PROTECTION RELAY TESTING FOR COMMISSIONING SWP

1. PURPOSE AND SCOPE

The purpose of this Standard Work Practice (SWP) is to standardise and prescribe the method for testing of protection relays for **commissioning purposes**. This is done in accordance with guidelines as set down in the Ergon Energy Relay Configuration Standards.

Protection systems are made up of many different types and makes of relays however the relays can be grouped by the function they perform. This SWP covers the individual tests required on a protection function not on an individual relay.

This SWP is to be used in conjunction with current Zone Substation Standard design and Ergon Energy Relay Configuration Standards. It is not intended to cover maintenance or evaluation testing as defined in this document.

2. STAFFING RESOURCES

Electrical Fitter and / or Mechanic

Competent Assistant

Required Training and Certificates

Regulatory Training

Course Code	Course Description
2120	Perform Cardio Pulmonary Resuscitation
2130	Low Voltage Switchboard Rescue

Additional Training

Course Code	Course Description
4428	Operate the Network
4430	Safe Entry to High Voltage Enclosures
8258	Secondary Systems Isolation

3. DOCUMENTATION

CS000501F115. Daily / Task Risk Management Plan (Form)

ES000901R102. Health and Safety Risk Control Guide (Reference)

MN000301R165. 8 Level Field Test Competency (Reference)

MN000301R167. Greenlining and Bluelining of Ergon Energy Substation Drawings (Reference)

MN000301W107. Commission New and Augmented High Voltage Plant (Work Instruction)

P53. Operate the Network Enterprise Process

SWMS007. Live Work (Low Voltage) SWMS007 (Safe Work Method Statement)

SP0506. Substation Primary Plant and Secondary Systems Field Testing SWP (Standard Work Practice)

Ergon Energy - Standard for Substation Protection

AM-P-STD-002A Auto-Reclose Standards

Relay Configuration Standards

Relay Application Guides

Ergon Energy Corporation Limited ABN 50 087 646 062
Ergon Energy Queensland Pty Ltd ABN 11 121 177 802

AS2067 Switchgear Assemblies and Ancillary Equipment for alternating Voltages above 1 kV

IEC 60255 Protection Standard

Powerlink AM–PR–0976 Protection Systems Commissioning Tests

AEMO – Power System Security Guidelines SO_OP3715

National Electricity Rules

National Electricity Network Safety Code

4. KEY TOOLS AND EQUIPMENT (AS REQUIRED)

- Switchboard Rescue Kit
- LV mats, covers, barriers as required
- Dry chemical fire extinguisher
- Automated secondary injection test set and test software, i.e. Omicron CMC, Doble F6 series or equivalent
- Manufacturer's software to communicate with and configure relay under test. (Software version controlled by the protection group and can be found on the Protection Intranet Site.)
- Insulated test leads and test blocks
- Class 00 Low Voltage Gloves

Additional PPE Required

Nil.

5. DEFINITIONS, ACRONYMS AND ABBREVIATIONS

5.1 Protection Relay Life Cycle

5.1.1 Evaluation testing

Testing of a relay to ensure it meets Ergon Energy requirements before implementation into the Ergon Energy network. It will test every feature that Ergon Energy intends to use in the relay with application of secondary volts and currents to simulate a series of realistic system fault conditions. A by product of this testing will be test plan templates for commissioning and maintenance testing.

5.1.2 Commissioning testing

Testing to:

- verify an individual relay scheme works and that the settings applied are correct as per the PSR,
- validate the relay scheme is fit for purpose in the particular installation.

Commissioning testing in the context of this document encompasses the following:

- System Testing – Testing using secondary injection based on system parameters in primary values,
- Element Testing – Testing using secondary injection to check the accuracy of individual relay elements based on secondary values.
- Logic Testing – Testing to confirm the logic operates as per Ergon's RAG logic diagrams and the elements enabled as per the PSR.

5.1.3 Maintenance testing

Periodic or reliability centred testing of relays to:

- detect hidden failures,
- collect data so as to trend the deterioration of components,

- return the relay scheme to service in an acceptable standard.

5.1.4 Definitions

Relay Construction Types

- Electro Mechanical Relays (Electromotive force based)
- Electronic Relays (Discrete electronic component based)
- Digital Relays (Micro processor based)

Competent Person: A person who has acquired, through training, qualifications, experience or a combination of these, the knowledge and skills enabling the person to carry out the required tasks.

Nominal: Rating of input, for example CT inputs 1 Amp or 5 Amp.

Relay Configuration Standard: This controlled document describes the general settings employed to protect plant on the Ergon Energy network. The document is used as a template for the creation of the protection settings.

Relay Application Guide: Suite of Ergon Energy controlled drawings specific to a standard relay application

Extraction: Transfer of data from the relay to a PC

Sending: Transfer of data from a PC to a relay

Element Characteristic: Defines the overall operation of the element

Setting Threshold: Defines a single point within the Element Characteristic

5.2 Acronyms and Abbreviations

DIS: Direct Intertrip Send
DIR: Direct Intertrip Receive
Inom: Relay Nominal Current
Iset: Setting Current
PIR: Permissive Intertrip Receive
PIS: Permissive Intertrip Send
PSL: Protection Setting Logic
PSR: Protection Setting Request
RAG: Relay Application Guide
REF: Restricted Earth Fault
RCS: Relay Configuration Standard
SEF: Sensitive Earth Fault
SEL: Schweitzer Engineering Laboratories
tnom: Relay Nominal Operating Time

6. TEST PLANS

Test Plans will be developed in accordance with this SWP and:

- Ergon Energy Relay Configuration Standards
- Ergon Energy Relay Application Guides
- Ergon Energy Test Plan Templates
- Manufacturer Equipment Manuals

6.1 Test Plan Naming Convention

Standard Test Plans will have the following format:

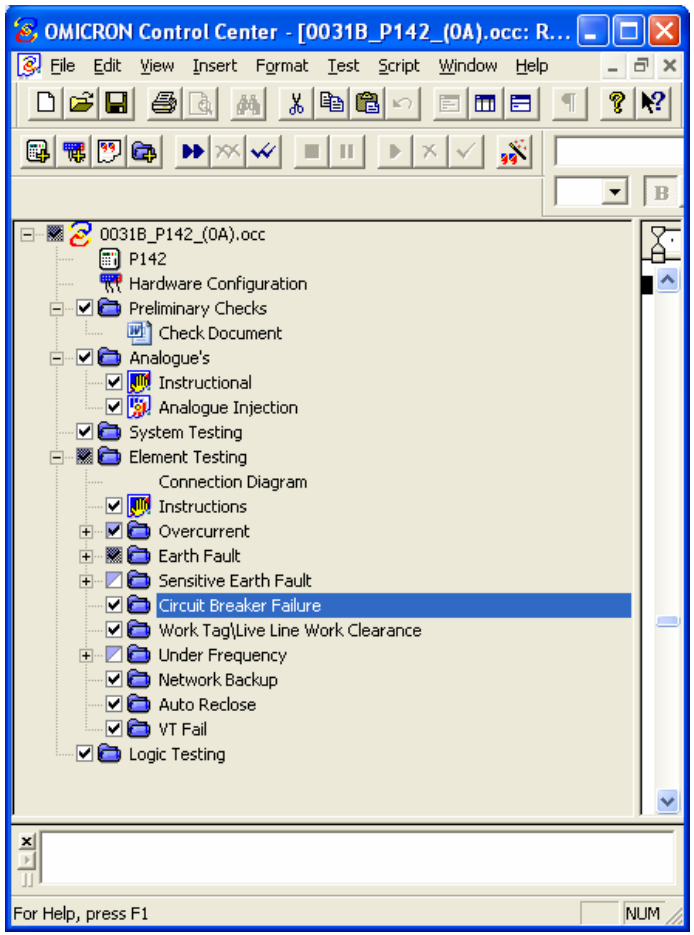
<RELAY CONFIGURATION STD>_<RELAY MODEL>_<(VER)>

e.g. 0031B_P142_(0A) refers to revision 0A of a test plan for a MiCOM P142 relay utilising Ergon Energy Relay Configuration Standard AM-P-STD-0031B.

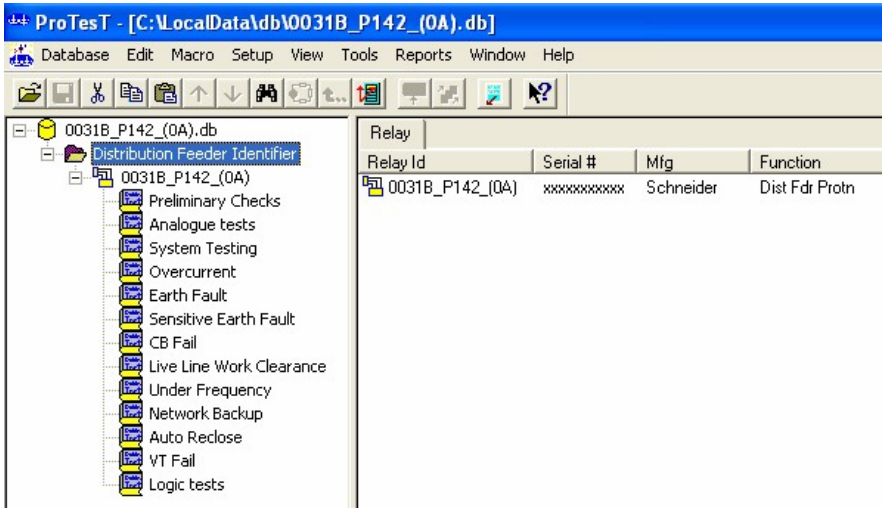
6.2 Test Plans Structure

Test Plans will have the following fundamental structure:

6.2.1 Omicron:



6.2.2 Doble:



6.3 Test Plans Modifications and Version Control

Version control of test plans will be facilitated by a document controlled by a Senior Commissioning Engineer. The version control document will contain the following details:

- Description of the test plan modification
- Reason for test plan modification
- Date of modification
- Author
- Approver

The version control document will be maintained by the test plan approver.

The version control document for test plans will be in the following format:

<RELAY CONFIGURATION STD>_<RELAY MODEL>_<(VER)>

Modifications to approved test plans on site can be made under the approval of a Senior Commissioning Engineer only. This approval is to be obtained prior to the relay being placed into service.

Any proposed amendments to approved Test Plans will be forwarded to the Test Plan Approver for review and incorporated into a revised standard test plan if appropriate.

Minor changes to test plans that do not warrant a revision update shall be noted in the version control document.

6.4 Test Plans Approval

Approval of test plans will be facilitated by a Senior Commissioning Engineer or delegate.

6.5 Protection Settings

- No changes to issued protection setting files are allowed during testing without the consent of a member of the Operational Technology Protection Team. This includes turning elements off for testing purposes which is to be avoided. Temporary mapping of I/O for testing is not permitted.
- Test the configured setting groups as defined on the PSR (this includes any alternate groups that may be enabled via SCADA).
- The basic testing philosophies in relation to setting changes are:
    - **Changes to relay logic** – this requires a full retest of the relay as per the approved test plan.
    - **Enabling a new element in the relay** – this requires a full retest of the relay as per the approved test plan.
    - **Changing firmware versions in the relay** – this requires a full retest of the relay as per the approved test plan.
    - **Changes to a particular element characteristic** – this requires retesting of the modified element only. Coupled with this will be a “compare” to verify the change has been successfully applied to the relay and no file corruption has occurred. The “compare” procedure to be followed is described under the Changers to a particular setting threshold dot point.
    - **Changes to a particular setting threshold** – this does not require retesting of the modified element. However a “compare” is required to verify the change has been successfully applied to the relay and no file corruption has occurred. The procedure to be followed is:
        - Download existing settings from the protection database,
        - Extract existing settings from relay and compare against the settings from the protection database,
        - If discrepancies are identified, contact the Protection Group for further advice,
        - If settings are as expected, implement changes as per the PSR,
        - Carry out required testing if required,
        - Extract “as tested” settings from relay and compare to expected settings from protection database.
        - When uploading new protection settings to a relay, appropriate secondary isolation must be in place.
        - Upon completion of the relay testing, the extracted “as tested” relay setting file and signed off PSR shall be returned to the Protection Group in a timely manner.

7. WORK PRACTICE STEPS

7.1 Carry out an On Site Risk Assessment

Prior to performing this activity any hazards associated with prerequisite tasks at the worksite shall be identified and assessed with appropriate control measures implemented and documented in accordance with CS000501F115 Daily/Task Risk Management Plan and using ES000901R102 Health and Safety Risk Control Guide.

If any risks cannot be managed or reduced to an acceptable level, do not proceed with the task and seek assistance from your Supervisor.

7.2 Competency and Safety Management

Ensure all persons required to use test equipment are competent in its operation.

Assign adequate staffing resources with required competencies to safely complete tasks as per MN000301R165 8 Level Field Test Competency.

All staff to comply with SP0502 Safe Entry to High Voltage Enclosure SWP and SWMS007 Live Work (Low Voltage) Safe Work Method Statement.

7.3 Preliminary Checks

Carry out the following preliminary comparisons:

- PSR / Setting files to relay:
  - Firmware version
  - Relay Model
  - Plant ID
- RAG / RCS to design drawings:
  - Relay model
  - Input / Output allocation
- Design drawings to relay:
  - Nominal current rating
  - Aux supply voltage
  - Aux input voltage
- Test Plan template:
  - Select the appropriate test plan template as detailed in the “Standard” field on the PSR.

7.4 PSR Sanity Checks

Carry out sanity checks of the protection scheme and settings to look for any possible abnormalities. This could include:

- Ensure setting reports, PSRs, Relay Application Guides and Relay Configuration Standards are followed and align,
- Ensure the scheme used matches the application,
- Check for irregular CT ratios (e.g. Feeders should be greater than the maximum expected load and transformers should be greater than 1.5 times the name plate MVA rating. All CTs in high impedance diff schemes are set to the same ratio. This information can be found in the Protection Setting Report.).

7.5 Populate the Test Plan

Apply relay specific settings to the appropriate standard test plan template as per the PSR.

7.6 Secondary Isolation

Carry out secondary isolation in accordance with Secondary Systems Isolation guidelines.

7.7 Apply PSR

Apply the approved settings to the relay under test.

7.8 Check Communications Functionality

- Engineering access
- SCADA interface

7.9 Time / Date Synchronisation

- Set the time / date to an incorrect value
- Check correct time stamp applied to relay within a 1 hour period max

7.10 Analogues

Carry out secondary injection to:

- Confirm test lead connection e.g. phasing,
- Confirm wiring to the relay,
- Check displayed values against expected values.

7.11 System Testing

System testing is to be completed based on primary values of the system in order to test the overall protection scheme and testing setup. Testing is to be performed as per specific direction in Section 8 of this document following parameters given in the Protection Setting Report.

7.12 Element Testing

Element testing is to be completed using secondary values of the system to test the specific, changeable protection elements of the relay. All enabled element testing is to be performed as per specific direction in Section 9 of this document following parameters given in the Protection Setting Report. Element accuracies are to be as per Section 11 of this document.

7.13 Logic Testing

Logic testing shall be performed on I/O according to the RAG logic diagram, Section 10 of this document and the elements that are enabled as per PSR.

Functional operation of the relay will be verified by the test plan results from the secondary injection test set and by the Greenlining and Bluelining of Ergon Energy Substation Drawings and RAG logic diagrams.

7.14 SCADA Testing

Check all protocol points as per the RCS. Where possible, points should be checked individually, however it may not be possible to achieve this in all cases.

7.15 Recheck Time / Date

Confirm time stamp has been applied and time and date is correct.

7.16 Apply Test Sticker

Apply a test sticker to the relay indicating the following:

- PSR number
- Date of test
- Initial of tester

7.17 Settings Returned to Protection Group

- Extract all “as tested” setting files from the relay
- Sign off on PSR
- Forward signed off PSR and extracted setting files to Protection Group in a timely manner.

7.18 On Load Checks

Carry out on load checks to verify primary analogue values and phase angles to relay displayed values.

Verify sequence components as required.

Verify diff and bias currents as required.

Line diff specific:

- Energise feeder from each end in turn and record diff current from line capacitance.

- Close feeder and remeasure diff currents. Any change in diff current is due possibly to CT errors or communications propagation delays.
- If anticipated load current is inadequate to be above the supervision level of the relay, primary injection will be required to check stability of the diff scheme.
- Confirm line diff protection does not trip if communication channel fails.

8. SYSTEM TESTING REQUIREMENTS (BASED ON PRIMARY VALUES

8.1 Calculations

Secondary Current = Primary Current × CT Ratio ($I_{Secondary}$ / $I_{Primary}$)

Secondary Voltage = Primary Voltage × VT Ratio ($V_{Secondary}$ / $V_{Primary}$)

Secondary Impedance = Primary Impedance × VT Ratio / CT Ratio

Note:- All values are complex numbers, Nominal System Volts (11000 V, 22000 V, 33000 V etc.)

Three Phase Source Impedance = (Nominal System Voltage at faulted Point) / ($\sqrt{3}$ × Three Phase Fault Current)

Three Phase Fault Current at measuring point = (Nominal System Voltage at measuring point) / ($\sqrt{3}$ × (Three Phase Source Impedance to measuring point + Three Phase Impedance from measuring point to the Fault))

8.2 Distance Relay System Testing

Carry out the following tests:

- 3 phase fault for each zone at the line angle
- Earth fault for each zone at the fault loop impedance angle

Earth fault loop impedance from measuring point = 3 × (Zero Sequence Impedance from measuring point to fault - Positive Sequence Impedance from measuring point to fault) + Positive Sequence Impedance from measuring point to fault

The above tests will be carried out utilising the following reaches:

- 50% of Zone 1
- 50% between Zone 1 and Zone 2
- 50% between Zone 2 and Zone 3

In addition to the above tests, the fault locator will be tested for correct operation by applying a single phase to ground fault at 50% of the feeder length.

8.3 Directional Over Current and Earth Fault

Carry out the following tests:

- 3 phase fault at 50% of line at the line angle
- Earth fault on each phase at 50% of the line at the line angle

8.4 High Impedance Differential Protection

- Confirm the setting voltage is less than half the lowest knee point voltage of all CTs in the scheme
- Check that any resistor (shunt or stabilising) utilised in the circuit is utilising at least 2/3 of the total available resistance.

8.5 Transformer Biased Differential Protection

8.5.1 Through fault stability for phase faults

Determine load side transformer current at the break point between Slope 1 and 2. From this load side current determine the source side current if the transformer was on top tap and determine the source side current if the transformer was on bottom tap.

Simulate load at break point between Slope 1 and Slope 2 at top and bottom taps as per transformer nameplate and CT ratios. If the protection has only one slope carry out test at two times the transformer rating (test may be subject to VA rating of test set). Observe diff and bias currents in the relay. Check the diff current is less than 90% of the operating characteristic at the measured level of bias.

8.5.2 Through fault stability for earth faults

Inject only zero sequence current at the relay rated current into all windings with an in zone earth in turn while not injecting into any other winding. Verify relay has zero bias and zero restraint current.

8.5.3 Relay operation

Simulate an in zone earth fault at the system fault level on the source side of the transformer. Check for relay operation.

8.6 Restricted Earth Fault

Carry out an injection trip test at primary values into each individual REF CT element of the relay based on the PSR. This injection shall be carried out on the CT input for all in zone CTs. (Note the earth CT normally carries no current in service.)

8.7 Overcurrent

Carry out an injection test on the relay based on primary values at minimum phase fault level to check for relay operation (minimum phase fault to be given in Protection Setting Report).

8.8 Earth Fault

Carry out an injection test on the relay based on primary values at minimum earth fault level to check for relay operation (minimum earth fault to be given in Protection Setting Report).

8.9 Sensitive Earth Fault, Neutral Check

Carry out an injection test on the relay based on the SEF primary earth fault current from the PSR.

9. ELEMENT TESTING REQUIREMENTS (BASED ON SECONDARY SETTINGS

9.1 Timed Overcurrent / Earth Fault

- Check pickup for all phases
- Time at 2x, 5x, 10x pickup on all contacts that are tripped by this fault type.
- If an instantaneous element is enabled and set at a value less than or equal to 10 times pickup, only the 2x and 5x tests are required.
- Operate time only need be recorded for 1 earth fault and 1 phase fault at each of the current multiples.

9.2 Directional Overcurrent / Earth Fault

- Check maximum torque angle at 2x pickup
- Check pickup for all phases
- Time at 2x, 5x, 10x pickup on all contacts that are tripped by this fault type
- If an instantaneous element is enabled and set at a value less than or equal to 10 times pickup, only the 2x and 5x tests are required
- Operate time only need be recorded for 1 earth fault and 1 phase fault at each of the current multiples.

9.3 Definite Time

- Check pickup for all phases
- Check timing at 2x pickup on all contacts that are tripped by this fault type (check this value does not exceed the current limits and thermal rating of the relay set by the relay manufacture). Test set limitations or relay specifications may prevent timing tests at 2x pickup therefore a more suitable

value can be selected to prove the operation of the element. No less than 1.2 is recommended.

9.4 Distance Functions

9.4.1 Multiple characteristic

- Relays that contain for instance a mho and quad characteristic for the same fault type should be tested together.

9.4.2 Line and Resistive Reach

- Relay operation for zone boundaries set in the grading plan should be tested. This shall include A-B, A-E, B-E and C-E faults at the line angle.
- If the relay has a quad set then the resistive and reactive reach shall be tested. If the quad has a setting to apply a tilt angle that angle shall be tested. The resistive reach on a mho characteristic shall not be tested since the reach can be overly sensitive to measurement errors when the mho crosses the x axis at a shallow angle.
- Test reverse element if set.
- Tripping times to be checked at 50% of Z1 reach for Z1 and 50% of (Z1+Z2) reach for Z2 and 50% of (Z2+Z3) for Z3 etc.

9.4.3 Voltage Supervision

- Simulate a single and three phase loss of VT supply and confirm VT supervision operation
- Test that relay distance elements are blocked for VT supervision operation in accordance with relays designed operation.

9.4.4 Switch on to Fault

- Test Zone 2 phase, Zone 2 ground and specific overcurrent elements timing for a switch onto fault condition
- Test “Switch on to Fault” drop off times.

9.4.5 Load encroachment blinders

- Test that relay is blocked for load encroachment in accordance with relays designed operation.

9.5 Inter-tripping Schemes

9.5.1 Direct

- Check DIS initiates correctly as per logic
- Check DIR initiates correctly as per logic
- Time overall operation in each direction end to end

9.5.2 Permissive Under-Reaching

- Check PIS initiates correctly as per logic
- Check PIR initiates trip if Z2 is active and does not trip if Z2 is inactive
- Time overall operation in each direction end to end
- Time overall loop time with a loop applied at the remote end.

9.5.3 Permissive Over-Reaching

- Check PIS initiates correctly as per logic
- Check PIR initiates trip if Z2 is active and does not trip if Z2 is inactive
- For ECHO-Logic, check that the relay performs as per the relay manufacturer’s logic diagram

- For weak in feed, check that the relay performs as per the relay manufacturer's logic diagram
- For current reversal, check that the relay performs as per the relay manufacturer's logic diagram
- Time overall operation in each direction end to end
- Time overall loop time with a loop applied at the remote end.

9.6 Feeder Current Differential Functions

Current differential tests may require a temporary second relay at site to facilitate characteristic testing.

9.6.1 Current Differential Characteristic

- Test pickup for all phase to ground and A–B phase faults
- Test the slope characteristic – two points per slope
- Test the alpha plane characteristic (SEL relays):
  - Confirm 87LPP, 87L2P and 87GP Settings.
  - Inject a through fault above the supervision element. Increase the current in the temporary relay to prove 87LR.
  - Inject a through fault above supervision element setting and rotate remote currents to confirm accuracy of 87LANG.
  - Confirm operation of 87LA, 87LB, 87LC, 87L2 and 87LG elements.

9.6.2 Current Differential Inter-Trip (for three ended schemes)

- Disconnect the communication links between the relays at the two remote sites while maintaining the communication paths between the local relay under test to the remote end relays.
- Inject a differential current in the relay under test and verify that the two remote relays have tripped.

9.6.3 Current Differential Stability

- Stability checks will be covered off through on load testing or primary injection.

9.7 Transformer Current Differential Functions

9.7.1 Differential / REF Pickup and Timing

- Find the pickup for each phase of each winding utilised
- Time each output contact at twice the pickup – one phase of one winding only.

9.7.2 Differential / REF Characteristic

- Test the slope characteristic – two points per slope
- Time each output contact at twice the pickup
- Check second harmonic restraint by using three phase injection into HV input.

9.8 Transformer Thermal Protection

9.8.1 HV Thermal Overload

- Time at 1.5, 2 and 3 times pickup setting on all contacts that are tripped by thermal overload
- Record pickups for the 5 minute and 2 hour alarms for all phases.

9.8.2 LV Thermal Overload

- Time at 1.5, 2 and 3 times pickup setting on all contacts that are tripped by thermal overload
- Record pickups for the 5 minute and 2 hour alarms for all phases.

9.9 Capacitor Bank Protection Functions

9.9.1 Over Current / Overload

Refer to overcurrent relay tests as described in this SWP.

9.9.2 Earth Fault

Refer to earth fault relay tests as described in this SWP.

9.9.3 Under Voltage

- Check undercurrent element pickup for all phases
- Check timing of operation.

9.9.4 Balance Protection

- Check alarm and trip level pickup
- Time alarm at below trip pickup for all contacts
- Time trip at twice pickup to all contacts.

9.9.5 Under Frequency

Refer to under frequency tests as described in this SWP.

9.9.6 Close inhibit (capacitor discharge)

- Check timing for close inhibit.

9.10 High Impedance Differential

- Check pickup
- Check trip time at twice set point.

9.10.1 High Impedance Bus Protection

Pickup

- Test voltage pickup and record the current value at tested voltage.
- Test trip time at twice pickup.

Current Supervision (where applicable)

- Test pickup.
- Test trip time at twice pickup.

9.11 Low Impedance Bus Protection

Pickup

- Test pickup on every CT input
- Test trip time at twice pickup on every CT input.

Stability

- Test stability on every CT input.

9.12 Under Frequency Protection

- Check for pickup.
- Check timing of operation - inject at 10mHz above set threshold and step down to below pickup. Measure operating time.
- Check under voltage block.

9.13 Circuit Breaker Fail / Local Backup Functions

- Test pickup of current check element
- Test drop off (CBF timer to reset if the check values drop off during the timing period)
- Test operation time at 2 times pickup
- Test all internal and external initiations in accordance with the RAG logic diagram (all faults types should initiate CB Fail).

9.14 Transfer Trip Functions

- Time all trip inputs to all trip outputs.

9.15 Relay Indication Functions

- Ensure that for all faults that the front panel on the graphical display or labelled LEDS of the relay accurately reflects the fault type and zone
- If possible via self test, ensure that all LEDs are operating correctly
- Ensure that the relay is named correctly on the LCD display.

9.16 Event and Disturbance Recorder Functions

- Ensure both the event and disturbance recorder are working correctly and that you can download events
- Clear event records where possible after relay testing is completed.

9.17 Network Backup / NPS Protection

- Check pickup.
- Time at 2x, 5x, 10x pickup on all contacts that are tripped by this fault type.
- Test minimum response time if set.

10. LOGIC TESTING

Test Non Protection Functions

10.1 Auto Re-close

- Initiation and blocking of A/R should be tested for every fault type (e.g. OC, EF, SEF, DIFF) and relay state (e.g. normal, LLWC) in accordance with the RAG logic diagram and PSR.
- Auto re-close shall only be initiated by faults within the assigned protection zone i.e. Current Differential, Distance Zone 1, IDMT and High set over current and earth fault. SEF shall not initiate a re-close nor should it initiate if Live Line Work Clearance is enabled.
- It should be tested that auto re-close is initiated for fast zone 2 faults and not initiated for slow zone 2 faults for non-communicating schemes. The Protection Group may choose to initiate auto re-close on a slow zone 2 fault following a risk assessment which will be specified in the Protection Setting Report.
- Number of re-close attempts, dead times, reclaim times, direct to lockout should be tested in accordance with the PSR.

10.2 Auto Re-close, Work Clearance and SEF On Off

10.3 Trip Circuit Supervision

10.4 Live Line Work Clearance

10.5 Setting Group Selection Logic

11. PROTECTION RELAY – ACCURACY AND TIME REQUIREMENTS

Plant and equipment should not be commissioned unless the test result meets the C4 or C3 criteria defined in the maintenance acceptance criteria document. Plant may only be commissioned at P2 level with specific approval from the Senior Commissioning Engineer. Plant may not be commissioned at a P1 level.

All Accuracy and Time requirements can be found in the Big MAC (Maintenance Acceptance Criteria).

Relay Type	Test	Accuracy *(whichever is the greater)*	Time *(whichever is the greater)*
Distance	Line Reach Z1 (all fault types)	5% or 0.1ohms of PPS ohm	< 40ms
Distance	Line Reach all other forward zones (all fault types)	5% or 0.1ohms of PPS ohm	set time + (5% or 40ms)
Distance	Resistive Reach Z1 (all fault types)	5% or 0.1ohms of PPS ohm	< 40ms
Distance	Resistive Reach all other forward zones (all fault types)	5% or 0.1ohms of PPS ohm	set time + (5% or 40ms)
Distance	Reverse Reach (all fault types)	10% or 0.2 ohms of PPS	< 40ms
Distance	Permissive Under Reaching Fast Z2 (all fault types)	5% or 0.1ohms of PPS ohm	>35ms<65ms
Distance	Permissive Over Reaching Fast Z2 (all fault types)	5% or 0.1ohms of PPS ohm	>35ms<65ms
Distance	PIS	5% or 0.1ohms of PPS ohm	< 35ms
Distance	DIS	N/A	< 35ms
Distance	Fault Location	5%	N/A
Current DIFF	Cdiff (all fault types)	5%	< 40ms
Current DIFF	CDIT	N/A	< 20ms (CHECK END TO END)
Current DIFF	SEL 311L 87LA, 87LB & 87LC Trip	N/A	<60ms
Current DIFF	SEL 311L 87L2 & 87LG Trip	N/A	< 90ms
Transformer	Differential	5%	< 40ms
Transformer	Instantaneous Overcurrent/ Definite Time	10%	< 40ms
Transformer	REF	10%	< 40ms
Transformer	Thermal	10%	set time + (10% or 40ms)
Bus Zone	High Impedance	5%	<30ms
Bus Zone	Low Impedance	5%	<30ms
Capacitor	Instantaneous Overcurrent/ Definite Time	10%	< 40ms
Capacitor	Under Voltage	10%	set time + (10% or 40ms)
Capacitor	Over Load (SPAJ) - Pickup	I_{set} + (5% or 0.01*I_{nom})	N/A

Relay Type	Test	Accuracy *(whichever is the greater)*	Time *(whichever is the greater)*
Capacitor	Over Load (SPAJ) – Time Curve	N/A	set time +/- 12.5%
Capacitor	Balance – Pickup	I_{set} + (5% or 0.01*I_{nom})	N/A
Capacitor	Balance – Time Curve	N/A	set time +/- 12.5%
Capacitor	Close Inhibit (capacitor discharge)	N/A	set time +/- 5%
Distribution Fdr.	OC/EF IDMT- Pickup	I_{set} + (5% or 0.01*I_{nom})	N/A
Distribution Fdr.	OC/EF IDMT- Time curve	N/A	set time +/- 12.5%
Distribution Fdr.	OC/EF DEF TIME - Instantaneous OC/ Definite Time	10%	< 40ms
Distribution Fdr.	SEF – LLWC	10%	set time +/- (5% or 40ms)
Distribution Fdr.	Auto Reclose	N/A	+/- 100 ms
Feeder	OC/EF Directional	+/- 5 degrees	(set time +/- 12.5%) + <50mS
General	Switch onto fault operation	N/A	< 50ms
General	Switch onto fault reset	N/A	set time +/- 10%
General	Circuit breaker fail	10%	set time + (5% or 40ms)
General	Bus Multi Trip	N/A	<10ms
General	Bus Multi Trip @ 70% Aux Volts	N/A	<15ms
General	CB Fail Bus trip	N/A	<15ms
General	Transfer trips	N/A	<15ms
General	Analogues	5% or 1% of Nominal	N/A
Under Frequency	Under frequency	+/- 0.02 Hz	set time +/- 10% or 40ms

11.1 Acronyms and Abbreviations

PPS: Positive Phase Sequence
DIS: Direct Intertrip Send
PIS: Permissive Intertrip Send
I_{nom}: Relay Nominal Current
I_{set}: Setting Current
PIR: Permissive Intertrip Receive
PIS: Permissive Intertrip Send
PSL: Protection Setting Logic
PSR: Protection Setting Request
RAG: Relay Application Guide
REF: Restricted Earth Fault
RCS: Relay Configuration Standard
SEF: Sensitive Earth Fault
SEL: Schweitzer Engineering Laboratories
I_{nom}: Relay Nominal Operating Current
I_{set}: Relay Current Setting
SPAJ: ABB Protection Relay
LLWC: Live Line Work Clearance