# PROTECTION RELAY TESTING FOR COMMISSIONING SWP

## 1. PURPOSE AND SCOPE

The purpose of this Standard Work Practice (SWP) is to standardise and describe the method for testing of Ergon Energy protection relays for commissioning purposes. This SWP should be interpreted in conjunction with Standard for Substation Protection (V1.0) - 2948492 and the Ergon Energy Protection Standards 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 not intended to cover maintenance or application testing as defined in this document, nor does it cover work on Powerlink assets.

## 2. STAFFING RESOURCES

Adequate staffing resources with the competencies to safely complete the required tasks as per 8 Level Field Test Competency - 2597616.

These competencies can be gained from, but not limited to any or all of the following:-

- Qualifying as an Electrical Fitter Mechanic
- Qualifying as a Technical Service Person
- Training in the safe use of relevant test equipment.

Requirement for all live work:

- Refer to Live Parts Safe Work Method Statement

All resources are required to:

- Have appropriate Switching and Access authorisations for the roles they are required to perform and have the ability to assess and maintain relevant exclusion zones from exposed live electrical apparatus.
- Hold current licences for any vehicles and equipment they may be required to operate.

***Required Training***

Staff must be current in all Statutory Training relevant for the task.

Current certification Working Safely On or Near Electrical Network Infrastructure - Participant Guide - 2941492.

Contractors must have completed Ergon Energy's Generic Contractor Worker Induction.

## 3. DOCUMENTATION

8 Level Field Test Competency - 2597616

AEMO – Power System Security Guidelines SO_OP3715

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

Electrical Safety Rules 2022 - 6503074

EQL Safe Work Method Statements

Greenlining and Bluelining of Ergon Energy Substation Drawings -2597658 (Reference)

HazChat - On-Site Hazard Assessment

IEC 60255 Protection Standard

National Electricity Network Safety Code

National Electricity Rules

Operate the Network Enterprise Process - 2909674

Protection Standards - Relay Application Guides and Relay Configuration Standards

Safe Entry to High Voltage Enclosures - 2888222 (Standard Work Practice)

Standard for Auto-Reclose (V1.0) - 2945445 (Standard)

Standard for Maintenance Acceptance Criteria - 2928929 (MAC)

Standard for Substation Protection (V1.0) - 2948492 (Standard)

Substation Primary Plant and Secondary Systems Field Testing -2902800 (Standard Work Practice)

Test and Commissioning Manual - 2877081 (Reference)

Transformer Primary Injection Testing - 2916916

Working Safely On or Near Electrical Network Infrastructure - Participant Guide - 2941492

## 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
- 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 Application 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 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
$I_{nom}$: Relay Nominal Current
$I_{set}$: Relay Current Setting
LLWC: Live Line Work Clearance
PIR: Permissive Intertrip Receive
PIS: Permissive Intertrip Send
PPS: Positive Phase Sequence
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
SPAJ: ABB Protection Relay
$t_{nom}$: Relay Nominal Operating Time

## 6. TEST PLANS

Test Plans will be developed in accordance with this SWP

and:

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

Note that all relay configurations files for a project will have an associated Protection Setting Report that details how the settings have been derived and the philosophy and background underlying the settings. This protection Setting Report is considered the prime document for resolving any conflict between the configuration file and other design documentation.

### 6.1 Test Plan Naming Convention

Test plans used for a project will have the following naming convention when run:

**SSSS_FFFF_J11M_YYYYMMDD**

SSSS – Substation Identifier

FFFF – Feeder / Bay identifier

J11M – Relay Identifier

YYYYMMDD – Test Date

### 6.2 Standard Test Plan Naming Convention

Standard Test Plans will have the following format:

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

e.g. STNW1007_142_0A refers to revision 0A of a test plan for a MiCOM P142 relay utilising Ergon Energy Relay Configuration Standard STNW1007.

#### 6.2.1 Standard Test Plans Modifications and Version Control

Version control of standard test plans will be contained in each test plan as a separate section. The version control section will contain the following details:

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

Version control will be maintained by Engineering Field Support facilitating the development of standard test plans.

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

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

### 6.3 Test Plan Development, Approval and Use

#### 6.3.1 Standard Test Plan Development

The writer is required to be a competent test technician or engineer and shall develop the plan in accordance with this SWP and other reference material.

The approver is an RPEQ engineer from Engineering Field Support Secondary Systems team or delegate.

#### 6.3.2 Non-Standard Test Plan Development

Non-Standard Test relay applications should be avoided since protection settings should be produced in line with appropriate protection standards. In cases where this is unavoidable, Non-Standard Test Plans can be written by Engineering Field Support or delegate to follow the intent and principles of this SWP and other reference material and ensure that all active elements of the relay have been tested.

Approval must be obtained from Engineering Field Support to use a Non-Standard Test Plan for commissioning of a particular project. Such approval is based on an evaluation of the benefits of developing a Standard Test Plan for future use versus the risk of a Standard Test Plan not being used (for example, a Standard Test Plan would not normally be developed for a relay at the end of its period contract).

### 6.3.3 Relay Tester

The Relay Tester is responsible for applying setting values to a test plan to suit the application and elements used in a particular relay.

The Relay Tester can assume that a "PASS" value obtained from an automated test is valid, will investigate any "FAIL" result to determine any test plan errors or relay defects. Refer to section 8.

### 6.3.4 Continuous Improvement of Test Plans

Where improvements or changes are identified by a Relay Tester in either a Standard or Non-Standard Test Plan, they should forward this information to the Engineering Field Support to allow for continuous improvement in relay testing.

## 6.4 Protection Settings

- No changes to issued protection setting files are allowed during testing without the consent of a member of the Engineering Field Support 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). Where setting groups have identical settings, only one group needs to be tested provided that it is confirmed the settings as applied to the relay are in fact identical in all respects. Any setting group that is operationally selectable must be configured.
- The basic testing philosophies in relation to setting changes are:
    - **Changes to relay logic** – this requires a full retest of the relay.
    - **Enabling a new element in the relay** – this requires a full retest of the relay.
    - **Changing firmware versions in the relay** – this requires a full retest of the relay.
    - **Downloading a new configuration to a relay** - When downloading a new configuration file to relay, all functions must be re-tested. An exception to this is when no new functions are being added (for example a pickup change only) and the relay software has a "compare" function to verify that no file corruption on download has occurred. In this case the procedure to be followed is:
        - Upload existing settings from relay and compare to expected settings from protection database.
        - If settings are as expected, download modified settings to relay.
        - Upload new settings from relay and compare to expected settings from protection database.
    - **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 "Changes to a particular setting threshold" dot point below.

- **Changes to a particular setting threshold** – in a digital relay, 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.
  - 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.

  It is preferable to download a new file to a relay (as per above) rather than just change a setting by the front panel in order to ensure integrity of the protection database and the setting file.

When changing a relay setting in relays other than digital relays, verification that the setting has been applied correctly must be obtained.

- When changing a potentiometer setting, repeat secondary injection. This is required since there may be a noisy spot in the potentiometer.
- When changing a time lever in an electromechanical relay, repeat secondary injection. This is required due to the non-linear nature of older relays. The exception here is if it is a temporary decrease and the setting will be returned to its previous value.
- When changing a tap setting in an electromechanical relay, secondary injection is preferred but not required.

## 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 HazChat - On-Site Hazard Assessment.

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 8 Level Field Test Competency -2597616.

All staff to comply with Safe Entry to High Voltage Enclosures -2888222 (Standard Work Practice) and EQL Safe Work Method Statements.

### 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.

Note that when changing settings, although most electronic relays will remain inactive during the setting change, it is possible that a spurious trip output can be generated and precautions should be in place to ensure this has no system impact. Normally this means secondary isolation of the affected relay outputs, however under some circumstances the protection may be left in service subject to a risk assessment. At all times however there must be adequate protection in service to protect plant, if there is any doubt contact Protection Team for a review.

### 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 Relay Testing

#### 7.11.1 Test Plan

Using the approved test plan from Engineering Field Support, run all tests using values from parameters given in the PSR. Any fail results should be investigated and Engineering Field Support should be contacted if required.

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.

### 7.12 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.

#### 7.12.1 Current Differential Stability

- Stability checks will be covered off through primary injection (or load testing if not possible or practicable).

#### 7.12.2 Transformer Current Differential Functions

Refer to Transformer Primary Injection Testing - 2916916 -Transformer Primary Injection Testing for primary injection requirements.

#### 7.12.3 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.

#### 7.12.4 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.

### 7.13 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.

### 7.14 Recheck Time / Date

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

### 7.15 Apply Test Sticker

Apply a test sticker to the relay indicating the following:

- PSR number
- Date of test
- Initial of tester

### 7.16 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.

### 7.17 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.

### 7.18 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.

## 8. 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 Engineering Field Support. Plant may not be commissioned at a P1 level.

All Accuracy and Time requirements can be found in Standard for Maintenance Acceptance Criteria - 2928929 (MAC).