance with the coordination study.

#### Apply testing label to equipment

### Note corrective actions taken, deficiencies, recommendations, and any general comments.

### Finish recording data on test forms, completely filling in the blanks. Enter into electronic database as required in section 1.04.E

### Turn in 3 copies of report to the DISTRICT for review and approval.

## START-UP AND ENERGIZING SERVICES

### Provide a manufacturer service representative to assist the contractor with startup and energization of all of the electrical apparatus.

## THERMAL IMAGING

### Provide IR scans of all Switchboard, MCC, ATS, Panelboard and Transformer connections 30 days from Start-up. Provide the DISTRICT with a pre-paid Purchase Order for follow-up scan of the same equipment

end of section