



A Division of Transnet SOC Limited

# TECHNOLOGY MANAGEMENT

## SPECIFICATION

### TRANSFORMER PROTECTION RELAYS FOR AC DISTRIBUTION AND TRACTION SUBSTATIONS

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**Table of Contents**

1.0	SCOPE .....	3
2.0	ABBREVIATION AND ACRONYMS .....	3
3.0	NORMATIVE REFERENCES .....	3
3.1	IEC STANDARDS .....	3
3.2	SANS STANDARD: .....	4
3.3	TRANSNET PUBLICATIONS: .....	4
4.0	SERVICE CONDITIONS .....	4
4.1	ENVIRONMENTAL CONDITIONS .....	4
4.2	MECHANICAL SERVICE CONDITIONS .....	4
4.3	ELECTRICAL SERVICE CONDITIONS .....	4
5.0	TECHNICAL REQUIREMENTS .....	4
5.1	TRANSFORMER PROTECTION RELAY REQUIREMENTS .....	4
5.2	RELAY FUNCTIONS .....	5
5.3	SELF MONITORING FUNCTION .....	6
5.4	INTERFACE AND COMMUNICATION .....	6
5.5	EVENT RECORDING .....	7
6.0	RATING PLATE, INSTRUCTION LABELS AND MARKINGS .....	7
7.0	TESTING AND INSPECTIONS .....	7
8.0	DOCUMENTATION REQUIREMENTS .....	7
9.0	QUALITY ASSURANCE .....	7
10.0	PACKAGING, STORAGE AND HANDLING .....	7
11.0	TRAINING .....	8
12.0	GUARANTEES AND DEFECTS .....	8

## 1.0 SCOPE

This specification covers Transnet Freight Rail's requirements for a transformer protection relay to be used in AC distribution substations and 25 kV AC traction substations.

## 2.0 ABBREVIATION AND ACRONYMS

2.1	A	Amps
2.2	AC	Alternating Current
2.3	CT	Current Transformer
2.4	COMTRADE	Common Format for Transient Data Exchange
2.5	DC	Direct Current
2.6	DNP	Distribution Network Protocol
2.7	DMT	Definite Minimum Time
2.8	EMC	Electromagnetic Compatibility
2.9	FAT	Factory Acceptance Test
2.10	Hz	Hertz
2.11	IDMT	Inverse Definite Minimum Time
2.12	IEC	International Electro-technical Commission
2.13	ISO	International Organization for Standardization
2.14	kV	Kilovolts
2.15	SANAS	South African National Accreditation System
2.16	SANS	South African National Standards
2.17	TFR	Transnet Freight Rail
2.18	TMS	Time Multiplier Settings
2.19	USB	Universal Serial Bus
2.20	V	Volts

## 3.0 NORMATIVE REFERENCES

Unless otherwise specified all materials used, equipment developed and supplied shall comply with the latest edition of the relevant International Electro-technical Commission (IEC), International Organization for Standardization (ISO), South African National Standards (SANS) or Transnet publications.

### 3.1 IEC STANDARDS

- 3.1.1 IEC 60255-1: Measuring relays and protection equipment – Part 1: Common requirements
- 3.1.2 IEC 60255-5: Electrical relays part 5: insulation coordination for measuring relays and protection equipment – Requirement and tests.
- 3.1.3 IEC 60255-21: Electrical relays part 21: Vibration, shock, bump and seismic tests
- 3.1.4 IEC 60255-27: Electrical relays part 27: Product safety requirements

**3.2 SANS STANDARD:**

- 3.2.1 SANS 9001: Quality management systems - Requirements.
- 3.2.2 SANS 60076-1: Power transformers – Part 1 General
- 3.2.3 SANS 60529: Degree of protection provided by enclosures (IP code)
- 3.2.4 SANS 61000: Electromagnetic compatibility (EMC).
- 3.2.5 SANS 61850: Communication networks and systems in substations.

**3.3 TRANSNET PUBLICATIONS:**

- 3.3.1 BBB 8205: High Voltage Supply Transformers in accordance with IEC 60076 and BS 171.
- 3.3.2 BBG 2415: 25 kV AC Single Phase 20 MVA Transformer.
- 3.3.3 CEE.0224: Drawings, catalogues, instruction manuals, spares list for electrical equipment supplied under contract.

**4.0 SERVICE CONDITIONS****4.1 ENVIRONMENTAL CONDITIONS**

Altitude:	0 - 1800 m above sea level
Relative humidity	10% to 90%
Ambient temperature	-10° C to +55° C
Wind pressure	750 Pa
Lightning conditions	20 ground flashes/km <sup>2</sup> per annum
Pollution	Heavily salt laden with industrial pollutants including diesel- electric locomotive emissions

**4.2 MECHANICAL SERVICE CONDITIONS**

- 4.2.1 The device may be exposed to vibration and shock. The relay design must ensure reliability of the equipment under such conditions.
- 4.2.2 The relay shall be able to handle vibrations and shock as per IEC 60255-21 specification.

**4.3 ELECTRICAL SERVICE CONDITIONS****4.3.1 RELAY POWER SUPPLY VOLTAGE**

- 4.3.1.1 The auxiliary supplies of the relay shall range from 48V to 120V DC nominal. The supply voltage tolerance shall be  $\pm 20\%$  of nominal.

**4.3.2 FREQUENCY RANGE**

- 4.3.2.1 The relay shall be suitable for single phase 50Hz AC traction supply systems. The relay shall be able to operate at a frequency range of 47Hz – 52Hz with negligible change of accuracy.

**5.0 TECHNICAL REQUIREMENTS****5.1 TRANSFORMER PROTECTION RELAY REQUIREMENTS**

- 5.1.1 The relay shall have a modular design to enable easy replacements, as well as readily available retrofitting of individual components.
- 5.1.2 The relay shall have an integrated real time clock with battery and the clock can be synchronised with the external PC.
- 5.1.3 The degree of enclosure protection of the relay shall be IP50 or better in terms of SANS 60529.

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- 5.1.4 The relay insulation degree shall conform to the IEC 60255-5 specification.
  - 5.1.5 The relay shall be able to operate with a current transformer (CT) input of both 1A and 5A.
  - 5.1.6 The relay shall have Electromagnetic compatibility (EMC) rating that complies with minimum standards of SANS 61000 specifications.
  - 5.1.7 The relay shall meet safety requirements that conform to IEC 60255-27 specification.
  - 5.1.8 Relay settings shall be password protected with different levels of access e.g. viewer, editor or master to prevent unauthorised tampering.
  - 5.1.9 It is preferred that the relay be mounted upright for readability.

## **5.2 RELAY FUNCTIONS**

### **5.2.1 Duo Bias Differential Protection**

- 5.2.1.1 The relay shall be incorporated with transformer duo biased differential protection capability for both single-phase and three phase transformers.
- 5.2.1.2 The duo bias protection element shall follow a configurable duo bias curve, that has a minimum of three operating regions (the initial setting, slope 1 and slope 2).
- 5.2.1.3 The relay shall be equipped with current transformer (CT) ratio correction and vector group matching functionality.
- 5.2.1.4 The duo bias differential protection element shall be able operate on definite minimum time (DMT) with a time delay that shall have a minimum range of 0 to 10 seconds in increments of 0.01 seconds.

### **5.2.2 Restricted Earth Fault Protection**

- 5.2.2.1 The relay shall at minimum be incorporated with high-impedance restricted earth fault protection capability for both single-phase and three-phase transformers.
- 5.2.2.2 The relay shall have a minimum of two restricted earth fault protection elements that operate independently of each other.
- 5.2.2.3 The restricted earth fault protection element shall operate on DMT with a time delay that shall have a minimum range of 0 to 10 seconds in increments of 0.01 seconds.
- 5.2.2.4 The supplier shall specify the recommended surge protection for the restricted earth fault element.

### **5.2.3 Overcurrent Protection**

- 5.2.3.1 The relay shall be incorporated with inverse definite minimum time (IDMT) and DMT overcurrent protection element for single and three-phase transformers.
- 5.2.3.2 The relay characteristic curves shall comply with the IEC 60255 requirements for inverse, very inverse and extremely inverse characteristic curves.
- 5.2.3.3 The Time Multiplier Setting (TMS) of the IDMT shall have a minimum range of 0 seconds to 10 seconds with an increment of 0.01 seconds.
- 5.2.3.4 The DMT overcurrent protection element's delay time shall have a minimum range of 0 to 10 seconds in increments of 0.01 seconds.

### **5.2.4 Earth Fault Protection**

- 5.2.4.1 The relay shall be incorporated with IDMT and DMT earth fault protection.
- 5.2.4.2 The TMS of the IDMT shall have a minimum range of 0 to 10 seconds in increments of 0.01 seconds.
- 5.2.4.3 The DMT time delay element shall have a minimum of range of 0 to 10 seconds in increments of 0.01 seconds.

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**5.2.5 Pole Discrepancy Protection**

- 5.2.5.1 The relay shall be incorporated with pole discrepancy protection to prevent the transformer from single phasing.
- 5.2.5.2 The pole discrepancy protection element shall be configurable to be used for either a 3 pole or 2 pole system.
- 5.2.5.3 The pole discrepancy protection element shall be able to operate on DMT with a time delay that shall have a minimum range of 0 to 10 seconds in increments of 0.01 seconds.

**5.2.6 Undervoltage Protection**

- 5.2.6.1 The relay shall be incorporated with an undervoltage protection element to detect abnormal system overloads.
- 5.2.6.2 The undervoltage protection element shall be able to operate on DMT with a time delay that shall have a minimum range of 0 to 10 seconds in increments of 0.01 seconds.

**5.2.7 Inrush Current Supervision**

- 5.2.7.1 The relay shall be incorporated with inrush current inhibitor protection element to prevent the operation of the relay during transformer magnetizing conditions. The protection element shall be able to differentiate between inrush currents and fault current.
- 5.2.7.2 The inrush protection element shall be configurable to set the level of harmonic content that will ensure the operation of the relay is inhibited.

**5.3 SELF MONITORING FUNCTION**

- 5.3.1 The relay shall be equipped with a watchdog for continuous self-monitoring facility. If failure occurs an alarm shall be issued by closing an alarm output contact.
- 5.3.2 The relay shall monitor both the analogue and digital circuitry.

**5.4 INTERFACE AND COMMUNICATION**

- 5.4.1 The relay shall be fitted with a user interface that has a clear visible digital display, input buttons and USB/Ethernet port for interfacing the relay and a personal computer. All interfacing options shall be permanently and clearly marked.
- 5.4.2 The relay interface shall be menu driven to enable viewing of records, parameters and fault reports by means of computer software and/or relay display screen.
- 5.4.3 The relay shall be programmable by means of a Transnet issued computer, and manually by means of keypad and alphanumeric display on the relay.
- 5.4.4 The relay programming software shall be compatible with Transnet issued computers with 64-bit Windows XP/7/vista/8/10/11 and later versions.
- 5.4.5 The relay programming software shall be issued via a USB and shall be available for download from the Original Equipment Manufacturer's website. The updated versions of the software shall also be accessible for download from the OEM's website.
- 5.4.6 The relay programming software, along with subsequent updates shall be provided and utilized by Transnet at no additional cost and shall not include any subscription fees.
- 5.4.7 The relay shall be accessible remotely and shall have high cyber security encryption data levels.
- 5.4.8 The relay shall have the minimum of 8 binary inputs and 8 binary outputs which shall be independently configurable. The binary inputs/outputs shall be able to operate within a range of 30 – 150 V at 10 A
- 5.4.9 The relay shall have Ethernet connection capability that complies with SANS 61850.
- 5.4.10 The relay shall be compatible with DNP 3.0 communication protocol.
- 5.4.11 The relay shall be programmable via USB or an Ethernet cable.

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**5.5 EVENT RECORDING**

- 5.5.1 The relay shall be able to capture and store faults events.
- 5.5.2 A minimum of 100 fault records and more than 2000 events shall be available for investigations. The recordings shall be accessible via Transnet issued computer.
- 5.5.3 The recordings shall be in COMTRADE format and be exportable to CSV format. The recordings shall be viewable on a relay interface software which allows display and analysis.
- 5.5.4 The relay shall have an oscillography recording of minimum 1 second pre and post fault recording.

**6.0 RATING PLATE, INSTRUCTION LABELS AND MARKINGS**

- 6.1 The relay ratings, input/output options and all interfacing options on the relay shall be permanently and clearly marked.
- 6.2 For identification, all the relay contacts, symbols, and numbering shall be clearly and permanently marked on the module.

**7.0 TESTING AND INSPECTIONS**

- 7.1 Transnet reserves the right to be present at all tests and inspections called for in this specification.
- 7.2 The responsibility of arranging the tests called for in this specification rests with the successful tenderer.
- 7.3 A Transnet Freight Rail, Technology Management (Energy and Electrical Technology) department representative may request any additional test deemed necessary to ensure compliance.

**8.0 DOCUMENTATION REQUIREMENTS**

- 8.1 Drawings and documents submitted with tender shall be written in English.
- 8.2 All units indicated in the documentation shall be in metric system.
- 8.3 The manufacturer must provide a soft copy and a hard copy of the technical specification of the relay.
- 8.4 The manufacturer must provide a soft copy and a hard copy of the software manual of the relay.
- 8.5 The manufacturer must provide a soft copy and a hard copy of the relay installation procedure.
- 8.6 The manufacturer must provide type test certificates from a SANAS/international accredited laboratory to verify conformance to the requirements and these must be submitted with tender documents.
- 8.7 TFR reserves the right to require any additional information: manuals, catalogues, drawings, etc. that may contribute to complete information supplied by the manufacturer.

**9.0 QUALITY ASSURANCE**

- 9.1 The manufacturer shall ensure a manufacturing process that is compliant with specification SANS 9001.

**10.0 PACKAGING, STORAGE AND HANDLING**

- 10.1 The supplier must accommodate for vibrations during transportation to prevent damage of the equipment.
- 10.2 The package shall have handling instructions on it.

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**11.0 TRAINING**

- 11.1 The supplier shall provide support whenever is required, this can be in form of telephone, email communication or onsite visit.
- 11.2 Training and support shall be provided by the supplier if required, at the cost of the supplier.

**12.0 GUARANTEES AND DEFECTS**

- 12.1 The successful tenderer shall accept liability for makers' defects, which may appear in design, material and workmanship.
- 12.2 The successful tenderer shall provide all information regarding guarantees and warranties in writing.

**END**