

Title: **REQUIREMENTS FOR THE
WIRING OF INDOOR
SWITCHGEAR FROM 11KV UP
TO AND INCLUDING 33KV FOR
THE WIRES BUSINESS**

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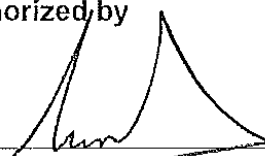
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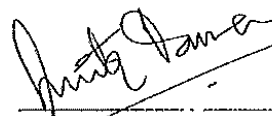
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1. Introduction

Control and auxiliary circuit design and wiring requirements have traditionally been included in each switchgear specification with sometimes contradictory and opposing requirements. The aim of this document is to ensure a standardised approach and philosophy for the design and wiring of indoor switchgear control and auxiliary circuits.

2. Supporting clauses

2.1 Scope

2.1.1 Purpose

This is a national standard covering the design philosophies for control and auxiliary circuits as well as the requirements for the wiring and terminal numbering of all types of indoor switchgear and associated instrument transformers. This standard is applicable to all:

- indoor switchgear where the protection/control scheme and metering panel pertaining to the circuit-breaker is housed in a remote location with respect to the circuit-breakers (off-board protection/control schemes).
- indoor switchgear where the protection/control scheme is located on the circuit-breaker panels (on-board protection/control schemes)

Note: Both Withdrawable Pattern Air-Insulated Indoor Primary Switchgear (AIS) and Fixed Pattern Metal-Enclosed Indoor Primary Switchgear (GIS) are covered by this standard.

2.1.2 Applicability

This document shall apply throughout the Distribution and Transmission Divisions of Eskom Holdings SOC Limited.

2.2 Normative/informative references

Parties using this standard shall apply the most recent edition of the documents listed below:

The following documents contain provisions that, through reference in the text, constitute requirements of this specification. At the time of publication, the editions indicated were valid. All standards and specifications are subject to revision. Information on currently valid national and international standards and specifications can be obtained from the Information Centre and Technology Standardisation Department at Megawatt Park.

2.2.1 Normative

- [1] 240-56065131, Distribution Standard Part 7: Specification for 11 kV, 22 kV and 33 kV withdrawable pattern air-insulated indoor primary switchgear.
- [2] 240-56062704, Distribution Standard Part 7: Specification for 11 kV, 22 kV and 33 kV fixed pattern indoor primary switchgear.
- [3] 240-70413291, Specification for electrical terminal blocks.
- [4] 240-61266445, Specification for Distribution Protection Schemes: Medium Voltage Cable Feeder and Busbar Arc Flash
- [5] IEC 60617-2, Graphic symbols for diagrams - Part 2: Symbol elements, qualifying symbols and other symbols having general application.
- [6] IEC 60617-8, Graphic symbols for diagrams - Part 8: Measuring instruments, lamps and signalling devices.

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- [7] IEC 60898-1, Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Part 1: Circuit-breakers for a.c. operation.
 - [8] IEC 60898-2, Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Part 1: Circuit-breakers for a.c. and d.c. operation.
 - [9] IEC 62491, Industrial systems, installations and equipment and industrial products — Labelling of cables and cores
 - [10] SANS 1507-2, Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 2: Wiring cables.
 - [11] SANS 1507-3, Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 3: PVC distribution cables.
 - [12] SANS 60050-441, International Electrotechnical Vocabulary Chapter 441: Switchgear, control gear and fuses
 - [13] SANS 60529, Degrees of protection provided by enclosures (IP Code).
 - [14] SANS 60947-2, Low-voltage switchgear and control gear – Part 2: Circuit-breakers.
 - [15] SANS 62271-1, High-voltage switchgear and control gear - Part 1: Common specifications.
 - [16] SANS 62271-100, High-voltage switchgear and control gear - Part 100: High voltage alternating-current circuit-breakers.
 - [17] SANS 62271-102, High-voltage switchgear and control gear - Part 102: High-voltage alternating current disconnectors and earthing switches.
 - [18] SANS 62271-200, High-voltage switchgear and control gear - Part 200: AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV.
 - [19] D-DT-5408 Drawing – Various sheets

Note: When an enquiry is issued based on this standard, the editions of the normative references that are current at the date of issue of the enquiry shall apply, unless otherwise agreed with Eskom. However in special cases, the responsible engineer may rule that the editions of one or more normative references applicable at the effective date of the Eskom standard shall apply.

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

The definitions given in SANS 60050-441 and the following shall apply.

Definition	Description
Control Plant Auxiliary Transformer	A power voltage transformer for auxiliary a.c. power supply to switching stations.
Off-board protection and control schemes	Protection and control schemes located / housed in a remote location with respect to the switchgear.
On-board protection and control schemes	Protection and control schemes located on the door of the LV compartment of the switchgear panels.
Spring limit switch	a limit switch that is operated by the moving circuit-breaker mechanism spring when it reaches a predetermined position.

Definition	Description
Stand-off remote control unit	Also referred to as the umbilical cord or pendant control . A removable device connected to the LV compartment of a switchgear panel by means of a lead of approximately 20 m length. This device is used by an operator for remote tripping/closing of circuit-breakers, and/or racking in/out of circuit-breakers, VTs and auxiliary transformers, and/or opening/closing of motorised disconnectors.

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
AIS	Air Insulated Switchgear
CB	Circuit-breaker
CPAT	Control Plant Auxiliary Transformer
CT	Current Transformer
GIS	Gas Insulated Switchgear
MCB	Miniature Circuit-Breaker
RT	LV compartment relay terminal
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition
SLS	Spring Limit Switch
VT	Voltage Transformer

2.5 Roles and responsibilities

PTM&C COE is responsible for the development and maintenance of this standard, and for compliance evaluation of new offers or designs.

2.6 Process for monitoring

The development of this standard is monitored by the SCOT Protection and Automation Study Committee and the BOC processes.

2.7 Related/supporting documents

Not applicable.

3. Requirements

3.1 General

- 1) The requirements for control and auxiliary circuits shall be in accordance with the relevant parts of SANS 62271-1, SANS 62271-100, SANS 62271-102, SANS 62271-200 and the requirements of this standard. Where conflicting requirements exist, the requirements of this standard shall take precedence.
- 2) The convention applied to schematic wiring diagrams and the requirements of this standard shall be that status contacts, limit switches, pressure switches, relay contacts etc. are shown assuming the following reference conditions:
 - a) circuit-breaker main contacts are open;
 - b) springs are discharged;
 - c) gas compartments are without pressure (where applicable);
 - d) relay coils are de-energised;
 - e) no a.c. or d.c. supplies are connected;
 - f) circuit-breaker racked in and positioned in the service position (AIS circuit-breakers only);
 - g) earthing switches not applied;
 - h) disconnectors in the open position (where applicable)
 - i) compartment doors in the closed position (where applicable); and
 - j) Primary cables are de-energised.
 - k) Electronic devices are off/failed.

The schematic wiring diagrams submitted to Eskom for approval shall comply with this convention and shall state the conventions on the drawings.

- 3) The interface for all internal switchgear wiring to Eskom shall be via panel terminal strips X1 and X2 and the interface for RTU (RS485 Serial) SCADA communications shall be via panel terminal strip X3, these shall be in accordance with D-DT-5408 drawing. All terminal strips shall be located in the LV compartment of the switchgear panel.
- 4) The 110 V d.c. or 220V d.c. and 230 V a.c. power supplies required for the switchgear will be provided by Eskom via the terminals allocated in accordance with D-DT-5408 drawing.
- 5) The switchgear panels will be delivered with the 110 V d.c or 220V d.c. "protection" and "control". and 230 V a.c. power supplies of all adjacent panels in a busbar section connected together:
 - 110V d.c. or 220V d.c. positive "protection" supply terminals connected together,
 - 110V d.c. or 220V d.c. negative "protection" supply terminals connected together,
 - 110V d.c. or 220V d.c. positive "control" supply terminals connected together,
 - 110V d.c. or 220V d.c. negative "control" supply terminals connected together,
 - 230V a.c. live supply terminals connected together, and
 - 230V a.c. neutral supply terminals connected together.

Jumpers shall be of minimum cross sectional area of 2.5sqmm. Bus section panels will not include the above jumpers

- 6) MCBs shall comply with the requirements of SANS 60947-2 and IEC 60898 (Parts 1 and/or 2 as appropriate). In particular:
 - a) Breaking capacities shall be in accordance with IEC 60898 (I_{cn}/I_{cs}) and SANS 60947-2 (I_{cu} = I_{cs}) and shall be at least 5 kA;
 - b) The utilisation category shall be 'A' (SANS 60947-2);

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- c) The maximum service voltage shall be at least $V_N + 20\%$;
 - d) The pollution degree shall be '3' or higher (SANS 60947-2);
 - e) The shall be suitable for isolation (SANS 60947-2); and
 - f) The protection curve shall be 'C' (SANS 60947-2 and IEC 60898).
- 7) All MCBs shall be wired with the source supply at the top, and the load supply at the bottom. Where MCBs are polarity sensitive, polarity markings shall be provided on the front of the MCB in accordance with IEC 60898-2. Additionally, the manufacturer shall provide their schematic wiring diagrams indicating the correct wiring polarity with the source supply at the top.
- 8) Low-voltage fuses shall not be used.
- 9) D-DT-5408 makes provision for dedicated DC supply terminals to Ethernet network switches which may be fitted as part of the on-board protection schemes.

3.2 Circuit-breaker spring charging motor control circuits

- 1) The motor control circuit shall include thermal overload and short-circuit protection via a suitably rated MCB.
- 2) The spring charging motor shall be suitable for operating at any d.c. voltage between 85 % and 110 % of the nominal control voltages measured at the device terminals. The maximum continuous current drawn by the spring charging motor (per mechanism) shall be 10 A. The spring charging time shall not be greater than 10 s. The motor starting current shall be less than 3 times the continuous current rating with a duration not greater than 100 ms.
- 3) Automatic re-charging of closing springs shall be provided by means of an interlock arranged via a normally-closed spring limit switch contact.
- 4) In addition to the spring limit switch contacts required for motor control, spare contacts of the type and quantity specified in D-DT-5408 drawing shall be provided.

3.3 Motorised racking / disconnecter switching motor control circuits

- 1) The switchgear shall be provided with motorised racking / disconnecter switching motor control circuits that accept pulsed operating (e.g. rack-in / rack-out or open / close) signals and which ensure that the required operation is fully completed. In the case of withdrawable AIS switchgear, this shall include motorised rackable circuit-breakers, VTs and CPAT's, and in the case of GIS switchgear (Fixed Pattern etc.), motorised disconnectors.
- 2) The pulsed operating signals are provided via a remote switch interfaced via terminals which shall be provided in the corresponding LV compartment in accordance with D-DT-5408. In the case of motorised racking, the rack-in/rack-out signals are also provided via a stand-off remote control unit (umbilical cord). A female receptacle for the stand-off remote control unit shall be fitted to the door of the LV compartment and wired directly to the motorised racking circuitry. The wiring of the receptacle shall be done in such a way that the same stand-off remote control unit may be used for stand-off remote controlled switching (trip / close – see 3.5 below) and racking of circuit-breakers.
- 3) In the case of motorised racking, electronic racking motor controllers shall be supplied without on-board rack-in / rack-out push-buttons. The "fault" contact from the electronic racking motor controller shall be wired to the panel's "circuit-breaker/panel not healthy common alarm" terminals in accordance with D-DT-5408 drawing. A normally-closed when "ready" status contact from the electronic racking motor controller, indicating that the withdrawable part is ready to be racked in or racked out (based on the interlocking requirements of the relevant switchgear specification), shall be wired to terminals which shall be provided in the LV compartment in accordance with D-DT-5408 drawing. A logic diagram for the electronic racking controller shall be supplied as part of the panel schematic wiring diagrams.

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- 4) The motor for motorised switching devices shall be suitable for operating at any d.c. voltage between 85 % and 110 % of the nominal control voltages measured at the device terminals. The continuous power drawn by each motor shall not exceed 100 W, unless otherwise approved.
 - 5) The motor circuit shall include protection against continual motor running (over-run) in case of a mechanical failure of the mechanism (e.g. by the interrupting of motor supply after a predetermined time). The specific method used to achieve this requirement shall be indicated on the schematic wiring diagrams submitted to Eskom. All contacts in motorised controls shall be capable of interrupting the maximum current drawn by the device being operated in their respective branch of the circuit.
 - 6) The stand-off remote control (i.e. umbilical cord) and/or remote triggering of motor control circuits shall be wired to terminals which shall be provided in the LV compartment in accordance with D-DT-5408 drawing.
 - 7) The stand-off remote control unit female receptacle for motorised racking / disconnecter switching shall be accessible from the front of the panel without leaving ground/floor level.

3.4 Circuit-breaker control circuits

3.4.1 Closing control circuit

- 1) Shunt closing coils shall be suitable for operating at any d.c. voltage between 85 % and 110 % of the nominal control voltages measured at the coil terminals.
- 2) Sliding link test terminals shall be used at the Eskom wiring interface points to the closing circuits as per D-DT-5408.
- 3) The circuit-breaker shall close correctly when an electrical closing pulse of 100 ms duration is applied to the closing coil.
- 4) The total power drawn by the closing coil of the circuit-breaker shall not exceed 500 W unless otherwise approved.
- 5) For closing coils rated less than 200 W, the closing coils shall not operate if a 60 μ F capacitor, charged to 0,6 times the nominal d.c. control voltage, is discharged through the closing coil. The closing coils shall have an L/R time constant of less than 20 ms.
- 6) Each closing coil shall be wired in series with the following contacts:
 - a. a normally-closed circuit breaker auxiliary control contact (52b), to allow closing only when the circuit-breaker is open, and to interrupt closing coil current once the circuit-breaker closes.
 - b. a normally-open spring limit switch contact to prevent damage to the closing coil if a sustained closing pulse is applied when the closing springs are not fully charged.
- 7) Closing coils shall be clearly marked with the manufacturer's name and part number. The manufacturer shall submit data sheets indicating the operating voltage, current and actual resistance value at 20 °C.

3.4.2 Tripping control circuit

- 1) Shunt tripping coils shall be suitable for operation at any d.c. voltage between 70 % and 110 % of the nominal voltages, measured at the coil terminals.
- 2) Sliding link test terminals shall be used at the Eskom wiring interface points to the tripping circuits as per D-DT-5408.

- 3) Each circuit-breaker shall be equipped with two shunt-tripping coils (of identical function) and associated electrical tripping control circuits. The two tripping control circuits shall be electrically and physically separated in order to allow for independent control systems to be applied to each system. Neither tripping coil shall influence the operation of the other if one is damaged. Tripping coils shall not have a particular polarity, nor shall they affect operation when energised simultaneously.
- 4) The tripping control circuits shall be monitored individually. The tripping coils shall be rated to carry a continuous 20 mA d.c. current for monitoring purposes without overheating or burning out.
- 5) The total power drawn by each tripping coil of the circuit-breaker shall not exceed 500 W unless otherwise approved.
- 6) For tripping coils rated less than 200 W, the tripping coils shall not operate if a 60 μ F capacitor, charged to 0.6 times the nominal d.c. control voltage, is discharged through the tripping coil. The tripping coils shall have an L/R time constant of less than 20 ms.

3.4.3 Anti-pumping

All circuit-breakers shall be equipped with anti-pumping circuitry to prevent repeated tripping and closing of a circuit-breaker in the event that the tripping and closing pulses are sustained. Anti-pumping arrangements shall be subject to Eskom's written approval and shall be demonstrated as part of the routine and site-testing procedures. The anti-pumping control relay shall continue to operate at a supply voltage below the minimum operating voltage of the closing coil. Anti-pump control relay shall only be connected to the closing circuit.

3.5 Stand-off remote controlled switching (trip / close) of circuit-breakers

- 1) Provision shall be made for stand-off remote controlled trip / close functions for each circuit-breaker. The pulsed trip / close signals are provided via a stand-off remote control unit (umbilical cord). A female receptacle for the stand-off remote control unit shall be fitted to the door of the LV compartment and wired directly to terminals in the LV compartment in accordance with D-DT-5408. The wiring of the pins associated with the male-female interface shall be in accordance with the relevant switchgear specification.
- 2) The stand-off remote control unit female receptacle for circuit-breaker switching shall be accessible from the front of the panel without leaving ground/floor level.
- 3) The buttons on the stand-off remote control unit shall be labelled and colour coded as follows:
 - "CLOSE", colour Red, shall close a circuit-breaker, rack-in a circuit-breaker and/or close a disconnecter.
 - "TRIP", colour Green, shall trip a circuit-breaker, rack-out a circuit-breaker and/or open a disconnecter.

The close and trip buttons shall be oriented such that the close button is above the trip button.

3.6 Heater control circuits

- 1) Suitably rated electric heaters shall prevent moisture from condensing and being deposited inside the air insulated compartments of the switchgear panel. Heaters shall maintain a dew-point greater than the ambient temperature and shall circulate the air constantly to all parts of the enclosure.
- 2) Unless approved otherwise by Eskom, heaters shall be located inside the busbar, cable and circuit-breaker compartments in the case of AIS. The heaters shall be permanently connected and shall not be de-energized when the switchgear is in service. No Heaters are required for compartments housing VT's and CPAT's.
- 3) Heaters shall be installed to avoid damage to temperature-sensitive components. Heater elements shall be shrouded and leads, which are heated by the conduction of heat from the element, shall be insulated by heat-resistant insulating material, e.g. ceramic beads or silicone rubber.

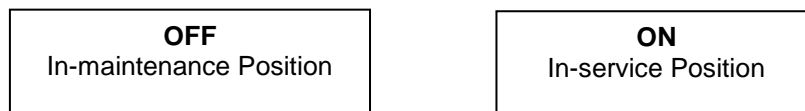
- 4) The electrical supply for heaters shall be single-phase 230 V a.c.
- 5) The total power drawn by compartment heaters shall not exceed 200 W (per panel), unless otherwise approved. The first 100 W of heating capacity per compartment shall be permanently connected. The heater power drain larger than 100 W shall be switched via a pre-set thermostat or humidistat to prevent the compartment from overheating. This function shall be demonstrated and agreed upon with Eskom.
- 6) The heaters shall be equipped with suitable temperature- or current-activated alarm contacts to indicate failure thereof or loss of supply to the heater circuit. The heater fail alarm shall be wired to terminals in the LV compartment in accordance with D-DT-5408 drawing. Refer to clause 3.9 for alarm contact requirements. This functionality shall be demonstrated and agreed upon with Eskom.

3.7 Circuit-breaker ancillary functions

3.7.1 DC isolation control switch/function (GIS switchgear only)

All panels that include motorised controls and/or circuit-breaker trip and close coils shall be fitted with a d.c. isolation control switch that will isolate all tripping/opening and closing pulses coming in externally to the panel. The d.c. isolation control switch shall isolate the d.c. supply to the spring charging motor control circuit and circuit-breaker, disconnecter and earth switch control circuits.

This control switch shall be labelled as follows:



When the control switch is in the “OFF/ In-Maintenance Position” this condition is to be alarmed to the circuit-breaker common alarm terminals provided in the LV compartment in accordance with D-DT-5408 (for circuit-breaker not healthy indication). Refer to clause 3.9 for alarm contact requirements.

The DC isolation switch allows for isolation of electrical controls to moving parts of the switchgear by maintenance personnel. The point of isolation is provided within arm’s reach of the switchboard.

It shall be acceptable for the DC isolation switch to be replaced by one or more MCBs in the LV compartment which provide the same isolation function. Such MCBs are to include the description “DC Isolate” in their label inscriptions. The DC isolation function shall be applicable to both on- and off-board protection scheme applications.

3.7.2 Auxiliary switches

- 1) Circuit breaker auxiliary switch contacts (52a and 52b) shall always replicate the main contact position. In addition to the auxiliary switch control contacts required for control interlocking, the number and type of auxiliary contacts required for each mechanism shall cover the requirement specified in D-DT-5408. Each auxiliary circuit indicated in D-DT-5408 drawings shall be independent of one another (i.e. changeover contacts shall not be used). Auxiliary switch contacts shall reproduce main contact timing to acceptable limits approved by Eskom.
- 2) All spare auxiliary contacts shall be wired independently to the terminals in the LV compartment in accordance with D-DT-5408 drawing. The use of auxiliary relays to multiply the number of auxiliary contacts is not acceptable.
- 3) Auxiliary switch contacts shall be protected against ingress of dust particles to degree IP 55 in accordance with SANS 60529. Where Eskom considers it necessary, dust guards shall be fitted at no extra cost. Cascading of auxiliary switches via mechanical means is acceptable provided that mechanical endurance testing has been satisfactorily carried out.

3.7.3 Spring limit switches (SLS)

- 1) Spring limit switches shall always reproduce the charge status of the mechanism spring. In addition to the spring limit switch contacts required for control interlocking, the number and type of spring limit switch contacts required for each mechanism shall cover the requirement specified in D-DT-5408.
- 2) A normally-open spring limit switch contact of each mechanism shall be used to block an electrical close operation.
- 3) The use of auxiliary relays to multiply the number of spring limit switch contacts required is not preferred but can be done if sufficient physical spring limit switch contacts cannot be provided.

3.7.4 Circuit-breaker operation counter

- 1) Each circuit-breaker shall be provided with an operation counter that is advanced each time the circuit-breaker main contacts open. Mechanical operation counters are preferred, but electrical counters are also acceptable. The circuit-breaker operation counter shall be non-resettable.
- 2) The counter shall have a minimum capability of counting up to 99 999 operations. The supplier shall submit full details of the operation counter on request by Eskom.

3.8 Interlocking circuits

3.8.1 Spring charging motor control circuit interlocks

- 1) Where the design of the mechanism allows for manual charging of the mechanism spring, the supply voltage to the spring charging motor shall be disconnected when the spring charge handle is inserted for manual charging of the spring. Alternatively, the charging handle shall be so designed that it self-disengages should the motor start running. This is to prevent possible injury to the operator should the motor start running while the manual charging handle is inserted onto the mechanism.
- 2) A direct means to achieve the following functions shall be provided:
 - a) closing operation shall be possible only when the closing spring is fully charged;
 - b) the closing spring can only be released when the main contacts are fully open; and
 - c) a device shall be employed to block overcharging of the closing spring when the manual charging facility is employed.

3.8.2 Sulphur hexafluoride (SF6) alarm auxiliary circuits and control circuit blocking interlocks

SF6 gas may be used as a circuit-breaker interrupting medium. In GIS, SF6 may be used for insulation purposes, or for insulation purposes and as an interrupting medium for circuit-breakers.

- 1) SF6 gas-filled compartment(s) shall be provided with a density switch (which may be incorporated into a gauge indicating pressure compensated for temperature) having contacts which shall operate in three stages as follows:
 - a) Healthy/Normal gas level which indicates acceptable operation level
 - b) on reaching the non-urgent alarm / warning level
 - c) on reaching the critical low level
- 2) In the case of GIS switchgear where the gas is used as insulating medium, a trip sequence may be initiated on loss of gas pressure as determined by the manufacturer's recommendation.
- 3) It shall be possible to verify the correct operation of gas density/pressure switch circuits without having to disconnect wiring or having to perform gas-handling operations on the switchgear.

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- 4) The density switch shall provide electrically separated normally-closed contacts for indication purposes as per the requirements of D-DT-5408.
 - 5) The SF6 warning and critical low contacts associated with SF6 compartment insulation shall be derived directly from the density meter or pressure gauge and not via auxiliary relays.
 - 6) The SF6 warning and critical low contacts associated with a circuit-breaker interrupter may be derived using an auxiliary relay associated with the density switch.
 - a. Where auxiliary relays are used to multiply the alarm or blocking indication contacts, the circuit design shall be such as to indicate the alarm / block condition in the event of a loss of auxiliary d.c. supply or circuit failure. The relays shall continue to operate at a supply voltage below the minimum operating voltage of the tripping coils.
 - b. normally-open contacts from the critical low indication shall be wired into all tripping and closing control circuits to block the operation of the circuit-breaker.

3.9 Alarm circuits

- 1) All circuit-breaker alarms shall be wired to separate terminals provided in the LV compartment in accordance with D-DT-5408.
- 2) Three alarm circuits shall be provided:
 - a) Circuit-breaker not healthy common alarm: This alarm shall monitor and indicate an abnormal state of the circuit-breaker. This alarm is activated under any of the following conditions:
 - d.c. isolation control switch is selected to "OFF" (if applicable), or
 - spring charging motor control circuit MCB trips (if applicable), or
 - electronic racking motor controller faults (if applicable).

Note: This alarm is not raised by the SF₆ gas pressure alarms, or the spring in the discharged state, or for a heater failure.

- b) Low gas alarms as per Section 3.8.2.
- c) Switchgear heater alarm: This alarm shall monitor and indicate the status of the heater circuit. This alarm is activated when the temperature threshold is reached (i.e. when heaters cool down due to failure thereof or loss of a.c. supply). Tripping of a heater supply MCB (where provided) shall raise the circuit-breaker heater alarm.

3.10 CT wiring requirements

- 1) Three CT cores shall be provided in all incomer and feeder circuit-breaker applications: 1 x Protection and 2 x Measurement. The position and orientation of the CT cores relative to the busbar and circuit-breaker shall be as indicated in Figure 1.
- 2) One set of Protection CT cores shall be provided in bus section circuit-breaker applications.
- 3) The position, orientation and associated terminal numbering for the CT cores shall be done in accordance with the relevant sheets of D-DT 5408. The P1 terminal of a CT shall always face its associated circuit-breaker.
- 4) The switchgear shall be supplied with the CT secondaries shorted and earthed (from the top (Eskom) side of the CT terminal strip (X1)) in the LV compartment using insulated wire jumpers in accordance with D-DT-5408.

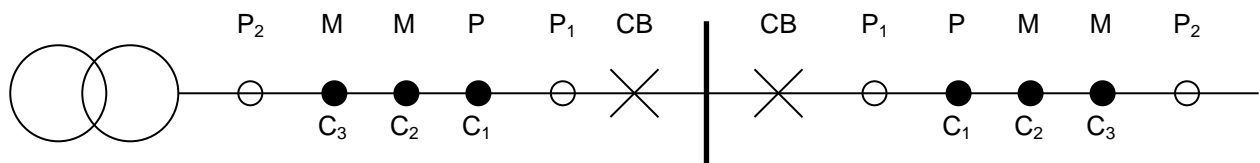


Figure 1: CT position for all indoor applications

3.11 VT wiring requirements

- 1) The protection VTs shall be wired to terminals provided in the VT panel LV compartment and shall be bus-wired to the designated terminals provided in each circuit-breaker panel LV compartment in accordance with D-DT-5408 drawing. The protection VTs shall be buswired to all circuit-breaker panels associated with the same busbar section as the VT panel.
- 2) The measurement VTs shall be wired to the terminals provided in the VT panel LV compartment in accordance with D-DT-5408.
- 3) VT bus-wires of different zones must not be paralleled / crossed over to another zone i.e. crossing over a bus section.

3.12 VT and CPAT panel wiring requirements

- 1) The VT and CPAT panels shall be wired in accordance with D-DT-5408.
- 2) In the case of AIS switchgear, "busbar earthed" indication contacts shall be provided on each VT panel designated for busbar earthing.
- 3) In the case of busbar earthing of AIS switchgear utilizing a withdrawable earthing switch, provision shall be made for stand-off closing of the busbar earthing switch when racked into the VT panel. The pulsed close signal is provided via a stand-off remote control unit (umbilical cord). A female receptacle shall be fitted to the door of the LV compartment and wired directly to the earth switch closing circuit. The wiring of the pins associated with the male-female interface for the close control function shall be in accordance with the relevant switchgear specification. Opening of the busbar earthing switch shall only be via the mechanical open control for the busbar earthing switch.

Note: The busbar earthing switch may be a withdrawable circuit-breaker.

3.13 On- and Off-board protection system wiring

The switchgear shall be designed for the mounting and interfacing to an on-board protection scheme to be installed in the LV compartment of every panel. The protection system includes arc sensors for each air-insulated compartment (including the cable and busbar chambers of GIS panels). An alternative application design choice by Eskom may be to fit the protection scheme off-board of the switchgear, but including arc sensors on the switchgear.

- 1) In cases where on-board protection is used, the switchgear supplier shall provide an ordering option which includes:
 - a. Mounting of the protection module in the 19-inch rack aperture of the LV compartment door
 - b. Termination of the protection module wiring tail to existing terminals in the LV compartment (approximately 30 wires), as per a wiring schedule to be supplied by Eskom.
 - c. Installation of wire jumpers between existing LV compartment terminals (approximately 15 jumpers), as per a wiring schedule to be supplied by Eskom.
 - d. Mounting and routing of fibre optic arc sensor leads in each air-insulated compartment (including GIS cable and busbar compartments), and terminating these on the protection IED.

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Eskom will free issue the protection scheme and arc sensor leads (including mounting brackets) to the switchgear supplier in this case.

- 2) In cases where off-board protection is used, the switchgear supplier shall mount and route free-issued fibre optic arc sensor leads in each air-insulated compartment, leaving remaining slack coiled in the associated panel's LV compartment.

3.14 Wiring, terminal blocks and terminal strips

3.14.1 Terminal blocks and terminal strips

- 1) Each LV compartment shall be provided with not less than 6 spare terminals. Spares of each terminal block type used shall be provided in proportion to the numbers used.
- 2) The arrangement of the terminal strips in the LV compartment shall allow the unobstructed entry of the incoming control cables in the top and bottom-entry configuration (as applicable).
- 3) Secondary terminals shall comply with [3] 240-70413291. The terminal blocks shall be of the screw clamp, spring loaded insertion type. The minimum terminal width shall be 8mm. The terminal blocks shall be capable of accepting back-to-back insulated hook blade lugs without damaging or deforming the lugs. Only Eskom approved terminal blocks shall be used.
- 4) Control cabling applied by Eskom to interface with the circuit-breaker will be multi-core, PVC insulated, steel-wire armoured and PVC sheathed in accordance with SANS 1507-3.
- 5) In order to facilitate easy access to all terminals and wires, a minimum gap of 30mm shall be provided between trunking and the top and bottom or left and right of the terminal blocks. To further improve accessibility, the terminal attachment rail may be mounted on posts or an angle iron such that the rail is raised from the back plate by 40mm.
- 6) Trunking shall be provided at the top and bottom of each terminal rail and shall easily accommodate the wiring. Trunking shall be of the 'fine' tooth type (tooth width 6.1 mm as opposed to 12.0 mm). 60 mm (h) x 40 mm (w) trunking is preferred.
- 7) All wiring is to be stripped of as much slack as possible so as to leave maximum trunking space for Eskom wiring.

3.14.2 Wiring

- 1) Wiring shall comply with the requirements for insulated wire in accordance with SANS 1507-2 and shall have a rated operating voltage of 600/1000 V (phase-to-earth/phase-to-phase).

Note: SANS 1507-2 requires that wiring insulated for 1000 V phase-to-phase shall withstand 2000 V for 10 minutes.

- 2) Wiring for CTs, VTs, CPATs and motor control circuits shall be carried out using stranded copper conductor with a minimum nominal cross-sectional area of 2,5 mm².
- 3) Wiring for control and other auxiliary circuits shall be carried out using multi-stranded copper conductor with a minimum nominal cross-sectional area of 1,5 mm².
- 4) All wiring shall be grey in colour, except that yellow/green wiring shall be used for earth wires. CT and VT wiring may be colour coded Red, White, Blue and Black (neutral) as appropriate.
- 5) Secondary wiring shall be identified at both ends in an approved manner (e.g. by ferruling), and shall present a neat appearance. It shall be braced, placed in plastic trunking, clipped and/or laced to prevent chafing due to vibration. All secondary equipment, terminals, labels and so on shall be completely accessible after the wiring and cabling has been completed.
- 6) Wires shall be identified using the remote-end connection method of IEC 62491 unless approved otherwise by Eskom. Wires terminating at the X1 and X2 terminal strips shall in addition be identified using the label indicated on D-DT-5408.

- 7) All wires shall be terminated using suitable hook-blade or ring lug terminations. The terminating method shall ensure that the numbered ferrule may not fall off when disconnecting the wire. In this regard, the use of one or more strands of wire to retain the ferrule is not acceptable.
- 8) All wires for interfacing with Eskom shall terminate on the bottom of the respective terminal strip, such that Eskom wiring may be terminated at the top of the terminals.
- 9) Wiring shall be routed in the corners of compartments, avoiding any screw studs or sharp objects that protrude into the compartment. Wiring shall be installed in such a way so as not to compromise any medium voltage electrical clearances in air. All auxiliary wiring passing through main circuit compartments shall be protected by metal trunking or screening.
- 10) Wiring supports shall be riveted or screwed in position. No stick-on wiring supports (e.g. using mirror tape or double-sided adhesive tape) shall be used - specifically with regard to arc sensor wiring.
- 11) Connections to equipment on swing doors or frames shall be so arranged as to give the conductor(s) a twisting motion and not a bending motion (e.g. arranged vertically over the hinge).
- 12) All holes for purposes of inter-panel wiring shall be finished and/or fitted with grommets such as to protect wiring insulation from damage.

3.14.3 Standard terminal strip layout

- 1) The terminal strips used for interfacing with external cabling shall be numbered, and interfacing wires ferruled in accordance with D-DT-5408 (all applicable sheets) and shall be designated as defined in Table 1 below.

Table 1: RT Terminal strip designation and location

1	2	3	4	5
RT Terminal Strip	Description / Application	Incomer and feeder circuit-breaker panels	Bus-section circuit-breaker panels	VT & CPAT panels
X1	Current transformer wiring, Voltage transformer wiring, status indications	x	x	x
X2	Circuit-breaker controls, alarms and status Indications, auxiliary device circuits	x	x	x
X3	RS485 serial communication for SCADA	x	x	x

- 2) All status and spring limit switch contacts as indicated on D-DT-5408 drawing shall be provided (as applicable to the switchgear type).
- 3) Where a particular function/alarm is not applicable (e.g. SF6 alarms for AIS switchgear), then the required terminals shall be provided but shall be left unwired, or the applicable terminals may be omitted. Alternative functions/alarms shall not be wired to standard terminals designated for another function/alarm.

3.14.4 Schematic wiring diagrams and layout drawings

- 1) All diagrams and drawings shall be labelled and annotated in English.
- 2) The schematic wiring diagrams shall use contact reference conditions as defined in clause 3.1 (2).
- 3) A schematic wiring diagram shall be provided detailing the specific wiring of the control, alarm and indication circuits. The diagram shall use the standard symbols of IEC 60617 (specifically Parts 2 & 8) and shall include a key to any abbreviations or device codes used. Particular attention shall be paid to the correct orientation of the symbols.
- 4) A separate sheet shall indicate for each component used on the schematic diagram the designation, make, type and rating of all control equipment (switches, auxiliary relays, heaters, motors, trip/close coils, terminal blocks, MCBs, etc.)
- 5) Diagrams shall show the relative timing of main and auxiliary switch contacts and if applicable, operating levels of pressure switches, reducing and safety valves and so forth on increasing and decreasing pressure.
- 6) A general arrangement drawing of the LV compartment shall be provided showing the relative positions of the terminals strips, arc detection relays, gland plates, overall dimensions, etc.
- 7) The layout of the LV compartment door shall be provided on a drawing showing:
 - a) In the case of off-board protection and control schemes, the position of the stand-off female receptacles and the local circuit-breaker schematic mimic indications as per the relevant switchgear specification, or
 - b) In the case of on-board protection and control schemes, the position of the stand-off female receptacles and the 19 inch rack (provided for the protection scheme) in accordance with the relevant switchgear specification.

4. Authorisation

This document has been seen and accepted by:

Name and surname	Designation
Danie du Plessis	Senior Manager - Transmission
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Prudence Madiba	Senior Manager – Generation
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PASC C&V List	

5. Revisions

Date	Rev	Compiler	Remarks
Feb 2020	3	C.M. Mohlokoana	Section 3.1(2) – Disconnecter reference condition amended from closed to open Section 3.5 – stand-off control unit colour coding indicated. Section 3.7.1 – DC isolating switch function may be substituted by MCBs. Section 3.8.2 – Differentiation made between SF6 alarm circuits when used as insulation medium vs circuit-breaker interrupting medium. Section 3.13 – Requirements for wiring of on- and off-board protection schemes updated.

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Date	Rev	Compiler	Remarks
March 2016	2	H. Sithole	Standard revised to include adoption of IEC 61850 and decentralised bus bar arc flash protection philosophy
Oct 2013	1	P. Almeida / M. Mohlokoana	Incorporated the new protection panel integration method for on-board relay fitting
June 2013	1	B. Mwarehwa	Final Document for Publication
Nov 2012	0	B. Mwarehwa	Draft document for Review created from DST 34-1996

6. Development team

The following people were involved in the development of this document:

- Stuart van Zyl
- Haggai Sithole
- Matankiso Mohlokoana

7. Acknowledgements

Not applicable.