# ATTACHMENT H

# Battery Energy Storage System (BESS) Technical Specifications and Interconnection Requirements

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**BESS Technical Specifications**

## 1. Introduction

Policy 25-01 communicates the guidelines to build a new facility on Tract J of the Port of Alaska (POA). It is based on applicable rules and tariffs crafted by the Federal Energy Regulatory Agency (FERC) and Alaskan agencies with jurisdictional authority over the project.

This policy addresses technical requirements for establishing and maintaining the BESS interconnection as well as certain aspects of cost responsibility. This policy covers interconnection of inverter and potentially non-inverter-based systems to the utility grid at a nominal voltage of 34.5 kilovolts (kV).

This policy is intended to augment a set of Technical Specifications developed for the POA by Chugach Electric Association (CEA). In the case of conflict between Policy 25-01 and the CEA Technical Specifications, please consult with POA for resolution.

### 1.1 Definitions

Battery Energy Storage System (BESS): A system of batteries, protection and control equipment, transformers, and buswork designed to deliver electrical power on a utility scale.

Electric Power System (EPS): Facilities owned and operated by the local electric utility (Chugach Electric Association 'CEA' in the case of the BESS point of interconnection).

Port of Alaska Engineering (POAE): The owner of this Policy and the agency to be contacted to resolve conflicts between this Policy and other standards or rules.

System Operator: The entity responsible for operating and dispatching the Electric Power System

### 1.2 Applicability

This Policy applies to the proposed BESS located on Tract J, Port of Alaska and supporting equipment. It is anticipated that additional technical specifications may arise out of future commercial arrangements. Chugach Electric Association (CEA) has produced a technical document to support the Port's BESS construction. Both this CEA technical document and Policy 25-01 apply to the project. In the case of conflict, consult with the Port Engineer for resolution.

1.3 Policy for Interconnection of BESS

These interconnection procedures are outlined by the appropriate rule or tariff associated with the facility size and point of interconnection.

1.4 Interconnection Costs

1.4.1 Because of the unique nature of the project, expenses associated with the BESS are subject to separate agreements beyond traditional rules or tariffs. CEA shall perform interconnection studies as required to identify any additions or modifications needed to the power system on or before May 1, 2026, and communicate these requirements to POAE.

1.4.2 The specifics of interconnection cost responsibilities will be determined by jurisdictional agreement, rule, tariff, or separate agreement.

1.5 Utility-Owned Equipment Requirements

1.5.1 POA is responsible for the design and construction of equipment it owns on its side of the interconnection.

1.5.2 CEA is responsible for the design and construction of equipment it owns on both sides of the interconnection, specifically mentioning communications systems supporting POA equipment.

1.6 General Interconnection Requirements

1.6.1 Where there is direct conflict between Policy 25-01 and the applicable rule or tariff, the rule of tariff shall prevail.

**2. BESS Performance Requirements**

2.1 Connecting and Disconnecting from Grid

2.1.1 When entering service, follow the requirements as specified in IEEE 1547 clause 4.10. These include the allowable voltage and frequency ranges, and performance when entering service.

2.1.2 Requirements for synchronization are specified in IEEE 1547 clause 4.10.4. These requirements provide maximum voltage step changes when synchronizing and synchronization parameter limits.

2.1.3 Automatic Lockout- protective functions shall include an automatic means to prevent the BESS from re-energizing a de-energized EPS.

2.2 Normal Operation

2.2.1 The Normal Voltage Operating Range for the BESS should be between 0.95 and 1.05 per unit. Operation outside this range is time-limited in nature in accordance with high- and low-voltage ride through requirements.

2.2.2 The Normal Frequency Operating Range is between 59.5 and 60.5 Hz. Operation outside if this range is time-limited in nature in accordance with high-and low-frequency ride-through requirements.

2.2.3 Power Factor- Unless otherwise specified in the executed contract or activated regulation function, the BESS shall operate automatically within a range of a power factor of 0.95 (either leading or lagging) or better at the point of interconnection.

2.2.4 Voltage Regulation Capability- The BESS shall have all the voltage regulation specified by IEEE 1547 clause 5 under “Category B” which includes constant power factor, voltage reactive power (Volt-VAr), active-reactive power (Watt-Var) constant reactive power (Fixed Q), and voltage-active power (Volt-Watt) modes. This functionality is to be disabled by default and may be activated by the Port.

2.2.5 Reactive Power Capability- The BESS needs to be capable of injecting or absorbing reactive power as required by voltage regulation functions, up to 44% of the MVA nameplate, or any active power output above 20% of the rated Active power.

2.2.6 Voltage Fluctuation Limits- In normal operation the BESS shall not cause repetitive changes of power output leading to voltage fluctuations.

2.2.7 Harmonic Limits- The BESS shall comply with any voltage and current harmonic limits in place at the time of the interconnection agreement. The Port shall not be liable for compliance requirements that arise after project approval.

2.2.8 DC Injection- Direct current, or a DC-offset, from the BESS is restricted because low levels can saturate instrumentation and interconnection transformers causing mis operation of equipment. The BESS shall not inject DC greater than 0.5% of the full rated output current at the point of interconnection.

2.2.9 Maintaining Phase-Voltage Balance- The BESS shall maintain a balanced power output during normal operations. The BESS should not create current unbalance that causes above 3% unbalance in service to other users.

2.3 <u>Responding to Abnormal Grid Conditions</u>

2.3.1 Unintended Islanding Detection. Anti-islanding capabilities are required for the BESS. The anti-islanding protection shall trip the BESS within two seconds of the formation of an island (loss of grid power). Trip time for the BESS will need to be coordinated with the local EPS distribution system. This may require additional equipment such as transfer trip or a suitable alternative. Additional requirements for anti-islanding protection are specified in IEEE 1547 Clause 8.1.

2.3.2 Voltage Ride Through and Trip- The BESS shall be configured for ride-through of abnormal voltages and tripping offline as described by the requirements in IEEE 1547 Clause 6.4.2. This functionality shall be enabled by default, unless otherwise specified by POAE.

2.3.3 Frequency Ride Through and Trip- The BESS shall be configured for (at a minimum) reducing active power output if the system frequency exceeds the value specified in IEEE 1547 in Clause 6, that being 60.036 Hz. If Alaska Railbelt standards differ, they shall govern. This function shall be enabled by default.

2.3.4 Frequency Regulation Capability- The BESS shall be configured for (at a minimum) reducing active power output if the system frequency exceeds the value specified in IEEE 1547 in Clause 6, that being 60.036Hz. If Alaska

Railbelt Standards set a different frequency, this shall govern. This function shall be enabled by default.

2.3.5 Limit Active Power- The BESS shall be capable of limiting active power as a percentage of the nameplate active power rating as described in IEEE 1547 Clause 4.6.2.

2.3.6 Limits on Transient Overvoltage from the BESS- The BESS shall not, by its design or application, cause transient overvoltages that may exceed utility or customer equipment tolerances. Events leading to over voltages include interaction of the BESS during ground faults, with grid switching transients, or from disconnection of the BESS. Specific limits are defined in IEEE 1547 Clause 7.4.

2.3.7 Open-Phase Conditions- The BESS must be able to sense open-phase conditions, cease to energize, and trip within 2 seconds. See IEEE 1547 Clause 4.1.

**3. Required Equipment and Metering**

3.1 <u>Facility Protective Equipment</u>

3.1.1 General- The BESS shall be designed and operated in such a manner that there are no noticeable adverse impacts to system voltage, frequency, harmonics, etc.

3.1.2 Listed Equipment- Fault interrupting devices located at the point of interconnection (POI) must be certified or listed (as defined in the latest edition of the National Electrical Code) as suitable for their intended application. This includes being able to interrupt the maximum available fault current expected at their location.

3.1.3 Visible Disconnect- Two manual-operated, unitized load-break disconnect switches located near the POI are required. The switches shall be used to establish visual-open working clearance for maintenance and repair work in accordance with Port rules and practices. The first switch shall be located on the Port side of the meter structure. This switch will be owned, operated, and maintained by the Port. The second switch is to be owned, operated, and maintained by the owner of the Electric Power System (EPS). During normal operation, the Port will notify the EPS Dispatch Center in advance of the operation of a disconnect switch. In the event of an emergency, this may not be possible.

3.1.4 Visible Disconnect Materials- The switches shall be gang operated and able to be locked open. These switches should not be used to break or make parallel operation between the BESS and the EPS.

3.1.5 Fault-Interrupting Devices- The type of fault interrupting device (breaker or recloser) and its protection and control system shall be determined as a part of site design. All fault interrupting devices shall comply with existing national and regional codes.

3.1.6 Protective Relaying- All relays must be multifunction microprocessor-based devices, from a list of Port-approved manufacturers. The relay supporting the interrupting device may contain all the functions for line and transformer overcurrent protection and, in addition, the overvoltage, undervoltage, over frequency, and underfrequency relay elements mentioned in the next section. If transfer trip is required, the relay must have the capability to communicate with the Mirrored Bits protocol.

3.1.7 Electromagnetic Interference- IEEE 1547 Clause 4.11.1 identifies the BESS immunity requirements for performance-critical controls and protections.

3.1.8 Surge Withstand- Voltage and current surge withstand requirements for the BESS are specified in IEEE 1547 Clause 4.11.2.

3.1.9 Direct Transfer Trip- The Protection and Control designer will determine if a direct transfer trip from neighboring power system to the BESS isolation device is necessary.

3.1.10 Voltage Regulator Bank- The regulator bank, if needed, must be able to maintain the generator voltage under stead state conditions without hunting and within +- 0.5% of any voltage level between 95% and 105% of the rated generator.

3.1.11 Power Factor Controller- The controller must be able to maintain a power factor setting within plus or minus 1 percent of the setting at full load at any set point between 95% lagging and 95% leading.

3.1.12 Data Gathering/ Event Recorder- The BESS shall have an event recorder to investigate operational difficulties. The event recorder shall provide the Port with sufficient information to determine the status of the BESS during system disturbances. The event recorder shall provide remote access from the POAE offices.

3.2 <u>Interconnection Transformer</u>

3.2.1 Winding Configurations- The following winding configuration requirements shall apply to the BESS:

3.2.1.1 Acceptable: Grounded Wye / Grounded Wye; Grounded Wye / Wye; and Grounded Wye / Delta.

3.2.1.2 Conditionally Acceptable: Delta / Delta; Delta /Wye; Delta / Grounded Wye

3.2.2 Basic Insulation Levels (BIL)- The rating of the BESS transformers shall not be less than 200kV.

3.3 <u>Grounding Transformer</u>- A grounding bank transformer is required. It can use either a wye-delta or zig-zag configuration. In either case, the connection of the grounding transformer must be configured to ensure the grounding transformer is in service when the BESS is in operation and is disconnected when the BESS is disconnected.

3.4 <u>Metering</u>

3.4.1 Introduction- The general requirements for BESS metering are like common utility metering. The Port requires that a meter be provided on the Port side of the interconnection and defers to CEA for requirements on the EPS side of the interconnection. Separate station service load metering is not required.

3.4.2 Basic Meter Programs- The meter will include (1) Bi-directional Active (MWh and Reactive (MVARh) (2) Sliding, Peak Demand (MW) Quantities; and (3) Interval MW, MVAR, Voltage, and Amperage data.

3.4.3 Port Visibility of Metering Data- The BESS metering data shall be viewable from POAE offices.

3.4.4 Primary Metering- The metering requirements will be defined during the facility design.

3.4.5 Control House- The BESS requires installation of a standard 12” by 90” meter panel inside a control house. The BESS project will include this feature.

3.5 Instrument Transformers- The BESS project design shall include instrument transformers at a rating and accuracy level to be specified by the design consultant.

3.6 Modifications to Equipment

3.6.1 Reach and Fault Clearing Time- The Port does not have access to utility protection and control coordination information. The relays associated with the fault interrupting device at the BESS must be designed to identify faults and isolate the BESS should system conditions arise that are potentially hazardous for the equipment. The design engineer shall coordinate with utility staff to deliver this protection.

3.6.2 Automatic Reclosing- A deadline check is required prior to automatic reclosing. The BESS shall not reclose into a dead circuit.

3.6.3 As the Port has no visibility of any constraints EPS may be subject to, the EPS operator shall be responsible for confirming that the BESS is compatible with local system transformers, protection and control equipment, and other substation equipment.

## 4. Telecommunications Requirements for the BESS

4.1 Application- The design consultant shall specify the protection, metering, SCADA, and electronic channels that will be required. Due to the highly specialized and critical nature of the electronic communication equipment, this design shall be approved by the EPS operator. Upon completion of project commissioning, ownership the communications equipment shall be delivered to the EPS operator. Expenses associated with ongoing operations shall be covered by the Power Purchase Agreement.

4.2 General Requirements- It is anticipated that a basic phone circuit will be adequate for BESS communications. The design engineer shall be responsible for acquiring the communications lines from a local phone company. He shall coordinate his work with the local EPS operator.

## 5. Commissioning and Testing Policy and Inspection Procedures for the BESS

5.1 General- The commissioning engineer shall provide full commissioning services for the BESS in compliance with IEEE 1547 and UL 1741. A project commissioning and testing plan (hereafter referred to as “the plan”) shall be prepared and certified (stamped and signed) by a professional engineer, preferably licensed in

Alaska. The plan shall be submitted to POAE a minimum of one month prior to energizing the BESS for the first time to allow for review, feedback, and approval.

5.2 Commissioning Engineer- The commissioning engineer shall provide a plan that considers all aspects of the BESS' potential impact on the local EPS and coordinates his/her work with the EPS operator. The commissioning plan shall consist of three parts: Manufacturing and Production Tests; Confirmation of Proper Installation and Settings, and Commissioning Tests.

5.3 Manufacturing and Production Tests-The following are required as part of the Manufacturing and Production Tests:

5.3.1 The utility voltage and frequency variation test procedure described in UL 1741 Section 68 shall be performed as part of routine production on all inverters used in the BESS. This testing may be performed in the factory or as part of a commissioning test. This testing ensures that the inverter ceases to deliver power to the EPS within a specified time for specified conditions.

5.3.2 A demonstration that the failure of a single generation system component will not cause a safety or power quality problem on the EPS.

5.3.3 The manufacturing and production tests as specified in Appendix D must be completed, and two copies of the test reports must be submitted to the Port Engineer two weeks prior to initial commissioning date.

5.4 Confirmation of Proper Installation and Settings- Confirmation of proper installation and settings must be performed once the BESS has been installed in the field. Inspections must be performed to verify-

5.4.1 The installation is built as planned according to the initial design reviewed and accepted by the Port.

5.4.2 Inverter and external relay settings are set according to the requirements in Section 2.

5.4.3 Required protective equipment and metering are installed as specified in Section 3.

5.4.4 Telecommunications requirements are met according to Section 4.

5.5 Commissioning Tests- Commissioning tests shall be performed by the commissioning engineer under the supervision of a professional engineer after installation and settings have been confirmed. The Port shall begiven the opportunity to witness the testing process. However, the Port's involvement will not relieve the commissioning engineer from his sole responsibility to verify the proper operation of the BESS. If equipment performance is found to be satisfactory, the final certification will be issued by the design engineer. Following the final certification, the BESS may be placed into operation. The following commissioning tests are the minimum-

5.5.1 Single-Phase Open: The BESS shall follow open-phase condition requirements per IEEE1547 Clause 6.2.2;

5.5.2 All-Phase Open: The BESS shall follow the cease to energize performance in IEEE 1547 Clause 4.5;

5.5.3 Return-to-Service: The BESS shall follow the return-to-service criteria in IEEE 1547 Clause 6.6 and Clause 4.10;

5.5.4 Verify Fixed Reactive Power: The BESS shall provide voltage regulation capability by changes in reactive power according to IEEE 1547 Clause 5.3. The fixed power factor mode may be tested if required, as specified in IEEE 1547 Clause 5.3.2.

5.5.5 Verify Telemetry Data: Telemetry data shall be monitored and assessed.

5.6 Pre-Witness Testing Meeting- Following the approval of the commissioning and testing plan, a pre-witness meeting shall be held. The pre-witness testing meeting shall include, as a minimum, the design engineer, the commissioning engineer, the port engineer, and a designated representative authorized by the EPS operator to be their representative. The purpose of the pre-witness testing meeting is to review the plan and ensure all parties understand their roles and responsibilities.

5.7 Establishing the Commissioning Date- The 'Initial Commissioning Date' shall be the date on which the Interconnection Customer test synchronized and performs a load-test on the BESS. The 'Final Commissioning Date' shall be the date when the BESS enters commercial operation. The Port shall strive to give EPS operator 30 days' notice of the proposed initial commissioning date. This date can be scheduled when the following conditions are met:

5.7.1 The manufacturing and production plan has been submitted and accepted.

5.7.2 The design engineer shall submit a report certified with a professional seal, covering all aspects of the commissioning and testing plan to be completed before commissioning with the following statement: "I have reviewed the installation of this project and its protection and control system and find it ready to perform settings verification and commissioning tests."

5.7.3 Following settings verifications and commissioning tests of the BESS, the design engineer shall review the performance of the equipment, and if satisfied, complete the commissioning report. The final report shall state the following: "I have reviewed the commissioning test results of this project and find it ready to enter commercial operation." This statement shall include a professional seal.

5.8 Warning Label for Protective Relays- Following commissioning, a warning label shall be affixed within 6 inches of any relay in the BESS control house that affects the operation of the BESS. The warning shall state the following: *"Warning!!! DO NOT alter or change any setting to this relay without first receiving approval from the Port Engineer. Failure to give notification of this action may result in damaged or destroyed electrical equipment, possible physical injury or death, and/or legal action."*

5.9 Design Changes after Final Commissioning- Any modification to the BESS facility impacting the protection and control system must be reviewed and approved by the Port Engineer. A demonstration of relay calibration, trip tests, and online tests may be required depending on the extent of the design change. Setting changes of any interconnection protection or synchronizing device must be approved by the Port Engineer and the EPS operator with a copy of the changes forwarded to both Parties.

**6. Ownership**

6.1 Ownership and Operation of the BESS- The Port shall own, operate, and maintain the BESS except for specialty equipment listed below which will be owned, operated, and maintained by the EPS operator. Copies of maintenance records for equipment supporting the BESS shall be made available to the Port.

6.1.1 Communications systems other than the feed to the Port.
6.1.2 Current Transformers.
6.1.3 Voltage Transformers.
6.1.4 Utility-side metering if so elected by the EPS Operator.

6.2 Operating Log- An Operating Log shall be provided and maintained with entries being made for change of status, maintenance outages, trip indications, or other unusual conditions found during inspections.

6.3 Communications Between the Port and EPS Operator- The Port and the EPS Operator shall exchange a 24-hours per day, 7-days per week primary and alternate contact information and keep the information current. The following information shall be openly communicated-

6.3.1 BESS problems that could lead to mis-operation.
6.3.2 Planned maintenance that affects the BESS.
6.3.3 Unplanned trips of the BESS.
6.3.4 Switching operations that could impact the BESS.
6.3.5 BESS being taken off-line or being returned to service.

**7. Maintenance**

The Port will own and maintain the BESS except for the items listed in Section 6.1. The design engineer shall prepare and certify a BESS maintenance plan that, at a minimum, checks the protection and control components at an interval as recommended by the manufacturer. The maintenance plan shall also include any items recommended by the manufacturers of system components (examples include production battery checks, dissolved gas analysis for transformers, replacing expiring batteries, etc.).

## Appendix A

List of Important Contacts

Jim Jager, Deputy Director of Programs
(907) 538-3277

Bill Carlson, Port Engineer
(907) 268-8097

Dustin Highers, VP Corporate Programs, Chugach Electric Association
(907) 762-4775

# Appendix B

Protection and Control Policy

This section describes the main protection and control requirements for the electrical system associated with interconnection installations. In general, protective relaying principles for electrical power systems are:

• The electrical system must be primarily designed to avoid hazards to customers, Port of Alaska personnel, and the general public;
• Damage to The Port's and utility customers' assets must be minimized in case of faults in the interconnected installations;
• The quality and reliability of service to customers in terms of voltage magnitude, voltage distortion, frequency, and service continuity must be kept within accepted industry tolerances;

The application of these principles follows these minimum design criteria:

• Use relays and interrupting devices to meet fault clearing and restoration times;
• Use overvoltage and undervoltage relay elements to disconnect equipment;
• Use overfrequency and underfrequency relay elements to disconnect equipment;
• Ensure that the neutral grounding agrees with Port and EPS policies regarding insulation, personnel safety, other electrical customers' voltage quality and ground-fault protection.

The principles and design criteria listed in the previous paragraphs use the recommendations in the latest revision of IEEE 1547, as well as Port of Alaska standards, as a basis.
The one-line diagram shown below is an example. The policies here described, which must be used in the design, construction, inspection, and testing of protective devices and associated controls to ensure it is consistent with all Port of Alaska standards and good utility practice.

C.1 Basic Requirements for Protection and Control Equipment

Existing Port-owned protection and control equipment may need to be replaced or modified to accommodate the BESS facility.

C.1.1 Protective Relays

The following are the most relevant aspects of BESS systems as they relate to relays:

• All relays used in new installations must be multifunction microprocessor-based devices. The manufacturers must be on the PacifiCorp list of accepted relay manufacturers (see C.5).
• The relay associated with the Interconnection Customer’s circuit breaker or recloser may contain all the functions for line and transformer overcurrent protection and, in addition, the overvoltage, undervoltage, overfrequency, and underfrequency relay elements mentioned in the next section. Where transfer trip is required, the relay must have the capability of direct communications.
• Existing Port-owned fault interrupting devices and protective relays may need to be replaced or modified to accommodate the BESS facility.

C.2 Relay and Control Settings

Any modifications of control and/or relay settings without review and acknowledgement of acceptance by the Port will be considered a breach of interconnect agreement and could lead to permanent disconnection from the Port’s system.
Should the customer require modification to the settings associated with control/protective devices connected to the distribution and/or transmission system they will contact the Port and provide in writing the justification and/or need for the proposed modifications. This will allow Port time to analyze and ensure there are no negative impacts to the associated connected systems and customers.

# Appendix C

Example of a Testing Procedure

The testing listed below is for reference only, and illustrates the level of detail that is involved with industry standards. The design engineer shall develop and approve the BESS-specific test sequence to confirm proper system operation.

D.1 Manufacturing and Production Commissioning Tests

1. Insulation Resistance Tests: Transformers winding-winding and winding- ground; Circuit breakers pole-pole and pole-ground as applicable to the equipment; buses and cables- phase-phase and phase-ground; dielectric test on insulating medium (gas or oil).
2. Power Transformers: Turns ratio testing.
3. Circuit Breakers and Circuit Switchers: Successful trip at 70% rated DC control voltage; contact resistance testing, trip and close timing tests.
4. Current Transformers and Current Circuits: CT saturation test, check CT polarity, verify excitation test data against manufacturer curves, prove CT ratios, current injection testing to achieve a five-amp secondary current, single- phase burden check on each phase, megger check with ground lifted to verify single ground point.
5. Potential Transformers: Check PT polarity, check turns ratios, verify single ground point.
6. Relay Check-Outs: Minimum pickup, time delay tests at least three test points to verify time delay characteristic curve, phase angle characteristic of directional relay, impedance pickup points at maximum torque angle and ±30°, slip frequency voltage matching phase-angle acceptance and breaker compensation time for synchronizing relays, communications signal level checks on pilot relays.
7. Primary Disconnect Switch: Description and labeling.
8. Functional Tests Post-Energization Pre-Parallel:

a. Check the operation of protective relays on their circuit breakers. Jumpering across contacts at the rear of the relay is not acceptable.
b. Check for proper secondary voltage on all voltage and frequency relays.
c. Check the synchronizing meter, synchronizing equipment, and phasing panel (if used) with the paralleling breaker closed and the generator offline. This typically requires lifting the generator leads. The equipment should show an ‘in-phase’ condition.
d. Check the generator phase rotation (PacifiCorp’s phase rotation is typically A B C counterclockwise). All three phases must be checked using hot sticks with a phasing tool or phasing panel provided by the Interconnection Customer. The synchronizing equipment typically checks one phase only. Interconnection customer to consult with PacifiCorp for area-specific phase rotation information.

D.2 Example of Non-Exporting Test Procedure

Depending upon the interconnection agreement, a non-export requirement may be applicable to the project. Should this non-export requirement be applicable to the project, the engineer shall specify the test procedure and submit it for review and approval by the Port. For illustration purposes only, the following is a series of tests that together constitute a generic non-export test plan.

<u>Power Flow Test</u>

1. Determined the appropriate secondary pickup current for the trip-point export flow.
2. Apply nominal system voltage and apply current in the zero-phase angle tripping direction until the relay trips.
3. Compare the design and field trip-points, which should be within 2%.
4. For relays with adjustable settings, repeat test at midpoint and maximum settings.
5. Repeat steps 1-4 at phase angles of 90°, 180°, and 270° angles. Verify that the relay does not operate.

Leading Power Factor Test

1. Apply rated voltage with a minimum pickup current setting for a leading power factor load current in the non-tripping direction (say 135°).
2. Increase current to relay rated current and verify that the relay does not operate.
3. For relays with adjustable settings, repeat the test for minimum, mid-point, and maximum settings.

<u>Minimum Power Factor Test</u>

4. At nominal voltage and with the field trip point determined in the Power Flow Test, adjust the current phase angle to 84° or 276°.
5. Increase the current level to pick up and verify the relay operates.
6. Repeat for current phase angles of 90°, 180°, and 270° and verify that the relay does not operate.

<u>Negative Sequence Voltage Test</u>

7. At nominal voltage and with the field trip point determined in the Power Flow Test, adjust the current phase angle 180° out of phase on all phases (Ia = 180°, Ib = 300°, Ic = 60°).
8. Remove Va voltage and observe that the relay does not operate.
9. Repeat for Vb and Vc. Load Current Test
10. Using the pickup settings from the Power Flow Test, apply the rated voltage and current at 180° from the tripping direction, to simulate normal load conditions (Ia = 180°, Ib = 300°, Ic = 60°).

Observe that the relay does not operate.

Unbalanced Fault Test

11. Using the pickup settings from the Power Flow Test, apply rated voltage and twice rated current to simulate an unbalanced fault in the non-trip direction (use Va = 0°, Vb = Vc = 180°, Ib = 0°, and Ic = 180°). Observe that the relay does not mis-operate.

Time Delay Settings Test

12. Using the pickup settings from the Power Flow Test, apply settings and set time delay to the minimum setting. Adjust the current source to the appropriate level to determine operating time and compare against calculated values.
13. Verify the timer stops when the relay trips.
14. Repeat at midpoint and maximum delay settings. Dielectric Test
15. Perform the dielectric test described in IEC 414 using 2 kV RMS for one minute.
Surge Withstand Test
16. Perform the surge withstand test described in IEEE C37.90.1. or IEEE/ANSI C62.45.