Eskom	Standard	Transmission

Title: **SPECIFICATION FOR HIGH VOLTAGE AIR INSULATED SWITCHGEAR RATED FOR VOLTAGES 1 KV AND ABOVE – OUTDOOR CIRCUIT-BREAKERS**

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Content

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1. Introduction

This standard specification sets out Eskom Transmission's specific and standardised requirements for outdoor air-insulated circuit-breakers for use in three-phase 50 Hz alternating current systems with nominal voltages from 6,6 kV up to and including 765 kV. The requirements for circuit-breakers are based on SANS 62271-100 (High-voltage alternating-current circuit-breakers). The standard covers both live-tank and dead-tank circuit-breakers. The circuit-breakers may be specified with or without current transformers (CTs). The circuit-breaker designs that offer non-SF6 (SF6-free) environmental-friendliness low Global Warming Potential (low GWP of 1 or less, or low CO2e), and meet this standard specification shall be considered. These shall have been designed and type tested in accordance with IEC62271-100 standard. At voltages of 132 kV below, these non-SF6 (SF6-free) circuit-breakers that offer environmental-friendliness (low GWP of 1 or less, or low CO2e) standard shall be preferred for Eskom Transmission contracting or once-off ordering, for all standard circuit-breaker ratings. Only at special applications (duty or higher ratings) where there is no evidence of the type-tested ratings of the non-SF6 (SF6-free) environmental-friendly circuit-breaker nor user onsite piloting experience that is positive, then SF6 gas circuit-breakers shall be specified by Eskom Transmission. For voltages above 132 kV, where there is evidence of type testing to meet Eskom Transmission specified ratings and the user onsite piloting experience that is positive, Eskom Transmission shall consider offered non-SF6 (SF6-free) circuit-breakers that offer environmental-friendliness (low GWP of 1 or less or low CO2e). Otherwise, the SF6 gas circuit-breakers shall be specified for all ratings that are without any proven non-SF6 (SF6-free) environmental-friendly of low GWP.

This standard specification includes the devices that are specified with the circuit-breakers, namely the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device), and digital online condition monitoring and/or integrated diagnostic devices. The type tested ratings of the circuit-breakers and their associated accessories are required to remain valid for the life-expectancy (minimum 40 years) specified herein, not unless the particular test has been qualified its validity for a specific period.

For special application switchgear requirements and/or unique projects, a separate standard specification shall be issued for use e.g. for HVDC bypass switches and selection applications (240-132306591), disconnecting circuit-breaker (DCB) (240-105506460), bypass switches for series capbanks, etc. Such requirement will be issued with separate Technical Schedules A and B in accordance with their technical standard specifications.

2. Supporting clauses

2.1 Scope

This document covers the Eskom Transmission high voltage air insulated outdoor circuit-breakers rated for 1 kV and above.

2.1.1 Purpose

This standard specification provides the specific and standardised requirements for outdoor air-insulated circuit-breakers in accordance with SANS 62271-100. The circuit-breakers are intended for use in substations having three-phase 50 Hz alternating current (a.c.) nominal operating voltages from 6,6 kV up to and including 765 kV. Circuit-breakers are required for general purpose power switching and protection applications as well as for special purpose applications such as the switching of earthed shunt capacitor banks, shunt reactors, capacitor-reactor combinations and generator unit synchronising.

The standard specification covers both live-tank and dead-tank circuit-breakers. The circuit-breakers may be specified with or without current transformers (CTs). The circuit-breaker designs that offer environmental-friendliness low Global Warming Potential (low GWP of 1 or less, or low CO2e) and meet this standard specification shall be considered. These shall have been designed and type tested in accordance with IEC62271-100 standard.

A set of technical schedules A and B accompanies this standard specification, which are as per Appendix B (Generic). Additional and special requirements are also included in Schedule A.

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The standard specification covers the design, manufacture, testing, supply, delivery, storage, installation (erection), pre-commissioning tests and the installation and maintenance training of outdoor type circuit-breakers and associated equipment specified herein.

2.1.2 Applicability

This document shall apply throughout Eskom Transmission.

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

NOTE: IEC standards (including IEC documents adopted as SANS standards without changes)

[1] ISO 9001, Quality Management Systems.

[2] Occupation Health and Safety Act (OHS Act) No 85 of 1993 – Construction and Electrical Machinery Regulations.

[3] 240-114967625, Operating Regulations for High Voltage Systems (ORHVS).

[4] 240-56063765, Eskom health and safety management – supplier requirements.

[5] SANS/ IEC 60050(441):1984: International Electrotechnical Vocabulary – Chapter 441: Switchgear, controlgear and fuses

[6] SANS 62271-1, High-voltage switchgear and controlgear – Part 1: Common specifications.

[7] SANS 62271-100, High-voltage switchgear and controlgear – Part 100: High-voltage alternating-current circuit-breakers.

[8] SANS 62271-110, High-voltage switchgear and controlgear – Part 110: Inductive load switching.

[9] SANS 62271-203, High-voltage switchgear and controlgear – Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV.

[10] SANS 62271-301, High-voltage switchgear and controlgear – Part 302: Dimensional standardisation of high-voltage terminals.

[11] SANS 62271-302, High-voltage switchgear and controlgear – Part 302: Alternating current circuit-breakers with intentionally non-simultaneous pole operation.

[12] SANS 60137, Insulated bushings for voltages above 1000V

[13] SANS 60060-1, High-voltage test techniques — Part 1: General definitions and test requirements.

[14] SANS 1019, Standard voltages, currents and insulation levels for electricity supply

[15] IEC 60721-2-6, Classification of environmental conditions. Part 2: Environmental conditions appearing in nature. Earthquake vibration and shock

[16] NRS 029, Current transformers for rated a.c. voltages from 3,6 kV up to and including 420 kV (maximum voltage for equipment).

[17] SANS 60044-1, Current Transformers

[18] SANS 60044-6, Current Transformers – Part 6: Requirements for protective current transformers for transient performance

[19] IEC 6189-1, Instrument transformers – Part 1 General requirements

[20] 240-56062864, Current transformers Eskom specific requirements up to 132kV in accordance with NRS 029 standard

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[21] IEC 60943, Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals

[22] 240-56030435, outdoor ceramic station post insulators for systems with nominal voltages up to 765kV specification

[23] SANS 60815-1:2009, Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles.

[24] SANS 60815-2:2009, Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 2: Ceramic and glass insulators for a.c. systems.

[25] SANS 60815-3:2009, Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 3: Polymer insulators for a.c. systems.

[26] SANS 61462, Composite hollow insulators — Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1 000 V — Definitions, test methods, acceptance criteria and design recommendations.

[27] SANS 62155, Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V.

[28] 240-142598739 Rev 3, …Guidance on technical Standards applicable for pollution related qualification of High Voltage equipment (internal Eskom Transmission Engineering Instruction)

[29] IEC 60376, Specification of technical grade sulphur hexafluoride (SF6) for use in electrical equipment.

[30] SANS/IEC 62271-4, High-voltage switchgear and controlgear- Part 4: Handling procedures for. gases for insulation and/or switching

[31] NRS 087, Guidelines for the management of SF6 (sulphur hexafluoride) for use in electrical equipment.

[32] 240-151122225, Specification for new SF6 gas supplied in standard gas cylinders with the Technical Evaluation Criteria

[33] SANS 10019, Transportable pressure receptacles for compressed, dissolved and liquefied gases - Basic design, manufacture, use and maintenance

[34] SANS 10263-2, The warehousing of dangerous goods – Part 2: The storage and handling of gas cylinders

[35] 240-125809509, Eskom Greenhouse Gas Emissions Reporting Procedure

[36] Cigre 2014, TB 589 by WG A3.27, The Impact of the Application of Vacuum Switchgear at Transmission Voltages (ISBN : 978-2-85873-287-6)

[37] Cigre 2021, TB 849, Electric performance of new non-SF6 gases and gas mixtures for gas-insulated systems”

[38] IEC 63360, Fluids for electrotechnical application: Mixtures of gases alternative to SF6 (CD, Final Draft or Latest published)

[39] IEC 60073, Basic and safety principles for man-machine interface, marking and identification – Coding principles for indicators and actuators

[40] IEC 60447, Basic and safety principles for man-machine interface, marking and identification – Actuating principles

[41] SANS 60529, Degrees of protection provided by enclosures (IP code)

[42] SANS 62262, Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)

[43] 240-75566441, Transmission Philosophy for Application of Point on Wave Switching of Circuit Breakers

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[44] 240-1489922148, User Specification for online condition monitoring device for air insulated circuit-breakers and isolators/Earthing switches

[45] SANS/ IEC 61850, (All parts) Communication networks and systems for power utility automation

[46] SANS 62271-3/ IEC 62271-3, High-voltage switchgear and controlgear — Part 3: Digital interfaces based on IEC 61850

[47] 240-120804300, Standard for the Labelling of High Voltage Equipment

[48] 240-62629353, Specification for Panel Labelling standard

[49] 240-64636794, Standard for Wiring and Cable Marking

[50] 240-75655504, Corrosion protection standard for new indoor and outdoor Eskom equipment, components, materials and structures manufactured from steel

[51] SANS 1091, National colour standard.

[52] SANS 121 (ISO 1461), Hot-dip galvanised coatings on fabricated iron and steel articles – Specifications and test methods

[53] 240-53902499, Standard for the transport, handling, storage and preservation of HV and MV switchgear.

[54] TPC41-141, Commissioning of new substation plant documentation and check sheets

[55] 240-148617190, Replace with new 132 kV circuit-breakers rated for 50 kA and above at the substations with fault-levels 30 kA and above (internal Eskom Transmission Engineering Instruction)

[56] 240-180000036, Install Surge Capacitors on 88 kV and 132 kV Feeder bays to mitigate overstress of CB's by switching transients upon permanent faults (sustained faults) (internal Eskom Transmission Engineering Instruction)

[57] IEC 60358-1, Coupling capacitors and capacitor dividers

[58] 0.52/30135, Switchgear Interface – 11 kV to 132 kV Circuit-breakers

[59] 0.54/07529, Wiring of outdoor 220 kV, 275 kV, 400 kV and 765 kV Live Tank circuit-breakers

[60] 0.54/8557, Wiring of outdoor 220 kV, 275 kV, 400 kV and 765 kV Dead Tank circuit-breakers

[61] 0.54/8829, Application Guide

[62] Appendix A – Supplier and Eskom Transmission's responsibilities

[63] Appendix B – Technical Schedules A & B (Generic typical example)

[64] Appendix C – Material and Corrosion Protection information

[65] Appendix D – Requirements for Wiring of Switchgear for Eskom Transmission

[66] Appendix E – Technical A & B Schedule for electronic controller (Controlled Switching Device/ PoW switching device) (Generic typical example)

[67] Appendix F – Surge capacitors used for mitigation of switching overstress on 132 kV CB of the MTS feeders

[68] Appendix G – Requirements for Switchgear Training from Suppliers and their OEM's

2.2.2 Informative

[69] Ref No 46-18 Rev 1, "System Operator: Evaluation of the Witkop, Nhluvuko 132 kV Circuit Breaker TRVs", by A. Bartylak (internal Eskom Transmission document),

[70] Dr Van Coller JM, Insulation coordination study and transient recovery voltage study of the proposed modifications to the Sasol East and West 132 kV substations (Secunda), (2016). (internal Eskom Transmission project),

[71] Ref 46-18 Rev 0, Evaluation of Medupi and Matimba TRVs for Commissioning of TSS Scheme

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2.3 Definitions

2.3.1 General

Definition	Description
Circuit-breaker	[IEC 62271-100 subclause 3.4.103] the mechanical switching device that is capable of making, carrying and breaking the normal currents, and also making and carrying for a specified time, and breaking currents under specified abnormal circuit condition such as those of short circuit. [IEV 441-14-20 definition] **(NOTE:** without malfunctioning when called to operate, even when it has been standing in one position for long duration.)
Dead-tank circuit-breaker	[IEV 441-14-25 definition] a circuit-breaker with interrupters in an earthed metal tank
Live-tank circuit-breakers	[IEV 441-14-26 definition] a circuit-breaker with interrupters in a tank insulated from earth.
SF6 circuit-breaker	[IEV 441-14-29 definition] A circuit-breaker in which the contacts open and close in sulphur hexaflouride.
Vacuum circuit-breaker	[IEV 441-14-29 definition; also IEC 62271-100 subclause 3.4.108] a circuit-breaker in which the contacts open and close within a highly evacuated envelope.
“a” contact	[IEC 62271-100 subclause 3.5.112] Make contact [IEV 441-15-12 definition] a control or auxiliary contact which is closed when the main contacts of the mechanical switching device are closed and open when they are opened.
“b” contact	[IEC 62271-100 subclause 3.5.113] Break contact [IEV 441-15-13 definition] a control or auxiliary contact which is open when the main contacts of the mechanical switching device are closed and closed when they are opened.
Anti-pumping device	[IEC 62271-100 subclause 3.6.128] [IEV 441-16-48 definition] a device which prevents re-closing after a Close-Open operation as long as the device initiating closing is maintained in the position for closing
Enclosure	[IEC 62271-100 subclause 3.5.123] part of switchgear and controlgear providing a specified degree of protection (see IEC 60529) of equipment against external influences and a specified degree of protection against approach to or contact with live parts and against contact with moving parts [IEV 441-13-01, modified]
Terminal	[IEC 62271-100 subclause 3.5.120] component provided for the connection of a device to external conductors

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Definition	Description
Operating sequence	[IEC 62271-100 subclause 3.6.103] [IEV 441-16-03 definition] (of a mechanical switching device) a succession of specified operations with specified time intervals
Breaking capacity	[IEC 62271-100 subclause 3.7.112] [IEV 441-17-08 definition] a value of prospective current that a switching device or fuse is capable of breaking at a stated volage under prescribed conditions of use or behaviour. **NOTE 1:** The voltage to be stated and the conditions to be prescribed are dealt with in the relevant publications. **NOTE 2**: For switching devices, the breaking capacity may be according to the kind of current included in the prescribed conditions, e.g., line-charging breaking capacity, cable charging breaking capacity, single capacitor bank breaking capacity, etc.
Capacitor bank breaking capacity	[IEC 62271-100 subclause 3.7.115] breaking capacity for which the specified conditions of use and behaviour include the opening of a capacitor bank
Capacitor bank inrush making capacity	[IEC 62271-100 subclause 3.7.117] making capacity for which the specified conditions of use and behaviour include the closing onto a capacitor bank
Making capacity	[IEC 62271-100 subclause 3.7.116] [IEV 441-17-09 definition] (of a switching device) A value of prospective making current that a switching device is capable of making at a sated voltage under prescribed conditions of use. NOTE: The voltage to be stated and the prescribed conditions are dealt with in the relevant specifications.
Out-of-phase (making or breaking) capacity	[IEC 62271-100 subclause 3.7.118] making or breaking capacity for which the specified conditions of use and behaviour include the loss or the lack of synchronism between the parts of an electrical system on either side of the circuit-breaker
Short Line fault (SLF)	[IEC 62271-100 subclause 3.1.119] short-circuit on an overhead line at a short, but significant, distance from the terminals of the circuit-breaker **NOTE:** As a rule this distance is not more than a few kilometres.
Current chopping	[IEC 62271-100 subclause 3.4.121] current interruption prior to the natural power frequency current zero of the circuit connected
Circuit-breaker class C2	[IEC 62271-100 subclause 3.4.115] circuit-breaker with very low probability of restrike during capacitive current breaking as demonstrated by specific type tests
Circuit-breaker class M2	[IEC 62271-100 subclause 3.4.117] frequently operated circuit-breaker for special service requirements and designed so as to require only limited maintenance as demonstrated by specific type tests
Circuit-breaker class E1	[IEC 62271-100 subclause 3.4.112] circuit-breaker with basic electrical endurance not falling into the category of class E2 as defined in 3.4.113

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Definition	Description
Circuit-breaker class E2	[IEC 62271-100 subclause 3.4.113] circuit-breaker designed so as not to require maintenance of the interrupting parts of the main circuit during its expected operating life, and only minimal maintenance of its other parts (circuit-breaker with extended electrical endurance) **NOTE 1** Minimal maintenance may include lubrication, replenishment of gas and cleaning of external surfaces, where applicable. **NOTE 2** This definition is restricted to distribution circuit-breakers having a rated voltage above 1 kV, and up to and including 52 kV. See Annex G for rationale behind introduction of class E2.
Circuit-breaker class S1	[IEC 62271-100 subclause 3.4.119] circuit-breaker intended to be used in a cable system
Circuit-breaker class S2	[IEC 62271-100 subclause 3.4.120] circuit-breaker used in a line-system
Gas	[IEC 63360 subclause 3.1.2] a pure gas or gas mixture used for insulation and/or switching within electric power equipment
Gas mixture	[IEC 63360 subclause 3.1.4] a gas made up of a minimum of two different pure gases used for insulation and/or switching within electric power equipment
Pure gas	[IEC 63360 subclause 3.1.3] a gas made up of identical atoms or molecules used for insulation and/or switching within electric power equipment
By-product	[IEC 63360 subclause 3.1.6] contaminant which is formed by the degradation of the gas by electrical arcs, corona effect or sparks, or formed by chemical reaction with other substances or materials
Specialised tools	any purpose-built tools that are necessary to carry out major (or specialised) maintenance on a circuit-breaker and its components
Routine inspection	visual investigation of the principal features of the switchgear and controlgear in service without dismantling. **NOTES** a) This inspection is generally directed toward pressures and/or levels of fluids, tightness, position of relays, pollution of insulating parts, but actions such as lubricating, cleaning, washing, etc. which can be carried out with the switchgear and controlgear in service are also included. b) Observations resulting from inspection can lead to the decision to carry out an overhaul. c) As indicated in note 1 above, routine inspection may include scheduled maintenance activities in accordance with the manufacturer's operation and maintenance instruction manual. d) Routine inspection may also be referred to as 1st line maintenance. This is the definition of "inspection" given in 3.1.8 of SANS 62271-1.

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Definition	Description
Minor maintenance	the execution of scheduled or preventive maintenance work in accordance with the manufacturer's operation and maintenance instruction manual and requiring the switchgear and controlgear to be taken out of service (i.e. in a down state). **NOTES** a) Observations resulting from minor maintenance can lead to the decision to carry out an overhaul. b) Scheduled maintenance is defined in 3.1.7 of SANS 62271-1. c) Minor maintenance may be time-based and/or condition-based. d) Minor maintenance may also include circuit-breaker examination (refer to 3.1.10 of SANS 62271-1) with diagnostic tests (refer to 3.1.9 of SANS 62271-1). Minor maintenance may also be referred to as 2nd line
Breakdown maintenance	unplanned (or unscheduled) maintenance work required to repair a fault and thus restore the switchgear and controlgear to an acceptable condition after a failure
Major maintenance (overhaul)	work performed with the objective of repairing or replacing parts which are found to be out of tolerance by inspection, test, examination, or as required by manufacturer's operation and maintenance instruction manual, in order to restore the component and/or the switchgear and controlgear to an acceptable condition (within tolerance). **NOTES** a) This is the definition of "overhaul" given in 3.1.11 of SANS 62271-1. Major maintenance involves the execution of specialised maintenance where specialised knowledge and skills are required and is also sometimes referred to as specialised maintenance.
Working clearance	straight line distance (clearance) from the closest live part at service voltage to ground level required to safely conduct work.
Submission	The tender in accordance with the requirements of the enquiry

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
ACSI	Abstract Communication Service Interface [IEC 61850-7-2]
AM SED	Asset Management, Substation Equipment and Diagnostics
AMSL	Above mean sea level
ARC	Auto re-closing
CB	Circuit-breaker
CT	Current transformer
CG	Care Group

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CO2e	Carbon Dioxide equivalent
DTCB	Dead-tank circuit-breaker
DN20	20 mm SF6 coupling. D = Diameter, N = Nominal and 20 = 20 mm inside diameter to determine the gas flow capacity. Coupling thread size is M 45 x 2
DN8	8 mm SF6 coupling. D = Diameter, N = Nominal and 8 = 8 mm inside diameter to determine the gas flow capacity. Coupling thread size is M 26 x 1,5.
Eskom	Eskom Holdings SOC (Ltd)
FCLR	Fault Current Limiting Reactor
FMECA	Failure Modes, Effects and Criticality Analysis
GOOSE	Generic Object Oriented Substation Event [IEC 61850-8-1]
GWP	Global Warming Potential
HVDC	High Voltage Direct Current
ITRV	Initial Transient Recovery Voltage
LTCB	Live-tank circuit-breaker
MCB	Miniature circuit-breaker
NRS	National Rationalised Standard
OEM	Original equipment manufacturer
PCB	Poly Chlorinated Biphenyls
PCD	Pitch Circle Diameter
PIU	Protection Interface Unit
POW	Point on Wave
ppmv	parts per million by volume
PTM&C	Protection Telecoms Metering and Control
RRRV	Rate of Rise of Recovery Voltage
SANS	South African National Standards
SCD	Specific creepage distance
SLS	Spring Limit Switch
SPS class	Site Pollution Severity class
TRV	Transient Recovery Voltage
TSS	Transient Stability Scheme
Tx	Transmission
USB	Universal Serial Bus
USCD	Unified specific creepage distance

2.5 Roles and responsibilities

Tx AM SED – shall ensure that the approved standard specification is in place for use by Eskom Transmission.

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Commercial Management – Make use of the up to date version of this document during procurement processes.

Project Management – Make use of the up to date version of this document during procurement processes and all stages of projects or asset creation.

Grids, Asset Management, Quality Management and Warehouse Management (Logistics) – Make reference to this document and the technical standard specification during switchgear asset entering service and its entire minimum service life expectancy as specified by Eskom Transmission.

Technical evaluator – Implement the contents of this document applicable to equipment covered by its scope. Technical evaluation report shall be compiled for Eskom Transmission purposes that indicates and refers to the clauses of this document.

The Supplier shall respond with the technical submission that meets the requirements of this technical standard specification, provide the required documentation, and ensure the compliance to the detailed list of Supplier and Eskom Transmission responsibilities are covered under Annexes. (Refer to Annex A)

2.6 Process for monitoring

None.

2.7 Related/supporting documents

Related Documents:

Technical A & B schedules for circuit breaker (for generic typical example- refer to Annex B).

Technical A & B schedules for electronic controller (for generic typical example- refer to Annex E).

Technical A & B schedules for surge capacitor (for generic typical example- refer to Annex F).

This standard specification supersedes these documents in Eskom Transmission:

240-56063756 Rev 6, Outdoor Circuit-breakers for system with nominal voltages from 6.6kV up to and including 765kV Standard

240-56030489, Distribution Standard Part 7: Standard requirements for the wiring of outdoor switchgear used in systems of nominal voltage up to and including 132 kV

240-124520996 Rev 1, Switchgear training requirements from original equipment manufacturers

240-56065202 Rev 1, Distribution Standard Part 7: Switchgear training requirements from original equipment manufacturers

240-46425564 Rev 7, Technical evaluation criteria for High Voltage Switchgear standard

3. Specification for High Voltage Air Insulated Switchgear rated for Voltages 1 kV and above – Outdoor Circuit-breakers

Below are the detailed contents of the Eskom Transmission Specification for High Voltage Air Insulated Switchgear rated for Voltages 1 kV and above – Outdoor Circuit-breakers.

3.1 Ratings

Below are standard Eskom Transmission ratings required to be met for circuit-breakers for this standard specification.

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3.1.1 Rated voltage (U_r) and number of phases

a) The rated voltage of circuit-breakers shall be in accordance with the values given in **Table 1**, which is in accordance with SANS 62271-100 subclause 4.1. The rated voltage required will be specified in Schedule A. The rated voltage offered shall be stated in Schedule B.

NOTE: The nominal system voltages (U_n) in Eskom Transmission are 6,6 kV, 11 kV, 22 kV, 33 kV, 44 kV, 66 kV, 88 kV, 132 kV, 220 kV, 275 kV, 400 kV and 765 kV.

b) The number of phases shall be three.

3.1.2 Rated insulation levels

The rated insulation levels of circuit-breakers shall be in accordance with the values given in Table 1, which is in accordance with SANS 62271-100 subclause 4.2 and SANS 1019. The rated insulation levels offered shall be stated in Schedule B. No additional altitude correction factors need be applied for equipment installed up to 1800 m AMSL.

Table 1: Rated voltage and insulation levels

Nominal system voltage U_n *[kV (r.m.s.)]*	**Rated voltage** *[kV (r.m.s.)]*	**Rated short-duration power-frequency withstand voltage** U_d *[kV (r.m.s.)]* u_r		**Rated lightning impulse withstand voltage** U_p *[kV (peak)]*		**Rated switching impulse withstand voltage** U_s *[kV (peak)]*	
		Phase-to-earth and between phases	**Across open switching device**	**Phase-to-earth and between phases**	**Across open switching device**	**Phase-to- earth and across open switching device**	**Between phases**
6,6 & 11	12 [e]	28		95		-	-
22	24 [e]	50		150		-	-
33	36 [e]	70		200		-	-
44	52 [e]	95		250		-	-
66	72,5 [e]	140		350		-	-
88	100 [e,f,g]	185		450		-	-
132	145 [e,f,g]	275		650		-	-
220	245 [e]	395		950		-	-
275	300 [e,h]	395	435	1050	1050 (+170)	850	1275
400	420 [j]	520	610	1425	1425 (+240)	1050	1575
400	550 [i, j]	620	800	1550	1550 (+315)	1175	1760
765	800 [k]	830	1150	2100	2100 (+455)	1550	2480
+/- 533 DC	[l]						

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NOTES

a) In this table, the withstand voltages apply at the standardised reference atmosphere (temperature, pressure and humidity) in accordance with SANS 62271-1.

b) The information in this table is based on SANS 1019 and SANS 62271-1.

c) The specification of the insulation levels given in this table is based on the SANS 1019 philosophy – i.e. by the judicious selection of protective devices and their location with respect to equipment to be protected, it is generally possible to adopt the same insulation level for internal insulation and external insulation for equipment suitable for use at altitudes up to 1 800 m AMSL (Above Mean Sea Level). This enables manufacturers and users to adopt internationally accepted designs for use in South Africa.

d) No additional altitude correction factors need be applied for equipment installed up to 1800 m AMSL.

e) For the purposes of Eskom Transmission standardisation of HV switchgear, the specified 22 kV circuit-breakers shall also be installed on 11 kV network, the 33 kV also be used on 22 kV and 11 kV networks, the 66 kV circuit-breakers also be used on 44 kV network, the 132 kV circuit-breakers also be used on 88 kV, the 275 kV circuit-breakers also be used on 220 kV network.

f) Eskom Transmission main transmission substations (MTS) on some 132 kV and 88 kV substations, it is characterised by high fault level (large MVA transformation) refer to Annex F. It is incumbent of the Supplier and OEM to provide details at tender stage of mitigation methods details, e.g. to offer surge capacitors to be installed with their circuit-breaker design, refer to Annex F.

g) To mitigate onerous switching transients upon 132 kV and 88 kV shunt capbanks application, the specified 132 kV circuit-breaker shall be with its electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device),

h) To mitigate onerous switching transients upon 275 kV shunt capbanks application, the specified 275 kV circuit-breaker shall be of twin-interrupter in-series (T-head) design, not the candle-stick single interrupter gap (breaking chamber) design. The electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) shall also be specified for this application.

i) The circuit-breakers specified for 550kV rating shall be installed on Eskom Transmission's 400kV network upon special requirements. The 550 kV circuit-breakers shall be with their grading capacitors. The circuit-breakers required for generator synchronising, shall be provided with proof of having passed the power frequency withstand (Wet conditions) in accordance with IEC 60060-1. The offered 550 kV circuit-breaker designs without grading capacitors shall not be accepted by Eskom Transmission.

j) To mitigate onerous switching transients upon 400 kV shunt reactors application and busbar reactors, the specified 400 kV or 550 kV circuit-breakers shall be with grading capacitors. Similarly the 765 kV circuit-breakers for reactor switching shall be with grading capacitors. The offered circuit-breaker designs without grading capacitors shall not be accepted by Eskom Transmission. The electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device)shall also be specified for this application

k) To mitigate onerous switching transients upon switching the 765 kV lines or feeders application and tie-bays, the specified 765 kV circuit-breaker shall be with pre-insertion resistors (PIR). The offered 765 kV circuit-breaker designs without pre-insertion resistors shall not be accepted by Eskom Transmission.

l) The circuit-breakers specified for DC application shall be installed on Eskom Transmission's +/- 533kV HVDC network upon special requirements (240-132306591). The voltage across open contacts is 133.3 kV DC rating.

Eskom Transmission main transmission substations (MTS) on some 132 kV and 88 kV substations, it is characterised by high fault level (large MVA transformation) refer to Annex F. It is incumbent of the Supplier and OEM to provide details at tender stage of mitigation methods details, e.g. to offer surge capacitors to be installed with their circuit-breaker design, refer to Annex F.

3.1.3 Rated frequency (f_r)

The rated frequency shall be 50 Hz, in accordance with SANS 62271-100 subclause 4.3.

3.1.4 Rated normal current (I_r) and temperature rise

The rated normal current of circuit-breakers shall be 2500 A, 3150 A and 4000 A, in accordance with SANS 62271-100 subclause 4.4.

The rated normal current required will be specified in Schedule A. The rated normal current offered shall be stated in Schedule B.

The standard rated normal currents of circuit-breakers are given in Table 2.

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Table 2: Standardised rated normal currents (I_r)

Nominal system voltage ***Un*** *[kV]*	**Rated normal current (I_r)** *[A]*			
	2500	**3150**	**4000**	**1800 DC**
22 (also used on 11)	x	-	-	-
33 (also used on 22 & 11)	x	-	-	-
66 (also used on 44)	x	x	-	-
132 (also used on 88)	-	x	-	-
275 (also used on 220)	-	x a)	x a)	-
400	-	x	x	-
400 (550 used on 400)	-	x b)	x b)	-
765	-	x	x	-
+/- 533 DC (Across open contacts withstand: 133.3 DC)	-	-	-	x b)

NOTES

a) The 275 kV shunt capacitor bank application shall have twin-interrupter in series (T-head) circuit-breaker, not a candle-stick single interrupter gap (breaking chamber) design in order to mitigate switching transients.

b) The 550kV rated circuit-breaker with grading capacitors requirement for higher specification applications – generator, shunt reactors, high switching transients and higher insulation. The offered 550 kV circuit-breaker designs without grading capacitors shall not be accepted by Eskom Transmission.

c) For Eskom Transmission's +/- 533kV HVDC system requirement, the rated normal current shall be 1800A DC as a minimum. It shall be demonstrated if the circuit-breaker can carry the current of 3300A upon emergency or future requirements.

d) The associated temperature-rise limits for the rated normal current given in **Table 2** shall be in accordance with SANS 62271-1 subclause 4.4 Table 3.

e) Based on the actual results of the circuit-breaker temperature rise type testing, the calculated maximum continuous current that the circuit-breaker can carry, without exceeding the maximum allowable temperatures for the major components, shall be stated in Schedule B for a maximum ambient temperature of i) 40 °C and ii) 45 °C (refer to c)).

f) Based on the actual results of the circuit-breaker temperature rise type testing, the highest measured temperature rise values for the major components (refer to SANS 62271-1 Table 3) when carrying rated current shall be stated in Schedule B.

3.1.5 Rated short-time withstand current (I_k)

The rated short-time withstand current of circuit-breakers shall be in accordance with the values given in Table 3, in accordance with SANS 62271-100 subclause 4.5. The rated short-time withstand current required will be specified in Schedule A. The rated short-time withstand current offered shall be stated in Schedule B.

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Eskom Transmission main transmission substations (MTS) on some 132 kV and 88 kV substations, it is characterised by high fault level (large MVA transformation) refer to Annex F. It is incumbent of the Supplier and OEM to provide details at tender stage of mitigation methods details, e.g. to offer surge capacitors to be installed with their circuit-breaker design, refer to Annex F.

3.1.6 Rated peak withstand current (I_p)

The rated peak withstand current of circuit-breakers shall be in accordance with the values given in **Table 3,** in accordance with SANS 62271-100 subclause 4.6. The rated peak withstand current required will be specified in Schedule A. The rated peak withstand current offered shall be stated in Schedule B.

3.1.7 Rated duration of short circuit (t_k)

The rated duration of the short circuit (t_k) shall be 3 seconds, in accordance with SANS 62271-100 subclause 4.7.

Table 3: Standardised rated short circuit-breaking, short-time and peak withstand currents

Nominal system voltage ***Un*** *[kV]*	**Rated short-circuit breaking and short-time (3 sec) withstand current** ***I*****SC, *I*****k** *[kA (r. m. s.)]*	**Rated peak withstand current** ***I*****p** *[kA (peak)]*
22 (also used on 11)	31,5	78,75
33 (also used on 22 & 11)	31,5	78,75
66 (also used on 44)	31,5	78,75
132 (also used on 88)	40	100
275 (also used on 220)	50	125
400*)	50 / 63	125 / 157,5
400 (550 used on 400)		
765	50	125
+/- 533 DC **)	20	50

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NOTES

a) Eskom Transmission main transmission substations (MTS) on some 132 kV and 88 kV substations, it is characterised by high fault level (large MVA transformation) refer to Annex F. It is incumbent of the Supplier and OEM to provide details at tender stage of mitigation methods details, e.g. to offer surge capacitors to be installed with their circuit-breaker design, refer to Annex F.

b) The 275 kV shunt capacitor bank application shall have twin-interrupter in series breaker, not a candle-stick single interrupter gap (breaking chamber) design in order to mitigate switching transients.

c) The 550kV rated circuit-breaker with grading capacitors requirement for higher specification applications – generator, shunt reactors, high switching transients and higher insulation. The offered 550 kV circuit-breaker designs without grading capacitors shall not be accepted by Eskom Transmission.

d) For Eskom Transmission's +/- 533kV HVDC system requirement, the rated normal current shall be 1800A DC as a minimum. It shall be demonstrated if the circuit-breaker can carry the current of 3300A upon emergency or future requirements.

*) - denotes that both 420kV and 550kV rated circuit-breakers are required to meet this criteria

**) - denotes that the +/- 533kV DC rated circuit-breakers are required to meet this minimum criteria.

The voltage across open gap is 133.3kV DC

3.1.8 Rated supply voltage of closing and opening devices and of auxiliary and control circuits (U_a)

a) The rated d.c. supply voltage (U_a) of closing and opening devices and of auxiliary and control circuits shall be 110 V or 220 V, in accordance with SANS 62271-100 subclause 4.8. The rated d.c. supply voltage required will be specified in schedule A.

b) The rated a.c. supply voltage (U_a) of heaters and other a.c. auxiliary circuits shall be single-phase 230 V, in accordance with SANS 62271-100 subclause 4.8.

3.1.8.1 Rated supply frequency of closing and opening devices and of auxiliary circuits

The rated supply frequency of heaters and other a.c. auxiliary circuits shall be 50 Hz, in accordance with SANS 62271-100 subclause 4.9.

3.1.9 Rated short-circuit breaking current (I_{SC}) of the circuit-breaker

a) The rated short-circuit breaking current (I_{SC}) of circuit-breakers shall be equal in value to the rated short-time withstand current (I_K) specified in **Table 3**, in accordance with SANS 62271-100 subclause 4.101. The rated short-circuit breaking current required will be specified in Schedule A. The rated short-circuit breaking current offered shall be stated in Schedule B.

b) Under certain system neutral earthing conditions, the single-phase (phase-to-earth) fault level may exceed the three-phase (phase-to-phase) symmetrical fault level and a higher single-phase-to-earth rated short-circuit breaking current may be required. The factor (up to 1,15) by which the 100 % symmetrical and asymmetrical single-phase rated short-circuit breaking current of the circuit-breaker exceeds the same three-phase rating will be specified in Schedule A. The factor offered shall be stated in Schedule B.

3.1.10 Transient recovery voltage related to the rated short-circuit breaking current of circuit-breakers

a) The first-pole-to-clear factor (k_{pp}) for circuit-breakers used in systems of nominal voltage up to and including 132 kV shall be 1,5 in accordance with SANS 62271-100 subclause 4.102, i.e. as applicable to circuit-breakers used in non-effectively earthed systems. For circuit-breakers used in systems of nominal voltage above 132 kV, the first-pole-to-clear factor shall be 1,3 in accordance with SANS 62271-100, i.e. as applicable to circuit-breakers used in effectively earthed systems. The first-pole-to-clear factor shall be stated in Schedule B.

NOTE: 44 kV to 132 kV networks are usually solidly earthed. However, in the interests of standardisation, due to the fact that certain 44 kV to 132 kV networks may be non-effectively earthed – a first-pole-to-clear factor of 1,5 is specified.

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b) The standard values of prospective transient recovery voltages given in SANS 62271-100 shall apply according to the circuit-breaker class specified in Table 4 for the relevant circuit-breaker application and as defined in SANS 62271-100.

3.1.11 Rated short-circuit making current of circuit-breakers

The rated short-circuit making current of circuit-breakers shall be equal in value to the rated peak withstand current specified in **Table 3**, in accordance with SANS 62271-100 subclause 4.103, and its Table 37 the peak factor for the rated short-circuit making current. The rated short-circuit making current required will be specified in Schedule A. The rated short-circuit making current offered shall be stated in Schedule B.

3.1.12 Rated operating sequence for circuit-breakers

a) The following rated operating sequence shall apply to all three-pole operated circuit-breakers intended for rapid auto-reclosing, in accordance with SANS 62271-100 subclause 4.104. The rated operating sequence required will be specified in Schedule A.

Three-phase auto-reclosing: O – t – CO – t' – CO (all poles), where t = 0,3 s and t' = 3 min.

NOTE: Preference will be given to circuit-breakers offered with a rated operating sequence where t' = 15s.

b) The following rated operating sequence shall apply to all single-pole operated circuit-breakers intended for rapid auto-reclosing. The rated operating sequence required will be specified in Schedule A.

Single-phase auto-reclosing: O (one pole) – t – C (one pole) – O (all poles) – t' – CO (all poles), where t = 0,3 s and t' = 3 min.

NOTE: Preference will be given to circuit-breakers offered with a rated operating sequence where t' = 15s.

c) The following rated operating sequence shall apply to all circuit-breakers not intended for rapid auto-reclosing. The rated operating sequence required will be specified in Schedule A.

O – t – CO – t' – CO (all poles) where t = t' = 3 min.

d) The rated operating sequence offered shall be stated in Schedule B. The minimum resting time (in minutes) required, in order to ensure dependable interruption capability within the circuit-breaker's rated characteristics, following the rated operating sequence under the most unfavourable conditions shall be stated in Schedule B.

e) All circuit-breakers, irrespective of whether they are intended for rapid auto-reclosing, shall be able to open-close-open before the closing spring needs to be charged again.

3.1.13 Characteristics for short-line faults (SLF duty)

Refer to SANS 62271-100 subclause 4.105 of for standardised characteristics for short-line faults (SLF). The Eskom Transmission circuit-breakers are specified with classification S2 (refer to **Table 4**) as they are intended for direct connection to overhead lines in systems with a solidly earthed neutral and all circuit-breakers having a rated voltage of 100 kV and above. These SLF characteristics are therefore applicable to all circuit-breakers for use in systems of nominal voltage above 66 kV, to be installed at substations of fault levels of 12,5 kA and above.

NOTE:

- 44 kV to 132 kV networks are usually solidly earthed.
- Eskom Transmission main transmission substations (MTS) on some 132 kV and 88 kV substations, it is characterised by high fault level (large MVA transformation) refer to Annex F. It is incumbent of the Supplier and OEM to provide details at tender stage of mitigation methods details, e.g. to offer surge capacitors to be installed with their circuit-breaker design, refer to Annex F

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3.1.14 Rated out-of-phase making and breaking current for circuit-breakers

The rated out-of-phase breaking current required will be specified in Schedule A in accordance with SANS 62271-100 subclause 4.106. The rated out-of-phase making and breaking currents of the circuit-breaker offered shall be stated in Schedule B.

3.1.15 Rated capacitive switching currents for circuit-breakers

a) The classification of circuit-breakers according to their restrike performance for line- and cable-charging current switching shall be in accordance with **Table 4** for the specified circuit-breaker application. The circuit-breaker class offered for line- and cable-charging current switching shall be stated in Schedule B.

- The rated line- and cable-charging breaking currents for circuit-breakers shall be in accordance with the preferred values given in SANS 62271-100 subclause 4.107.1 and 4.107.2 and its Table 9 and 6.111 Test-duty 2 LCC2 and Test-duty 2 CC2.

b) The circuit-breakers required for switching single capacitor banks shall be classified for class C2 (with type-testing evidence) in accordance with SANS 62271-100 subclause 4.107.3 and its Table 9 and 6.111, capable of a very low probability of restrike during capacitive current breaking. Up to the voltages of 132 kV, the circuit-breaker of a candle-stick single interrupter gap (breaking chamber) design shall be considered for this specified requirement. In this case, the following requirements are applicable:

- all circuit-breakers supplied for capacitor-bank switching shall be capable of capacitor switching without the need for controlled opening and/or closing.
- the circuit-breaker shall be capable of switching single capacitor banks type tested for Test-duty 1 BC1 in accordance with SANS 62271-100 subclause 6.111. The rated capacitor bank switching currents shall be in accordance with the preferred values given in SANS 62271-100 applicable Test-duty 1 BC1. The circuit-breaker class offered, rated capacitor bank switching currents (i.e. the rated single capacitor bank breaking current and the rated single capacitor bank inrush making current) and inrush current frequency shall be stated in Schedule B; and

c) The circuit-breakers required for switching capacitor banks in a back-to-back arrangement and/or multiple shunt capacitor banks on the busbar, shall be classified for class C2 (with type-testing evidence), capable of a very low probability of restrike during capacitive current breaking. For this application (back-to-back arrangement) on all voltages above 132 kV, the circuit-breaker with twin-interrupter gaps (breaking chambers) in series design shall be preferred by Eskom Transmission (no candle-stick single interrupter gap (breaking chamber) design shall be allowed even if used with its electronic controller (Controlled Switching device/ Point-on-Wave (PoW) switching device). In this case, the following requirements are applicable:

- the rated capacitor bank switching currents shall be in accordance with the preferred values given in SANS 62271-100 applicable Test-duty 2 BC2. The circuit-breaker class offered, rated capacitor bank switching currents (i.e. the rated back-to-back capacitor bank breaking current and the rated back-to-back capacitor bank inrush making current) and inrush current frequency shall be stated in Schedule B; and
- all circuit-breakers supplied for capacitor-bank switching shall be capable of capacitor switching without the need for controlled opening and/or closing.
- shunt capacitor banks will either be connected to a substation busbar or will form part of another device such as a thyristor switched reactive power (VAr) controller (thyristor controlled reactors).

NOTES

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- The backup circuit-breakers in the particular substations may not have adequate capacitive switching capabilities. This means that the circuit-breakers intended for shunt capacitor bank switching will have to be relied upon to satisfactorily and reliably (i.e. with a very low probability of restrike) switch the capacitive currents associated with the shunt capacitor banks.
- The shunt capacitor bank circuit-breaker will be required to switch more than once a day - in a single capacitor bank situation of the rating specified - with up to three banks installed on a single substation busbar.
- Where applicable, the shunt capacitor bank circuit-breaker will be required to switch more than once a day - in a back-to-back arrangement of the rating specified – also with above three capacitor banks connected on a substation busbar system (multiple shun capacitor banks and/or with filters).
- For the sake of standardisation, preference will be given to general-purpose circuit-breakers offered that are capable of capacitor bank switching duties. However, special-purpose circuit-breakers will be considered.
- Current-limiting reactors will normally be installed by Eskom Transmission between the circuit-breaker and the shunt capacitor bank being switched in order to obtain transient currents of manageable proportions for the power capacitor elements as well as the circuit-breaker.
- The use of electronic controller (Controlled Switching device/ Point-on-Wave (PoW) switching device) to provide optimal capacitor-bank switching is recommended. Refer to 3.2.20.

3.1.16 Inductive load switching for circuit-breakers

For circuit-breakers specified for reactor application switching duty, they shall be capable of switching shunt reactors and shall be in accordance with SANS 62271-100 subclause 4.108 designed to withstand re-ignitions. Refer to SANS/IEC 62271-110 as applicable to three-phase alternating current circuit-breakers having rated voltages of 52 kV and above.

For all circuit-breakers specified for reactor application switching duty, the type test report performed in compliance to SANS/IEC 62271-110 shall be provided with tender documentation. The chopping number of the circuit-breaker offered shall be stated in Schedule B.

Eskom Transmission details for its philosophy of point on wave (PoW) switching of circuit-breakers i.e the electronic controller, is detailed on the standard (240-75566441).

NOTES

- The use of controlled switching to provide re-ignition-free shunt reactor switching is recommended. Refer to 3.2.20. In the absence of electronic controller (Controlled Switching device/ Point-on-Wave (PoW) switching device), re-ignitions during opening of the contacts cannot be avoided due to the random operation (opening) of the circuit-breaker. By means of controlled opening, all poles of the shunt reactor circuit-breaker can be given a sufficiently long arcing time to ensure re-ignition-free interruption. The use of electronic controller (Controlled Switching device/ Point-on-Wave (PoW) switching device)) minimises high magnitude fast-fronted (steep) switching transients created during re-ignition events and will prolong the maintenance intervals of the circuit-breaker.
- Information obtained from tests conducted in accordance with SANS 62271-110, i.e. the circuit-breaker chopping number (used to determine the suppression peak overvoltage factor) and the re-ignition behaviour, can be used to correctly configure the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device).
- The maximum ratings of existing (earthed) shunt reactors are typically 40 MVAr to 50 MVAr at 132 kV, 100 MVAr at 400 kV and 400 MVAr at 765 kV (i.e. 133 MVAr per phase).

3.1.17 Number of mechanical operations for circuit-breakers

The number of mechanical operations of circuit-breakers shall be in accordance with the mechanical endurance class specified in **Table 4** for the specified circuit-breaker application and as defined in SANS 62271-100 subclause 4.110. The circuit-breaker class offered shall be stated in Schedule B.

3.1.18 Classification of circuit-breakers as a function of electrical endurance

The classification of circuit-breakers as a function of electrical endurance shall be in accordance with SANS 62271-100 subclause 4.111, for the specified circuit-breaker application. The circuit-breaker class offered shall be stated in Schedule B.

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Table 4: Classification of circuit-breakers (SANS 62271-100)

Circuit-breaker (**Circuit-breaker application -** as per its specific Technical A/B Schedule)	**Circuit-breaker class** [1)]	**Electrical endurance class** [2)]	**Re-strike performance during capacitive current breaking (line, cable and shunt capbank- charging)**	**Mechanical endurance class**
22 kV, 2500 A, 31,5 kA (CB combined with CT) COMBO	S1	E2 [1)]	C2	M2
33 kV, 2500 A, 31,5 kA (CB combined with CT) COMBO	S1	E2 [1)]	C2	M2
33 kV, 2500 A, 31,5 kA[7)]	S1	E2 [1)]	C2	M2
66 kV, 2500 A, 31,5 kA	S2	N/A	C2	M2
66 kV, 3150 A, 31,5 kA	S2	N/A	C2	M2
132 kV, 3150 A, 40 kA	S2	N/A	C2	M2
132 kV, 3150 A, 50 kA	S2	N/A	C2	M2
275 kV, 3150 A, 50 kA	S2	N/A	C2	M2
275 kV, 4000 A, 50 kA	S2	N/A	C2	M2
400 kV, 3150 A, 50 kA	S2	N/A	C2	M2
400 kV, 3150 A, 63 kA	S2	N/A	C2	M2
400 kV, 4000 A, 50 kA	S2	N/A	C2	M2
400 kV, 4000 A, 63 kA	S2	N/A	C2	M2
550 kV, 4000 A, 63 kA	S2	N/A	C2	M2
765 kV, 3150 A, 50 kA	S2	N/A	C2[8)]	M2
765 kV, 4000 A, 50 kA	S2	N/A	C2[8)]	M2
+/- 533kV DC [9)]	N/A	N/A	C2[8)]	M2

NOTES

1. Class S2 circuit-breakers (i.e. circuit-breakers intended to be used in line systems) are restricted to systems of rated voltages equal to or higher than 15 kV and less than 100 kV – in accordance with SANS 62271-100. Circuit-breakers for use at 11 kV are therefore classified as class S1 circuit-breakers. Class S2 circuit-breakers are specified due to the fact that they may be used in systems with direct connection to overhead lines / outdoor busbars without intervening cables. In the case where circuit-breakers are used in cable systems, class S2 circuit-breakers are suitable.
2. Class E1 and E2 circuit-breakers are for rated voltage up to and including 52 kV in accordance with SANS 62271-100. Class E2: Extended electrical endurance without auto-reclosing duty capability. Class E2: Extended electrical endurance intended for auto-reclosing duty for overhead line feeder application.
3. Unless otherwise mention on the Technical A/B Schedules, the 11 kV 2500 A circuit-breaker is used for transformer and bus-section applications at 11 kV only. Unless otherwise mention on the Technical A/B Schedules, the 22 kV 1600 A circuit-breaker is for transformer, bus-section and feeder application at 22 kV.
4. The 33 kV 2500 A circuit-breaker is for transformer, bus-section and feeder application at 33 kV, applicable to networks 11 kV, 22 kV and 33 kV.
5. Circuit-breakers specified with grading capacitors meant for 400 kV applications (to install upon high switching transients, generation synchronizing and shunt reactor switching. Where grading capacitors are specified, if the offered circuit-breaker design is without grading capacitors, it shall not be accepted by Eskom Transmission.
6. General-purpose circuit-breakers are required for transformer / bus-section applications. Class C2 is applicable to reactor bank switching, capbank switching and feeder application (including tie-bay breakers).
7. For +/- 533kV HVDC scheme application, the current shall be 1800A DC. It shall be demonstrated if the circuit-breaker does have the capability of carrying up to 3300A for the system emergencies and future requirements.

3.2 Design and construction

3.2.1 Design, Component and Material Changes

a) Design life expectancy of the equipment shall be to the type tested values of the design, mechanical and electrical endurances but is expected to be not less than 40 years when operating at least twice per day.

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b) Within normal operating specified in this standard specification, the Eskom Transmission approved equipment, its design and construction, shall require normal maintenance as stated by the OEM's instruction operating maintenance manuals, without any requirement for changes or modification.

i. During the period covered by a particular contract or product acceptance cycle, the Supplier shall not make any changes to the equipment or materials without receiving approval from Eskom Transmission. All concessions shall be approved by Eskom Transmission. No changes will be permitted to the mounting details of the equipment or in other points of interfacing with Eskom Transmission standard structures. If the Supplier decides to make any changes to the agreed-upon design of the circuit-breaker, then the change(s) (a modification instruction with pictures, drawings and measurements), together with the reasons for making the change(s), shall be forwarded to the Eskom Transmission contract manager and relevant technical switchgear equipment specialists in writing for assessment if approval can be considered (refer to 3.5.4 and Eskom Transmission Quality documentation).

ii. Suitable training and parts shall be supplied to Eskom Transmission within 90 days up to 6 months of any modification required for all circuit-breakers supplied to Eskom Transmission.

3.2.2 Service conditions

c) The normal service conditions for outdoor switchgear and controlgear specified in SANS 62271-1 shall apply. The following additional specific requirements shall be taken into account:

iii. a minimum ambient air temperature of -10 °C;

iv. a maximum ambient air temperature of +45 °C (refer to 3.2.2 c) iv.);

v. rapid temperature changes. The condensation of water vapour can take place within operating mechanism enclosures and hollow components. The average humidity is 95 %;

vi. wind velocity of 34 m/s (N);

vii. solar radiation up to a level of 1 100 W/m^2 (on a clear day at noon) as well as significant ultra-violet (UV) radiation intensity;

viii. the circuit-breakers shall be installed up to altitudes of 1 800 m;

NOTE: Due (in part) to the fact that the switchgear and controlgear shall be used up to altitudes of 1800 m AMSL (Above Mean Sea Level), altitude-corrected insulation withstand levels are specified in this document. No further altitude correction factors are therefore required for altitudes above 1000 m AMSL in accordance with SANS 62271-1.

- Airborne pollution in the form of dust, smoke, corrosive gases and saline content due to location in areas of industrial activity, close proximity to the sea and so on. The class of pollution characterising the site severity will be specified in Schedule A in accordance with SANS 60815-1:2009 (e.g. class "e" corresponding to "very heavy"); and
- The class of corrosion characterizing the site severity will be specified in Schedule A in accordance and the details required under subclause 3.2.7 shall be supplied with tender documentation.
- seismic activity up to 0,3g. Unusual service conditions, such as abnormal vibration, shocks, tremors, and/or tilting

d) Circuit-breakers for use in systems of nominal voltage up to and including 132 kV shall be suitable for operation in systems that incorporate a non-effectively earthed neutral. Circuit-breakers for use in systems of nominal voltage above 132 kV shall be suitable for operation in systems that incorporate an effectively earthed neutral.

NOTE: 44 kV to 132 kV networks are usually effectively earthed. However, certain 44 kV to 132 kV networks may be non-effectively earthed.

3.2.3 General

Note: Notwithstanding the requirements on 3.2.3.1 below, the Supplier of the switchgear shall respond to the following with the tender documentation:-

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- Provide the detailed Factory Failure Rate (FFR) percentage over the period of 5 years.
- Provide information on On Time Delivery (OTD) percentage over the period of 5 years.
- Provide technical response to Non-Conformance (NCR's) percentage over a period of 1 year

3.2.3.1 The following are the requirements for the circuit-breakers:-

a) Outdoor circuit-breakers shall comply with the requirements of SANS 62271-100 and the requirements of this standard specification. In case of the dead-tank circuit-breakers, it shall also comply with the requirements of SANS 62271-203. Where conflicting requirements exist, the requirements of this standard specification shall take precedence.

b) Circuit-breakers shall be of the live-tank or dead-tank design. The type of design required will be specified in Schedule A. The type of design offered shall be stated in Schedule B.

Live-tank circuit-breakers shall be specified as circuit-breaker only or as circuit-breaker combined with its current transformers (CTs), also known as a COMBO design. CTs shall be located on the same steel support structure as the circuit-breaker.

c) Dead-tank circuit-breakers shall be supplied with integrated ring-type current transformers (CTs). CTs shall be located at the base of the outdoor bushings.

The compartment/ tank metallic enclosure shall be made of aluminium or aluminium alloys for all standard Eskom Transmission requirements, unless the requirement is for coastal application, a different specification metal shall be indicated on the Technical A schedule. Other metals for compartment/ tank metallic enclosures with their corrosion treatment method in accordance with subclause 3.2.6 shall be shall be submitted with the tender documentation and will be subject to approval by Eskom Transmission.

d) Circuit-breakers shall be supplied complete with all the necessary components for the assembly. Live-tank circuit-breakers for use in systems of nominal voltage up to and including 132 kV shall be supplied suitable for a pole-beam support arrangement (two-column support with common base frame). Live-tank circuit-breakers for use in systems of nominal voltage from 132 kV up to and including 400 kV shall be supplied suitable for a three-column support arrangement. It will be specified in Schedule A whether circuit-breakers shall be supplied with the steel support structure.

NOTES

- For further information relating to the Supplier's and Eskom Transmission's scope of responsibility (refer to Annex A).
- For live-tank circuit-breakers for use in systems of nominal voltage up to and including 132 kV, the steel common base frame is supplied with the circuit-breaker (refer to c)). The circuit-breakers are supplied without the steel support structure columns (legs). Refer to Table 5 for further information on the standard Eskom Transmission support structure drawings.

e) Circuit-breaker operating mechanisms:

- Circuit-breakers shall be either three-pole ("3P") operated (i.e. single operating mechanism) or single-pole ("1P") operated (i.e. three operating mechanism), as specified in Schedule A.
- Circuit-breakers shall be designed for stored energy operation where energy is stored in a spring, unless otherwise approved by Eskom Transmission. The spring-hydraulic operated mechanisms shall be considered for Dead-tank circuit-breakers with the rated voltages of above 145 kV. The spring-hydraulic operated mechanisms may be accepted for use in the Live-tank circuit-breakers with the rated voltages of 550 kV and 800 kV. Circuit-breakers rating of the mechanical energy stored in charged spring (Closing/ Trip) shall be stated in Schedule B.

NOTE: Other hydraulic operated or pneumatic operated mechanisms will not be accepted for all voltages.

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- It shall be possible to charge the circuit-breaker operating mechanism spring both manually and electrically. Electrical charging shall be via a spring charging motor, unless otherwise approved by Eskom Transmission. Both manual and electric energy release shall be provided. The mechanical energy stored in the charged spring shall be stated in Schedule B. A mechanical device shall be provided to prevent over-charging of the closing spring when the manual charging facility is employed.
- Operating mechanisms shall be designed in such a way that in the case of failure to latch or of a command to trip during a closing operation, safe conditions are produced for the elements controlling the circuit-breaker.
- When a feeder circuit-breaker is in the closed position and the spring has been charged, it shall be able to “TRIP-CLOSE-TRIP” before the spring needs to be recharged

f) The insulation and/or arc-extinguishing medium of the circuit-breaker shall be either SF6 gas or environmental-friendly medium. The non-SF6 (SF6-free) circuit-breaker designs that offer environmental-friendliness of low Global Warming Potential (low GWP of 1 or less, or low CO2e) and meet this standard specification shall be considered by Eskom Transmission. These shall have been designed and type tested in accordance with IEC62271-100. The type of interrupting and insulation and/or arc-extinguishing medium technology offered shall be stated in Schedule B. The circuit-breakers type of interrupter design (e.g. puffer, self-blast, etc.) as well as the configuration of the moving contacts (e.g. single, double or triple motion design) shall be stated in Schedule B. Eskom Transmission shall specify in Schedule A if the required circuit-breakers shall be puffer (blow) type design and/or single motion operation.

g) Circuit-breakers shall be designed for minimal maintenance in accordance with the electrical and mechanical endurance class as specified in **Table 4**. The minimum expected lifespan shall be 40 years. Premature failures experienced in service of similar design circuit-breakers supplied elsewhere by the manufacturer shall be made known to Eskom Transmission, together with the recommended modifications. This information shall be provided with the tender documentation (refer to 3.2.26.1).

h) Dead-tank circuit-breakers detailed information on how CT’s are accessed for primary injection testing and CT replacement, without having to interfere with the SF6 circuit shall be provided with the tender documentation.

Live-tank circuit-breakers combined with CT’s (COMBO design) detailed information on how CT’s are accessed for primary injection testing and CT replacement, without having to interfere with the SF6 circuit-breaker integrity shall be provided with the tender documentation.

3.2.4 Construction requirements

The design and layout of the circuit-breaker, including control cable interfacing, shall facilitate installation with a minimum of on-site assembly work. The degree of assembly work in the factory shall be optimised such that on-site installation work is minimised. The following principles shall apply to the design of the equipment:

a) the various elements of the circuit-breaker shall be standardised. Standardisation of parts shall be pursued;

b) modular, pre-assembled elements shall be designed to facilitate handling and installation;

c) the equipment shall be designed to facilitate construction and maintenance activities for personnel; and

d) SF6 filter material housing shall be located (at the circuit-breaker pole) in such a manner so as to provide easy access when maintaining the unit.

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3.2.5 Circuit-breaker operating mechanism enclosure requirements

a) Circuit-breaker operating mechanisms, local control facilities and all parts requiring lubrication shall be protected by weatherproof enclosures. The degree of protection provided by these enclosures shall comply with the following minimum requirements in accordance with SANS 72271-100 subclause 5.13 and in line with SANS 60529 and and SANS 62262. The degree of protection offered shall be stated in Schedule B.

- enclosures containing exposed bearings, auxiliary switches, motors and other electrical devices shall comply with IP 55 (i.e. operating mechanism enclosure);
- where applicable, all open areas in the circuit-breaker common base frame as well as externally mounted indicating devices where there is a high probability of birds nesting, shall be suitably covered to IP 2X; and
- all other enclosures provided shall comply with IP 54.

b) The operating mechanism enclosure, handles and fixings shall be manufactured from 3CR12 stainless steel with corrosion protection in accordance with 3.2.7. The use of factory painted aluminium shall be considered if corrosion protection is in accordance with 3.2.6, and no parts exposed. The mechanism enclosures of the exposed aluminium shall not be acceptable.

c) Operating mechanism enclosures shall be arranged to facilitate easy access for inspection and scheduled maintenance which may include permissible in-situ cleaning, lubrication, repairs and adjustments to the operating mechanism. The 132 kV and below circuit-breakers' maximum height to the top of operating mechanism shall be 2,000 mm to allow servicing from ground ($U_n \leq$ 132kV), whereas for circuit-breakers required for 220 kV and above, the maximum height shall be such that it allows personnel without leaving ground, to perform viewing of indications and operating counter reading and make it possible for manual operating handles (U_n >132kV);

Any removable covers provided shall have bolt fastenings, subject to Eskom Transmission approval. All bolts shall be inherently corrosion resistant and have hexagon heads. Self-tapping screws, captive head nuts or cage nuts are not acceptable.

d) The circuit-breaker shall be designed for operation from the front of the operating mechanism enclosure.

e) Access to the operating mechanism enclosure(s) shall be through a hinged access door allowing accessibility to components installed in the enclosure (e.g. control levers, push-buttons, MCBs and secondary wiring terminal strips) in accordance with SANS 62271-1.

f) In the case of circuit-breakers for use in systems of nominal voltage up to and including 132 kV, servicing shall be possible from the ground level. In the case of circuit-breakers for use in systems of nominal voltage above 132 kV, where the servicing level may be above ground level, it shall be possible to view all circuit-breaker status indications and make necessary readings from the ground level. Details of special equipment required (including inspection platforms) to fulfil this requirement shall be provided with the tender documentation (refer to 3.2.26.1).

g) The front access door shall be secured with a heavy-duty locking mechanism.

h) The operating mechanism enclosure shall be capable of being padlocked to prevent unauthorized access. The locking facility shall accommodate padlocks that have a shackle diameter of 6 mm

i) The front access door of the operating mechanism enclosure shall be equipped with a travel stop, which shall retain the door in the open position. The facility shall be robust enough to withstand the force of wind in accordance with 3.2.2 c) 3.2.2.

j) A rigid, corrosion resistant, documentation pocket shall be provided for the safe-keeping of all relevant documentation (i.e. the installation, operating and maintenance instructions for the circuit-breaker and all routine test certification), on the inside of the operating mechanism enclosure front access door. The documentation pocket shall be securely attached and the means used (e.g. pop rivets) to secure the pocket shall not protrude through the door.

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k) Suitable facilities for storage and securing of the hand-operating tool(s) shall be provided on the inside of the operating mechanism enclosure front access door.

l) Earthing of the operating mechanism enclosure shall be via the steel support structure (e.g. via the common base frame and support legs or via the steel column support). If additional / visual earthing is required for the operating mechanism enclosure, all earthing terminals, fastenings and conductors shall be supplied and fitted by the Supplier and will be subject to approval by Eskom Transmission. In the latter case, the conductors shall be kept as short as possible and the earthing terminal on the operating mechanism enclosure shall be located towards the top of the enclosure housing. Earthing conductors shall be manufactured using galvanised steel. A 30 mm long, Ø25 mm (min) metallic boss, with an M12 thread throughout and welded to the equipment shall be used for all external earthing conductor fastenings. The boss shall be fitted with a M12 x 25 mm long setscrew, washer and spring washer. The boss and the setscrew on the enclosure shall be stainless steel of grades 304 and 316, respectively, unless otherwise approved by Eskom Transmission. The boss and the setscrew on the circuit-breaker steel support structure (e.g. the common base frame or the steel column support) shall be galvanised steel.

NOTE: The use of copper or aluminium is considered to present a theft risk and will not be accepted if metal is visually exposed. Such method shall meet subclause 3.2.6. The proposal to prevent visual exposure shall be presented to Eskom Transmission for approval with the tender documentation.

m) Operating mechanism enclosures shall make provision for the entry of Eskom Transmission control cabling from below. Refer to 3.2.22 b) & b) for the requirements of the control cable entry gland plates. All circuit-breaker cabling (i.e. to / from density monitoring devices and between poles) shall also enter the operating mechanism enclosure(s) from below, unless otherwise approved by Eskom Transmission.

NOTE: The use of plug-in type cable is not acceptable. Eskom Transmission prefers the normal gland plate and terminations made on terminals.

n) Where applicable, metallic cable racking used to mechanically protect and/or support circuit-breaker cabling (e.g. inter-pole cabling) shall be manufactured using galvanized steel, unless otherwise approved by Eskom Transmission.

NOTES

- The use of aluminium cable racking is considered to present a theft risk and will not be accepted.
- Where Eskom Transmission support structure legs are provided, no provision is made for securing or mounting inter-pole cable racking on the legs - requiring the (armoured) inter-pole cabling to be buried in the ground in accordance with 240-56030489, unless otherwise approved by Eskom Transmission.
- The use of plastic material cable ties shall not be accepted.

o) Upper surfaces of enclosures shall be shaped or sloped to prevent the accumulation of water.

p) Gaskets shall be made of neoprene rubber, nitrile rubber or cork, unless otherwise approved by Eskom Transmission. Felt or natural rubber gaskets are not acceptable. The gasket material offered shall be stated in Schedule B.

q) A gauze-covered drain hole with a minimum diameter of 25 mm and having no internal rim or ledge that is likely to obstruct drainage shall be provided at the lowest point of the operating mechanism enclosure.

r) Suitable lifting eyes shall be provided at the top of the operating mechanism enclosure. The lifting eyes shall be designed to provide for the lifting of the complete operating mechanism enclosure. Lifting eyes with a minimum diameter of 30 mm shall be provided.

s) The colour for the enclosure shall be "light grey" (G29) in accordance with SANS 1091 unless otherwise specified in Schedule A or approved by Eskom Transmission. The closest equivalent RAL colour shall be considered.

t) All circuit-breakers shall be fitted with a mechanical trip facility which does not require any voltage to operate and must be located inside the mechanism enclosure. It shall be clearly marked with warning labels.

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u) The Supplier shall provide with the tender documentation the information on each supplied equipment type specified below: Circuit-breaker operating mechanism enclosure heaters

i. Suitably rated electric heater(s) shall be installed to prevent moisture condensation inside the circuit-breaker operating mechanism enclosure. The heater size offered shall be stated in Schedule B.

ii. Heaters shall maintain a dew-point greater than the ambient temperature and shall circulate the air constantly to all parts of the enclosure.

iii. The electrical supply for heaters shall be single-phase 230 V a.c.

Heater control and alarm circuits shall comply with the requirements of **Annex D.** In the case of circuit-breakers for use in systems of nominal voltage up to and including 132 kV, heater fail alarm circuits shall be wired to terminals in accordance with 0.52/30135. In the case of circuit-breakers for use in systems of nominal voltage above 132 kV, heater fail alarm circuits shall be wired to terminals in accordance with 0.54/07529 and 0.54/8557.

3.2.6 Circuit-breaker support structure and foundation

The static mechanical loads (forces) on terminals due to flexible and tubular conductors (not including wind, ice load or the dynamic loads on the circuit-breaker itself) shall be in accordance with SANS 62271-100 subclause 5.106 and its Table 14, and the following:

a) The following mechanical loads and parameters relating to the design of the circuit-breaker support structure and foundation shall be stated in Schedule B and be shown on the general arrangement drawing (refer to 3.2.26.1):

- "static" dead weight of the circuit-breaker (N);
- the rated "static" terminal forces $F_{sh}A$, $F_{sh}B$ and F_{sv} (loads) of the circuit-breaker (N) due to connected conductors;
- "dynamic" horizontal force (load) exerted during operation on the foundation (N);
- "dynamic" vertical force (load) exerted during operation on the foundation (N);
- "dynamic" moment (torque) exerted during operation about the foundation (Nm);
- "dynamic" horizontal force exerted between circuit-breaker poles (centre phase interrupter chamber) during a rated (terminal fault) short-circuit (N);
- wind force (loading) exerted on the circuit-breaker due to a wind velocity of 34 m/s (N);
- maximum torque required for the foundation holding down bolt nuts used to secure the support structure column to foundation (Nm);
- mounting and fastening arrangement for the circuit-breaker support structure onto the foundation including the minimum required length of foundation holding down bolts; and
- centre of gravity of the circuit-breaker.

b) If specified in Schedule A, the steel support structure and/or concrete foundation shall be designed by the manufacturer, especially for system voltages 765 kV. A drawing showing the steel support structure and concrete foundation design details shall be provided with the tender documentation (refer to 3.2.26.1) and the drawing number(s) shall be stated in Schedule B.

The steel support shall be designed according to the following requirements (if part of the supply):

- Steel shall be in accordance with SANS 1431
- Steel shall be Grade 350W
- Steel shall be hot-dip galvanised in accordance with SANS 121
- Welding shall conform to the requirements of SANS 10044.
- Welds shall be seal welded.

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- Steelwork shall be fabricated, erected and leveled to a tolerance of ±1.5mm.
- Bolts and nuts shall be in accordance with SANS 1700:5.
- Bolts and nuts shall be Grade 8.8.
- Bolts, nuts and washers shall be hot-dip galvanised in accordance with SANS 121.
- Holes shall have diameter of 18mm for M16 bolts.
- All works shall comply with the requirements of SANS 1200

c) In the case of live-tank circuit-breakers for use in systems of nominal voltage up to and including 132 kV, the circuit-breaker common base frame (i.e. for a pole-beam support arrangement) shall be supplied with the circuit-breaker and designed to interface with the standard Eskom Transmission steel support structure and concrete foundation in accordance with the Application Guide (0.54/8829) drawings specified in **Table 5**.

i. The Supplier shall ensure that the their OEM factory circuit-breaker is centred on the support and in turn on the foundation.

ii. The Supplier shall check the holes made available for mounting their OEM factory circuit-breaker and mechanism boxes, including associated control cubicles.

d) Unless it is specified in Schedule A that the steel support structure and/or concrete foundation is to be designed by the manufacturer, the circuit-breaker shall be designed to interface with the standard Eskom Transmission steel support structure and/or concrete foundation in accordance with the Application Guide (0.54/8829) drawings specified in **Table 5**.

Table 5: Eskom Transmission standard civil design drawings for outdoor live-tank circuit-breaker steel support structures and concrete foundations

System voltage *[kV]*	**Steel support structure drawing number**	**Concrete foundation drawing number**
22 (COMBO design) (also used on 11)	0.54/8829 Sheet TBA[1)]	0.54/8829 Sheet TBA[1)]
33 (COMBO design) (also used on 11, 22)	0.54/8829 Sheet TBA[1)]	0.54/8829 Sheet TBA[1)]
33 (also used on 11, 22) and)	0.54/8829 Sheet 3A (drwgs: support – 0.54/302; top cap – 0.54/307)	0.54/8829 Sheet 3A (drwg – 0.54/10232)
66 (also used on 44)	0.54/8829 Sheet TBA[1)]	0.54/8829 Sheet TBA[1)]
132 (also used on 88)	0.54/8829 Sheet 5G (drwgs: support – 0.54/301; top cap – 0.54/307)	0.54/8829 Sheet 5G (drwg – 0.54/4358)
275 (CB also used on 220)	0.54/8829 Sheet 7E (drwgs: support – 0.54/302; top cap – 0.54/306)	0.54/8829 Sheet 7E (drwg – 0.54/4358)
400 (and when 550 kV CB specified)	00.54/8829 Sheet 8G (drwgs: support – 0.54/302; top cap – 0.54/306)	0.54/8829 Sheet 8G (drwg – 0.54/4358)
765	TBA[1), 2)]	TBA[1), 2)]
+/- 533 DC	TBA[1)]	TBA[1)]

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NOTES
1. Standardised drawings are not (yet) available.
2. The 765 kV requirement can be specified at Live-tank circuit-breakers or as Dead-tank circuit-breakers

3.2.7 Corrosion protection and lubrication

With caution taken during life of the circuit-breaker, for circuit breaker corrosion resistant, the SANS 62271-100 subclause 5.20 and SANS 62271-1 subclause 5.20 with its Annex H shall be applicable. Corrosion shall not affect the functionality of the equipment under defined service conditions.

a) All exposed metal shall be protected against corrosion in accordance with 240-75655504 for outdoor "high" to "very high" 'C4' and 'C5' (i.e. marine) corrosivity rating environments.

b) The minimum detailed specification ("DS") for all exposed metal in accordance with 240-75655504 shall be "DS-11" (3CR12), 'DS-18 (Stainless steel) and 'DS-13" (Hot-dip galvanised).

NOTE: Plastic or fibre-reinforced plastic materials for operating mechanism enclosures, or other applications where exposure to the elements is involved will be not accepted.

c) The corrosion protection system (i.e. the equivalent detailed specification "DS" number in accordance with 240-75655504) offered by the manufacturer for the following components shall be stated in Schedule B. Details shall be provided with the tender documentation (refer to 3.2.26.1):

- enclosures;
- nuts, bolts, studs and washers;
- bearing assemblies and linkages;
- structural steel (i.e. common base frame, support structure legs, etc.); and
- other exposed metal (excluding main HV terminals).

d) The behavior of lubricants that are exposed to air, SF6 gas and its arcing products shall be stable over the intervals between maintenance. The Supplier is required to identify the lubricants used and to submit details with the tender documentation (refer to 3.2.26.1) of tests carried out to prove suitability for the application. If possible, a list of equivalent lubricants from South African sources shall be provided. All liquids or chemicals shall be supplied with Material Safety Data Sheets (MSDS).

e) For all circuit-breaker types, the Supplier shall give details with the tender documentation (refer to 3.2.26.1) of the measures taken to prevent flange corrosion. These details shall include drawings of the flange arrangements, treatments and service experience.

f) The Supplier shall complete **Table C1** (Refer to **Annex C**)with detailed Material and Corrosion Protection Information and this shall be submitted by the Supplier with the tender documentation. This shall be the information on each offered type design, live-tank circuit-breaker and/or dead-tank circuit-breaker.

3.2.8 Terminal requirements

a) Main (HV) terminals

i. The type of circuit-breaker main terminals required will be specified in Schedule A. Unless otherwise specified in Schedule A, the circuit-breaker main terminals shall be in accordance with SANS 62271-301 and specifically;

ii. an 8 hole (2 x 4 hole pattern) aluminium flat pad with a 50 mm pitch (distance between holes) and having a minimum thickness of 20 mm. The diameter of the holes shall be 14 mm (M12).

NOTE: For the 220 kV and above circuit-breakers, an 9 hole aluminium flat pad with a 40 mm pitch having a minimum thickness of 20mm shall be acceptable. The diameter of the holes shall be 14 mm (M12).

iii. The arrangement of the HV main terminals shall be such that they can be removed without interfering with the integrity of the circuit-breaker.

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b) Earthing terminals

NOTE: Earthing of the circuit-breaker to the main substation earth grid is achieved through the support structure and the foundation holding down bolts, unless otherwise specified or approved by Eskom Transmission.

- If the continuity between the circuit-breaker and support structure is not achieved, then a suitably rated conductor (preferably not exposed copper and aluminium) shall be provided between the circuit-breaker and the support structure.
- In the case where the steel support structure is supplied with the circuit-breaker, an additional M16 (Ø18 mm hole) hole shall be provided in the steel support structure approximately 100 mm above the base of the support structure (i.e. above the concrete foundation) for the connection of external earthing conductors.

Details of the circuit-breaker HV main terminals and earthing shall be provided on the general arrangement drawings as described in 3.2.26.1.

3.2.9 Safety clearances and personnel safety

a) Live parts shall be isolated by means of elevation.

NOTE: The use of protective fences to prevent contact with live parts is not acceptable.

b) The electrical clearance from ground to live parts at system voltage, which based on the minimum safety clearances as required by statutory requirements contained in the Occupational Health and Safety Act No. 85 of 1993, shall be complied with. Electrical working clearances are given in **Table 6**.

Table 6: Minimum electrical working clearances

System voltage *(kV]*	**Working clearance (vertical) (C_{wv})** *(mm)*	**Working clearance (horizontal (C_{wh})** *(m)*
	Supplier to comply as per **NOTE**	
11 and 22	2 820	1,4
33	2 930	1,5
44 and 66	3 270	1,8
88 and 132	3 950	2,3
220 and 275	4 850	3,4
400	5 700	4,3
765	8 000	(TBA upon project)
+/- 533 DC		(TBA upon project)
NOTE: The working clearance is calculated by summating the height of a person with his/her arm in an extended upward position (i.e. 1800 + 700 = 2 500 mm) and the minimum safety clearance as required by the Occupational Health and Safety Act No. 85 of 1993.		

c) The distance from ground level to the base of any high-voltage (i.e. > 1000 V) insulation shall not be less than 2 500 mm.

d) Pressure relief devices (PRD) shall be orientated so as not to pose any hazard to personnel or adjacent equipment. Details of pressure relief devices (PRD) offered shall be provided with the tender documentation, and shall be stated in Schedule B.

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In the case of dead-tank circuit-breakers, the requirements for internal faults (internal arc) and pressure relief devices (PRD) shall be in accordance with SANS 62271-203. The Supplier shall provide details with the tender documentation (refer to 3.2.26.1) regarding the time during which an arc due to an internal fault up to a given value of short-circuit current will cause no external effects. The definition of this time shall be based on test results or an acknowledged calculation procedure. Refer to subclause D.1 of SANS 62271- 203. The duration of current without burn-through for different values of the short-circuit current may be estimated from an acknowledged calculation procedure.

3.2.10 Insulation requirements

a) Hollow insulators

- The insulator material shall be ceramic or of the silicone rubber composite type. If applicable, the material type will be specified in Schedule A. The type of insulator material offered and manufacturer shall be stated in Schedule B.
- Insulators of the ceramic type shall be in accordance with the requirements of SANS 62155 and SANS 60815-2.
- Insulators of the silicone rubber composite type shall be in accordance with the requirements of SANS 61462 and SANS 60815-3.

i. All composite or polymeric high voltage insulators shall conform to, the 1000hr salt-fog tracking and erosion test, contained in SANS/IEC 62217, “Polymeric HV insulators for indoor and outdoor use – General definitions, test methods and acceptance criteria” as a minimum or the minimum pollution related qualification as contained in the specific international (SANS,IEC, IEEE, ANSI etc.) equipment or product standards

ii. For ceramic insulators, consisting of glass or porcelain, SANS/IEC TS 60507, “Artificial pollution tests on high-voltage ceramic and glass insulators to be used on a.c. systems”, shall apply.

- Firstly comply with the two clauses above (i. and ii.) for polymer and ceramics respectively, also with SANS/IEC 62217 standard as a minimum requirement, and the Supplier shall provide the relevant accredited reports and certification with the tender documentation.
- Additionally, the qualification for heavy and very heavy pollution levels shall be provided based on certification of products meeting **either one** or **a combination of** the following technical standards or guidelines provided in **Table 7**. It should be noted that the requirements listed are not in any order of preference:-

Table 7: Test Standards or Methods applicable for heavy to very heavy pollution site severity

Standard Identifier	Title/Nature of test
SANS/IEC TS 60507	Artificial pollution test on high-voltage insulators to be used on a.c. systems
CIGRE TB 555	Artificial pollution test for polymer insulator, WG C4.303
CIGRE TB 691	Pollution test of naturally and artificially contaminated insulators, WG D1.44
SANS/IEC TR 62730	HV polymeric insulators for indoor and outdoor use tracking and erosion testing by wheel test and 5000hr test
SANS/IEC 60815 (or any of the preceding tests mentioned)	Pollution flashover performance curve tests

b) Minimum creepage distances

Creepage distance shall be in accordance with SANS 62271-1—subclause 5.14, and as follows:

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- The minimum unified specific creepage distance (USCD) required in accordance with SANS 60815-1 for external insulation shall be as specified in Schedule A. The unified specific creepage distance (USCD) for external insulation has been rationalised to:-
  - 34,7 mm/kV for "c - medium" site pollution severity (SPS) class;
  - 43,3 mm/kV for “d - heavy” site pollution severity (SPS) class; and
  - 53,7 mm/kV for "e - very heavy" site pollution severity (SPS) class.

NOTE: 34,7 mm/kV, 43,3 mm/kV and 53,7 mm/kV corresponds to a previous specific creepage distance (SCD) of 20 mm/kV, 25 mm/kV and 31 mm/kV respectively.

- Eskom Transmission has standardised on insulators that meet he minimum creepage distance of SCD of 31 mm/kV i.e. USCD of 53,7 mm/kV. The actual creepage distance offered shall be stated in Schedule B.

c) Clearances in air

- The Eskom Transmission specified minimum phase-to-phase clearances are based on the fact that twin bull conductors are required for the 2500 A current rating, and triple-bull conductors for 3150 A and 4000 A. The minimum phase-to-phase clearance, measured by the taut string method on the outer of metal-to-metal (outer of main HV terminal pad to pad) of single-mechanism type circuit-breakers, shall be as follows:
  - i. for 22 kV: 400 mm; and
  - ii. for 33 kV: 400 mm;
  - iii. for 66 kV: 700 mm.
  - iv. for 132 kV: 1,650 mm.
  - v. for 275 kV: 3,600 mm; and

NOTE: .Eskom Transmission reserves the right to call for clearances greater than those already successfully proven by dielectric tests.

- phase-to-phase and phase-to-earth clearances, measured by the taut-string method, shall be stated in Schedule B.

3.2.11 Position / status indication

He position indication shall be in accordance with SANS 62271-100 subclause 5.12 and the following:

a) The circuit-breaker main contact position indication shall be clearly visible from ground level and from outside the circuit-breaker operating mechanism enclosure when the front access door is closed.

b) The following symbols and colours shall be used for the position indication of the circuit-breaker main contacts:

- Circuit-breaker closed: "I" in white lettering on a red background
- Circuit-breaker open: "O" in white lettering on a green background

c) Lettering size shall be at least 30 mm, unless otherwise approved by Eskom Transmission.

d) The closing-spring condition (i.e. charged or discharged) shall be indicated by a mechanical device. It shall be clearly visible from outside the circuit-breaker operating mechanism enclosure when the front access door is closed. The words "SPRING CHARGED" and "SPRING DISCHARGED" shall be displayed in black lettering on a white background. The lettering height shall be at least 15 mm. The use of symbols to indicate spring condition will not be accepted.

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e) Each circuit-breaker shall be provided with an operation counter that is advanced each time the circuit-breaker main contacts open or alternatively each time the main contacts close (i.e. not both). Mechanical operation counters are preferred, but electrical counters are also acceptable. The circuit-breaker operation counter shall be non-resettable. The counter shall have, at least, a capability of counting up to 99 999 operations. The operation counter shall be connected prior to routine testing to reflect all factory and pre-commissioning operations. The type of operation counter shall be stated in Schedule B. The Supplier shall submit full details of the operation counter on request by Eskom Transmission.

f) In the case of SF6 circuit-breakers, pressure gauges (compensated for temperature and responding to SF6 gas density) shall be provided. These devices shall be sheltered from the elements to ensure that the reading provided is correct and to prevent ageing of the device, and this requirement shall apply to all circuit-breaker types with other insulation and/or arc-extinguishing medium.

g) All indicating devices shall be clearly visible and legible by persons with normal vision standing at ground level. In addition, it shall be possible to carry out all routine inspection activities from the ground level.

3.2.12 Labels

a) Operating labels associated with local operation of the circuit-breaker shall be securely attached to the inside of the operating mechanism enclosure front access door and be as follows (black text on white background, in English):

- Instructions for tripping and closing the circuit-breaker: These instructions shall be titled “TO TRIP” circuit-breaker and “TO CLOSE” circuit-breaker, respectively. Additional information required to perform these functions shall be referred to Eskom Transmission; and
- Instructions for charging the closing spring: The instruction shall be titled “TO CHARGE SPRING” and located near the actuator for local mechanical spring charging.

b) The actuator(s) for local opening and closing of the circuit-breaker shall be identifiable by all three of the following methods:

- by labelling, in English, printed with black text on a white background reading “TRIP” and “CLOSE”, respectively. The symbols “O” and “I” may be used as additional means to identify the respective trip and close controls;
- by actuating direction or position. A rotary switch shall be turned anti-clockwise to trip the circuit- breaker and clockwise to close the circuit-breaker. Trip and close push buttons shall be oriented vertically or horizontally and shall have the trip button at the bottom or to the left of the close button [IEC 60447]; and
- by colour coding. The colour green shall be associated with the trip control and red with the close control. Alternatively the controls shall be without unique colour.

NOTE: The Eskom colour coding convention for trip/close actuators is opposite to that specified in IEC 60073 (i.e. IEC requires trip red and close green).

c) The poles of the MV circuit-breakers combined with CT’s (COMBO design), specified for voltages up to 33 kV, shall be labeled L1, L2 and L3 as per Eskom Transmission standard interface drawing 0.52/30135 to allow users to associate CT secondary wiring with a specific primary pole. The pole markers shall be visible from ground level with the circuit-breaker connected in service position. The L1, L2 and L3 labels shall not be colour-coded so as to avoid association or confusion with the Red, White and Blue phases naming.

d) An appropriate warning label shall be displayed to draw attention to the danger of performing manual operations without an adequate amount of insulation and/or arc-extinguishing medium inside of the circuit-breaker.

NOTE: The warning label for the mechanical trip facility shall be displayed.

e) A warning label shall be displayed within the operating mechanism enclosure to draw attention to the minimum time interval required between repeated CO operations during testing.

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f) All relays, instruments, fuses, MCBs, control switches, luminous indicators and links, the functions of which are not clearly identified by signs or pictograms, shall be clearly labelled to indicate their functions. These labels shall be in text using black letters at least 5 mm high on a white background.

g) Where applicable, all labels shall be manufactured in accordance with Eskom Transmission standard (240-120804300 and 240-62629353) and shall be attached using inherently corrosion-resistant rivets or self-tapping screws. No stick-on labels, double sided tape or glue is accepted, unless otherwise approved by Eskom Transmission.

3.2.13 Requirements for sulphur hexafluoride (SF6) gas or alternative environmental-friendly low GWP insulation (where applicable)

For requirements of gases in the circuit-breaker, SANS 62271-100 subclause 5.2 shall be applicable. Requirements below, where applicable, shall be fulfilled by the Supplier for all circuit-breakers of SF6 gas or circuit-breakers that are using environmental-friendly low GWP (SF6-free design) insulation and/or arc-extinguishing medium. Furthermore, the Supplier shall provide additional specific details pertaining to non-SF6 (SF6-free) solution.

a) SF6 gas used as an insulation and/or arc-extinguishing medium shall comply with the requirements of IEC 60376.

b) All SF6 circuit-breakers shall be factory filled with new SF6 gas at the rated transportation pressure. All non-SF6 circuit-breakers (SF6-free design) shall be filled with its new environmental-friendly insulation and/or arc-extinguishing medium at the rated pressure for transportation.

c) The maximum SF6 gas leakage rate for the complete equipment shall be 0,5 % per year. The leakage rated offered shall be stated in Schedule B. This shall be stated for all the gas in the equipment as well as for any individual gas-filled compartment.

d) The SF6 gas on cylinders shall comply with the Eskom Transmission standard (240-151122225), all technical documentation required by this standard specification shall be submitted at tendering stage

e) The new Eskom Transmission ordered circuit-breaker shall be delivered to Eskom with its new gas cylinder of the insulation and/or arc-extinguishing medium for filling up to rated pressure. It shall be noted that Eskom Transmission reserves the right to decide at order placement whether to source the new SF6 gas cylinder for filling the circuit-breaker from its internal Eskom Transmission Contract for gas.

f) The SF6 gas cylinder from Supplier and its factory shall comply with Eskom Transmission standard (240-151122225), and shall be delivered with the specified technical details documentation. In addition to that set of documentation, a certificate guaranteeing SF6 purity to IEC 60376 shall be supplied with the circuit-breaker's gas cylinder.

g) Upon filling to rated pressure and testing the circuit-breaker, a SF6 purity analysis shall be carried out by the Supplier not less than 7 days after commissioning or as recommended by the OEM. Similarly, the non-SF6 (SF6-free) circuit-breaker shall be filled and tested, then purity analysis performed on its environmental-friendly insulation and/or arc-extinguishing medium as per Eskom Transmission minimum 7 days or as recommended by OEM. All gas filling shall be done by an accredited person. For SF6 gas circuit-breaker, the following parameters shall be checked, recorded and a report submitted to Eskom Transmission after filling:

- SF6 content (purity) - not less than 98%
- Dew-point (humidity/ moisture content) maximum, at rated filling pressure and +20°C – at commissioning shall not be above -10 °C. When equipment is in service it shall not exceed the critical limit of -5 °C.

For non-SF6 (SF6-free) circuit-breaker, the Supplier with its OEM shall provide details for parameters that shall be checked, recorded and a report submitted to Eskom Transmission after filling:

NOTE: As the reference unit, in accordance with SANS NRS 087:2008 subclause E.1.1 the volume concentration of the moisture contained in a gas shall be expressed in microliters per litre (µL/L).

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h) The following requirements are applicable to SF6 gas-filled circuit-breaker filling and pressure monitoring (also the non-SF6 (SF6-free) circuit-breakers employing the environmental-friendly insulation and/or arc extinguishing medium):

- In the case of circuit-breakers for use in systems of nominal voltage up to and including 132 kV, gas filling/evacuation points with DILO DN8 connections shall be provided.
- In the case of circuit-breakers for use in systems of nominal voltage from 220 kV up to and including 765 kV, gas filling/evacuation points with DILO DN20 connections shall be provided.
- Access to gas filling/evacuation points shall be at a height of not more than 2 400 mm above ground level. This is a maximum height since it allows for access to the filling/evacuation point without leaving the ground level.
- The gas filling/evacuation point and the gas pressure gauge shall be separated i.e. it shall not be necessary to remove the pressure gauge in order to access the filling/evacuation points.
- A dial type gauge responding to insulation and/or arc extinguishing medium density and indicating pressure compensated for temperature shall be suitably sized (typical 80-100 mm diameter).
- A density monitoring device (density switch) insulation and/or arc extinguishing medium, which may also be integrated into the dial type gauge as a dual function device, shall be provided. The density monitoring device switch shall provide the necessary contacts specified in 240-56030489.
- Pressure gauges for insulation and/or arc extinguishing medium shall be numerically marked and calibrated in Pascal's (kPa or MPa). Gauges shall measure "absolute" pressure and shall be clearly labelled 'ABSOLUTE'. Rated pressure shall be no more than 80% of the full-scale reading.
- The density monitoring device for insulation and/or arc extinguishing medium shall be suitable for outdoor application and resistant to operating vibrations, outdoor elements (hail/snow), etc.
- The type of gauge utilised shall be designed such as to prevent any corrosion of moving parts and contacts inside the gauge.

NOTE: Gauges filled with an inert gas to prevent corrosion and the ingress of moisture are acceptable.

- Density monitoring devices for insulation and/or arc extinguishing medium shall be shielded against direct sunshine and internal operating mechanism enclosure heater elements which could give rise to false readings and alarms.
- Non-return valves shall be fitted on all DN8 / DN20 fittings and pipe-work such that the gas pressure is maintained in the system and pipe-work when a circuit-breaker pole or the density monitoring device is removed or disconnected. The Supplier shall submit details of the arrangements offered together with the tender documentation (refer to 3.2.26.1).
- Any pipe work shall be made of stainless steel and mounted in such a manner that it is mechanically protected. The use of copper pipes is acceptable if painted in the factory before mounting to the circuit-breaker common base frame.
- For circuit-breakers with physically separated poles and associated operating mechanisms, a separate filling/evacuating and medium density monitoring point per pole shall be provided. For circuit-breakers with a common base frame, a single common filling/evacuating and medium density monitoring point for all poles may be provided.
- Electrical connections to the density monitoring device shall preferably not be the plug-in type. However, density-monitoring devices with locking facilities will be accepted.

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- Cabling to the medium density monitoring device for insulation and/or arc extinguishing medium shall be secured, protected from the elements and run into enclosures through a suitable compression gland or rubber grommet.
- Complete details of all insulation and/or arc-extinguishing medium pressure devices, including drawings, manufacturer's specifications, performance and test data, details of production tests and a quality control programme, shall be included with the tender documentation (refer to 3.2.26.1).
- Electrical interlocks and alarms provided by the gas density monitoring device shall be in accordance with 240-56030489.

i) The management of SF6 gas shall be in accordance with NRS 087, and the SF6 gas in cylinders shall comply to the Eskom Transmission standard (240-151122225).

3.2.14 Current transformers (CTs) for MV circuit-breakers combined with CT's (COMBO)

a) Current transformers (CTs) shall be outdoor post-type, manufactured and tested in accordance with 240-56062864 and standard interface drawing 0.52/30135.

Table 8: Summary of the CT's required for MV circuit-breakers combined with CT's (COMBO)

Item	Short Description	Specified CB rating (kV and kA)	Core Layout	Protection Core (P)	Bus Zone Core (B)	Measuring Core (M)	DC control voltage (V DC)
1.	CT 11 kV 2 500 A 31,5 kA 2P2M	22 kV; 31,5 kA	PPMM	1/2 400T MR	–	2 400/1 MR	110
2.	CT 11 kV 2 500 A 31,5 kA 2P2M	22 kV; 31,5 kA	PPMM	1/2 400T MR	–	2 400/1 MR	220
3.	CT 22 kV 2 500 A 31,5 kA 2P2M	22 kV; 31,5 kA	PPMM	1/2 400T MR	–	2 400/1 MR	110
4.	CT 22 kV 2 500 A 31,5 kA 2P2M	22 kV; 31,5 kA	PPMM	1/2 400T MR	–	2 400/1 MR	220
5.	CT 33 kV 2 500 A 31,5 kA 2P2M	33 kV; 31,5 kA	PPMM	1/2 400T MR	–	2 400/1 MR	110
6.	CT 33 kV 2 500 A 31,5 kA 2P2M	33 kV; 31,5 kA	PPMM	1/2 400T MR	–	2 400/1 MR	220

b) The number and type of CT cores required per phase, together with their position relative to the circuit-breaker and their respective standards or specifications will be specified in Schedule A.

c) The CT terminal numbering and wiring interface shall be in accordance with the Eskom Transmission standard interface drawing 0.52/30135 as specified in Schedule A.

d) The CTs shall be properly fixed and mechanically supported so that no movement is allowed during transportation or service fault conditions.

e) Where post-type CTs are provided, bolted tinned copper conductors, suitably dimensioned in accordance with the circuit-breaker and CT current ratings, shall be supplied and fitted between the CTs and the circuit-breaker terminals. The cross-sectional area of the copper conductors shall be stated in Schedule B. The CT main terminals shall be in accordance with a). The CTs shall be mounted on galvanized steel support brackets attached to the circuit-breaker base frame. OEM to provide an approved lifting method when required to replace.

f) It shall be possible to remove and replace the ring-type CTs without dismantling the circuit-breaker. The method to perform this shall be provided with tender documentation, and that shall be clear on the OEM Operation and Maintenance Instruction Manual.

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3.2.15 Current transformers (CTs) for dead-tank circuit-breakers

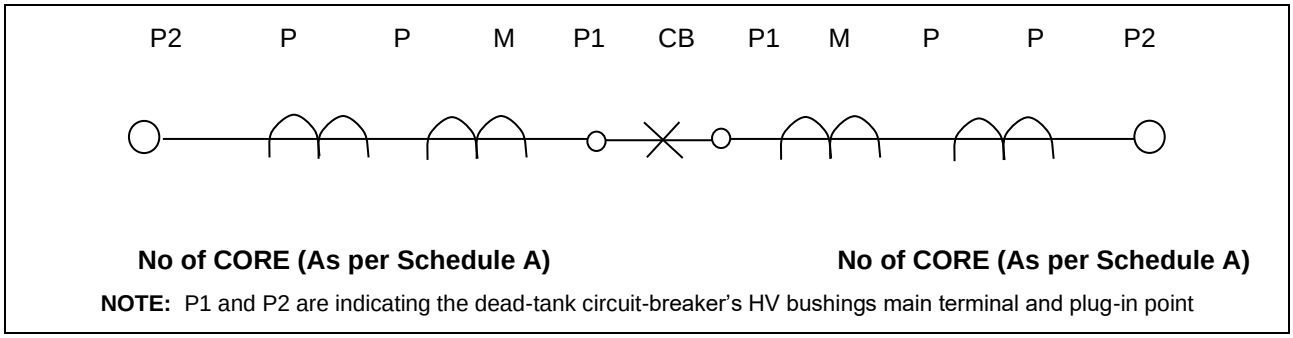
g) Current transformers (CTs) shall be of the integrated ring-type, manufactured and tested in accordance with IEC 61869-1 and IEC 61869-2.

h) The number and type of CT cores required per phase, together with their position relative to the circuit-breaker and their respective standards or specifications will be specified in Schedule A.

i) The CT terminal numbering and wiring interface shall be in accordance with the drawing specified in Schedule A.

j) It shall be possible to remove and replace the ring-type CTs without dismantling the circuit-breaker bushing. The method to perform this shall be provided with tender documentation.

k) Specific requirements for dead-tank circuit-breaker CT's:-



NOTE: P1 and P2 are indicating the dead-tank circuit-breaker's HV bushings main terminal and plug-in point

Figure 1: Typical arrangement of the CTs on the dead-tank circuit-breaker

3.2.15.1 Cores and class for CT's on dead-tank circuit-breakers

For Feeder bays, Coupler bays and Transformer bays CT's on dead-tank circuit-breakers

i. 765kV CT's:

Number of CT cores: 4 x Protection class TPY; 2 x Metering class 0.2

Table 9: 765kV ratios for multi ratio (MR) and fixed metering current transformers

Nominal ratio	Proposed Tapping points on secondary windings	Ratios available	Burden capability VA	Accuracy class	Ratio
3200/1	800/800/1200/400	3200/2800/2400/2000/1600/1200/800/400/1	10	0,2	800/1
800/1*	Fixed	800/1	10	0.2	800/1

NOTE: The asterisk (*) on the nominal ratio denotes that it is requirement for the 765kV Reactor Dead-tank circuit-breakers

Table 10: 765kV ratios for multi ratio (MR) and fixed protection current transformers

Nominal ratio	Proposed Tapping points on secondary windings	Ratios available	Class		Duty cycle
3200/1	800/800/1200/400	3200/2800/2400/2000/1600/1200/800/400/1	TPY	2000	C-O-C-O

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800/1*	Fixed	800/1	TPY	2000	C-O-C-O

NOTE: The asterisk (*) on the ratio denotes that it is the requirement for the 765kV Reactor Dead-tank circuit-breakers

Table 11: Values where TPY cores are used on dead-tank circuit-breakers

	Unit	765kV CT	400kV CT in Trfr Bay
Current transformer class		TPY	TPY
Number of Protection cores		4	2
Rated primary current (Ipn)	A	3150	3150
Rated secondary current	A	2	2
Rated frequency	Hz	50	50
System voltage and insulation level	kV	765	400
System voltage and insulation level	kV	1550	1050
Ith (Ipsc)	kA	50 for 1 sec	50 for 1 sec
Idyn	kA	127.5	127.5
Ratio to which specified data applies	-	3200/1 (MR)	3200/1 (MR)
Alf (Symmetrical short circuit)	-	20	20
Kssc (Asymmetrical short circuit)	-	15	15
Tp	msec	100	100
DC Component	%	55	55
Duty cycle: Single: t', t'al; Double: **t'**, t'al, tfr, t", t"al	msec	100	100
Duty cycle: Double: t', **t'**al, tfr, t", t"al	msec	40	40
Duty cycle: Double: t', t'al, **tfr**, t", t"al	msec	500	500
Duty cycle: Double: t', t'al, tfr, **t"**, t"al	msec	100	100
Duty cycle: Double: t', t'al, tfr, t", **t"**al	msec	40	40
Rb	Ω	12	12

- CT requirements for Shunt Reactor bays: Number of CT cores:

Dead-tank circuit-breaker CT's:2 x Protection class TPY (fixed 800/1) and 1 x Metering class 0.5 @ 800/1 5VA

Table 12: Values for the 765kV Reactor dead-tank circuit-breaker

	Unit	Dead-tank CB CT
Current transformer class		TPY

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	Unit	Dead-tank CB CT
Rated primary current (Ipn)	A	800
Rated secondary current	A	2
Rated frequency	Hz	50
System voltage	kV	765
Insulation level	kV	1550
Ith (Ipsc)	kA	50 for 1 sec
Idyn	kA	127.5
Ratio to which specified data applies	-	800/1 (Fixed)
Alf (Symmetrical short circuit)	-	20
Kssc (Asymmetrical short circuit)	-	15
Tp	msec	100
DC Component	%	55
Duty cycle: Double: **t'**, t'al, tfr, t", t"al	msec	100
Duty cycle: Double: t', **t'**al, tfr, t", t"al	msec	40
Duty cycle: Double: t', t'al, **tfr**, t", t"al	msec	500
Duty cycle: Double: t', t'al, tfr, **t"**, t"al	msec	100
Duty cycle: Double: t', t'al, tfr, t", **t"**al	msec	40
Rb	Ω	12

ii. 220kV – 400kV CT's:

Number of CT cores: 2 x Protection class PX; 2 x Bus Zone class PX; 2 x Metering class 0.2

NOTE: The 400kV dead-tank circuit-breaker used on the 765kV transformer bay on the 400kV side shall have the core requirements: 2 x Protection class TPY; 2 x Bus Zone class PX; 2 x Metering class 0.2

iii. 132kV CT's:

Number of CT cores: 2 x Protection; 2 x Bus Zone; 2 x Metering.

Class PX shall be specified by Eskom Transmission, not TPS.

3.2.15.2 Magnetizing curves

Details of magnetizing curves (on a log-scale) for the dead-tank circuit-breakers CT's shall be provided for the TPY cores with tender documentation. The other cores' magnetizing curves shall be provided upon Eskom Transmission request.

3.2.16 Switching surge control (where applicable)

a) In order to reduce complexity, circuit-breakers that require auxiliary devices in the main circuit (e.g. pre-insertion closing resistors or inductors) for switching surge control (TRV's, RRRV's) during no-load transmission line switching) may be considered for use in systems of nominal voltage 765 kV and will be subject to approval by Eskom Transmission. Information required for the selection of an appropriate resistance for the pre-insertion closing resistor will be provided by Eskom Transmission with the tender documentation.

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NOTE: The inclusion of pre-insertion resistors may impact on the mechanical endurance class of the circuit-breaker (e.g. reduce the number of mechanical operations from 10 000 (M2) to 2 000 (M1) operations). This should be considered when evaluating various alternative solutions.

b) For the switching of capacitor banks, reactor banks (also refer to 3.2.17) and 765 kV transformers, the preferred solution for switching surge control is by means of precise and repeatable operating characteristics in conjunction with an electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) (also refer to 3.2.20). Eskom Transmission details for its philosophy of point on wave (PoW) switching of circuit-breakers is detailed on the standard (240-75566441). Where the Supplier and OEM recommends suitable for their design to prolong its life-expectancy, the application of metal oxide surge arresters or surge capacitance connected in parallel with the circuit-breaker interrupters or at a suitable nearest location.

c) In order to ensure the recommended solution to protect the offered circuit-breakers that require auxiliary devices in the main circuit (e.g. surge capacitors) for switching surge control (TRV's, RRRV's, upon short-line faults (SLF) on the transmission line switching where the substation has high fault current, the Supplier shall offer that as part of the offered circuit-breaker. Also ensure it is optimised for mounting on Eskom standard steel support structure of the circuit-breaker.

NOTES:

- The electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) shall be IEC61850 protocol compliant.
- The circuit-breaker shall be operable and perform its function even when the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) is out of service.

3.2.17 Grading capacitors (where applicable)

a) Where grading capacitors are required for the distribution of voltage stresses across the interrupters of circuit-breakers having two or more interrupting units in series, this shall be stated in Schedule B together with the capacitance (in pF) per interrupting unit, the type of insulation material e.g. oil/paper and the manufacturer and type. This is applicable to the 400 kV and 765 kV circuit-breakers for reactor banks (shunt and series) and 550 kV circuit-breakers as they are applied at parts of the network where there are high switching transients (TRV's, RRRV's) on insulation and very heavy pollution locations and generator synchronising bays. The offered circuit-breaker designs without grading capacitors shall not be accepted by Eskom Transmission. The circuit-breaker for reactor bank application shall be equipped with its grading capacitors and shall be equipped with the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device).

b) The Supplier shall provide details with the tender documentation (refer to 3.2.26.1) of how to verify the condition of grading capacitors during the life of the circuit-breaker. The grading capacitors are required to last for the lifetime of the circuit-breaker without maintenance.

3.2.18 Extreme asymmetrical short-circuit interrupting capability (across the HV generator unit circuit-breaker)

For the specific circuit-breakers required for installation on the HV side of the generator transformer, just before the HV busbars, the capability of those circuit-breakers to withstand TRV's during generator synchronising (internal and external insulation) and the capability to interrupt short-circuit currents with a higher degree of asymmetry than required by the SANS 62271-100 standard will be specified by Eskom Transmission in Schedule A. Details will be provided with the tender documentation. Such capability shall be demonstrated by tests or calculations that show that the influence of the arc voltage will produce a current zero within the normal arcing time of the circuit-breaker. Eskom Transmission shall specify a circuit-breaker of the one higher insulation level, in order to mitigate the exceedance of its type-tested ratings and coping with switching stresses.

NOTE: Circuit-breakers typically placed on the high-voltage side of large generator step-up transformers may experience short-circuit currents that may, due to the extreme asymmetry of the short-circuit current, not have a current zero for a number of cycles, preventing interruption of the current. In such circumstances, the duty of the circuit-breaker can be eased, for example, by delaying its opening. Alternatively, it may be proven by tests or calculations that the arc voltage of the circuit-breaker is high enough to damp the d.c. component of the current so much that a current zero will occur.

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3.2.19 Requirements for simultaneity of poles during single closing and single opening operations

a) All interrupters in a pole and in all three poles of the circuit-breaker shall operate simultaneously on opening and closing – including infrequent operation and under extreme temperature conditions. Contact synchronism shall be retained within rated values during the expected maintenance intervals of the circuit-breakers. The expected degree of synchronism shall be in accordance with SANS 62271-100 subclause 5.101 and therefore as follows:

- the time interval between contact touch for all poles of the circuit-breaker shall not exceed 5 ms (a quarter of a cycle of rated frequency);
- the time interval between contact touch for interrupters in the same pole shall not exceed 3,3 ms (a sixth of a cycle of rated frequency);
- where applicable, the time interval between contact touch for individual pre-insertion closing resistors shall not exceed 10 ms (a half of a cycle of rated frequency); and
- where applicable, the time interval between contact touch for individual pre-insertion closing resistors in the same pole (series connected) shall not exceed 6,6 ms (a third of a cycle of rated frequency);
- the time interval between contact separation for all poles of the circuit-breaker shall not exceed 3,3 ms (a sixth of a cycle of rated frequency); and
- the time interval between contact separation for interrupters in the same pole shall not exceed 2,5 ms (an eighth of a cycle of rated frequency);

b) Refer to 5.101.1 of SANS 62271-302 for general guidance for circuit-breakers intended for operation with intentionally non-simultaneous poles (controlled switching - refer to 3.2.20).

3.2.20 Controlled switching

Eskom Transmission philosophy of point on wave (PoW) switching of circuit-breakers is detailed standard (240-75566441). Circuit-breakers required for shunt capacitor banks, reactor banks (shunt and/or busbar) and/or power transformers (765 kV) application duties, to mitigate generated switching transients, shall be switched using the electronic controller (Controlled Switching Device or Point-on-Wave (PoW) switching device). SANS 62271-302 provides guidance on the design, construction, specification and testing of circuit-breakers with intentional non-simultaneous pole operation which are excluded from the scope of SANS 62271-100. Circuit-breakers with intentional non-simultaneous pole operation are mainly used in Eskom Transmission with the controlled switching.

NOTE: Mechanically staggered poles used for controlled switching applications will not be accepted due to the limitation placed on the circuit-breaker mechanical endurance, unless otherwise accepted by Eskom Transmission.

The Supplier shall provide proof that the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) is compliant to IEC61850 protocol with the Tender documentation. For the offered circuit-breaker with this requirement, the Supplier shall complete the Technical Schedules B for the circuit-breaker and the Technical Schedule B for the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) of its standard (240-75566441).

a) Full details of the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) system offered, i.e. the manufacturer's technical specification/manual for the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) and necessary sensors and auxiliary equipment required to achieve controlled switching, shall be supplied with the tender documentation (refer to 3.2.26.1). However, the circuit-breaker shall be capable, operable and perform its function even when the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) is out of service.

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b) The Supplier shall state in Schedule B whether the circuit-breaker offered has been tested in accordance with SANS 62271-302. The Supplier shall indicate whether the circuit-breaker offered was tested independent from any particular electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) or whether it was tested with a dedicated electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) and the necessary sensors and auxiliary equipment which form part of the tested equipment.

c) The Supplier shall provide details with the tender documentation (refer to 3.2.26.1) regarding the mechanical characteristics of the circuit-breaker which affect the mechanical operating time, e.g. influence of ambient temperature, substation d.c. control voltage, standing time, operating pressure, contact wear. The cause of deviations in operating times shall be indicated in all cases, e.g. arising in the operating coil/latch assembly, energy storage device, etc.

d) The Supplier shall provide details with the tender documentation (refer to 3.2.26.1) of the circuit-breaker dielectric characteristic – as a function of time (closing) and as a function of SF6 gas filling pressure up to the maximum rated design pressure. The Supplier shall also supply the upper and lower limits of the dielectric characteristic which can be expected over the service life of the circuit-breaker. The critical arcing time window shall be indicated for re-ignition-free shunt-reactor switching. For controlled closing of shunt capacitor banks as well as for controlled opening of shunt reactors, a tolerance of less than ± 1 ms is required as a function of the above-mentioned parameters. If special measures are required to maintain operating times within these limits, this shall be stated with the tender documentation.

3.2.20.1 Additional requirements for the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) interface

The electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device), where applicable, shall form part of the additional Process Interface Unit (PIU) in the digital secondary plant interface option to the switchgear shall comply to SANS 62271-3/ IEC 62271-3.

The electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) shall implement the IEC 61850 logical node CPOW – Control Point-on-Wave switching.

a) Eskom Transmission prefers that the communication interface is 850NM fibre optic cable.

b) The electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) is to have a wiring loom that is able to connect to terminals in the Junction Box (JB) with approximately 20 wires and a length of approximately 2 metres. The wires in the loom shall be ferruled and include lugs, in accordance with standard 240-64636794. The point on wave (POW) relay with and without a wiring loom shall be ordering options.

c) The electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) shall include an oscillographic wave-form recorder. This recorder shall be triggered on every point on wave (PoW) device operation.

d) The Supplier awarded the Eskom Transmission contract shall also be able to provide the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) and its associated circuitry as a separate item as and when needed.A fully hardwired electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) shall be an ordering option for legacy applications.

NOTE: The electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) shall also be able to support hardwire interfacing for legacy brownfield applications. This shall be an ordering option.

e) The electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) and its associated circuitry are located at a remote location in a yard junction box (JB) in the yard or the relay panel in the control room associated with the particular circuit-breaker.

NOTE: The current Eskom Transmission applications are for the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) to be either located in the junction or control room.

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3.2.21 Pole discordance (PD) or phase discrepancy

NOTES

- A pole discordance (PD) or phase discrepancy condition is when one or more poles of a single-pole operated circuit-breaker (i.e. "1P") do not perform an operation in harmony with the other poles.
- The PD timer and its associated circuitry are to be provided as a separate contract item.
- This timer will receive its signal from a combination of normally-open and normally-closed auxiliary switch contacts.
- The PD timer and its associated circuitry are located on the control panel at a remote location in the control room associated with the particular circuit-breaker.

a) If a pole discordance condition persists for at least 100 ms, then the control circuitry associated with the circuit-breaker shall immediately initiate a trip command to all poles. The duration for which the discordance condition persists before tripping all poles, shall be controlled using a settable timer.

b) In order to determine the correct settings for this timer, the Supplier shall provide the following information with the tender documentation (refer to 3.2.26.1) about the timing events (with tolerances) between:

- main contact timing and the auxiliary contacts timing (“a” contact and “b” contact) of the same pole for both opening and closing operations;
- main contact timing and the auxiliary contacts timing (“a” contact and “b” contact) between all poles for both opening and closing operations assuming the open and close command is received simultaneously by all poles; and
- designation of auxiliary contacts (required for future testing);

c) In the case of single-pole auto-reclosing, where an intentional PD will exist for times in excess of 1 000 ms, the control circuitry shall deliberately permit this condition.

3.2.22 Auxiliary and control circuits

The auxiliary equipment shall be in accordance SANS 62271-100 subclause 5.4, and the auxiliary and control circuits designed and implemented in accordance with this specification requirements listed below **Table 13** as well as the further details under **Annex D** (Requirements Wiring of Outdoor Circuit Breakers), and the Eskom Transmission standard wiring interface drawings applicable for that voltage offered circuit-breaker.

Table 13: Eskom Transmission standard wiring interface drawings for outdoor circuit-breakers

CB Type	CB rating *[kV]*	System voltage *[kV]*	Rated DC Voltage (V)	Standard wiring interface drawing applicable	Wiring Schematics from the Supplier required
LTCB (COMBO)	33	11, 22, 33	110, 220	0.52/30135	Yes[5)]
LTCB	33, 66, 132	11, 22, 33, 66, 88, 132	110, 220	0.52/30135	Yes[5)]
LTCB	275, 400, 550	220[1)], 275, 400[2)], 765[3), 4)]	110, 220	0.54/07529	Yes[5)]
DTCB	400, 550, 765	400 [3)], 765[3) 4)]	110, 220	0.54/8557	Yes[5)]
LTCB	133 (across open contacts)	+/- 533 DC	N/A	N/A	N/A

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NOTES

1. The 220 kV system voltage uses 275 kV rated circuit-breakers.
2. The 400 kV system voltage uses both 420 kV and 550 kV rated live-tank circuit-breakers.
3. The dead-tank circuit-breakers can be specified for use in the 765 kV and 400 kV system voltages.
4. The circuit-breakers required for HVDC are specified on a separate Eskom Transmission standard specification
5. Supplier shall submit with tender documentation, the wiring schematics that are aligned to Eskom Transmission standard wiring interface drawings.

a) In the case of circuit-breakers for use in systems of nominal voltage up to and including 132 kV, the circuit-breaker auxiliary and control circuit wiring interface shall be in accordance with 052/30135. In the case of circuit-breakers for use in systems of nominal voltage above 132 kV, the wiring interface shall be in accordance with 0.54/07529 (Live-tank circuit-breakers) and 0.54/8557 (Dead-tank circuit-breakers). These standard wiring interface schematics shall be applicable to equipment with the higher rated voltages.

b) A removable 3 mm thick brass or aluminium gland plate (undrilled) having a minimum usable area of 200 mm x 100 mm shall be fitted at the bottom of the enclosure below the terminal strips for the bottom entry and glanding of all control cables. The gland plate shall be secured by a minimum of six M8 set screws with nuts and washers, unless otherwise approved by Eskom Transmission. In the case where CTs are supplied with the circuit-breaker, two gland plates each having a minimum usable area of 200 mm x 100 mm shall be fitted below each terminal strip. Earthing of the gland plate shall be via the set screws.

c) To facilitate LV control cable entry and connection, the distance between any part of the terminal strip and the gland plate shall not be less than 150 mm. The terminal strips shall be positioned and spaced to provide easy access to the terminals to insert the wiring.

d) A suitable earthing point shall be provided inside the operating mechanism enclosure to allow earthing of at least 10 spare secondary control cabling cores. This shall be achieved using a tinned copper earthing bar with M6 fasteners or a suitable number of earthed terminal blocks.

e) Induced electromagnetic disturbances in the secondary system of the circuit-breaker shall not cause spurious operation or damage. This applies under both normal operation and switching conditions, including interruption of fault currents in the primary system.

f) It shall be possible to change the d.c. control voltage at which the circuit-breaker operating mechanism operates by only replacing the opening and closing coils, operating mechanism motors and motor contactor coils.

g) Switchgear shall only be required to operate at one d.c. control voltage i.e. the closing and opening devices, operating mechanism motors and motor contactor coils to be supplied with the switchgear are required to be suitable for operation at either 110 V d.c. or 220 V d.c. as specified in Schedule A (Refer to **Table 13)**.

h) A readily available d.c. supply voltage "conversion kit" is required by Eskom Transmission from the Supplier in order to convert the circuit-breaker operating mechanism from 110 V to 220 V d.c. or vice versa. The conversion kit shall always be made available to Eskom Transmission to order upon emergencies and/or for spares. The Supplier shall keep the d.c. supply “conversion kits” in South Africa for the duration of the Eskom Transmission contract to ensure that they are readily available as and when required.

3.2.23 Time quantities for circuit-breakers

For time quantities, refer to Design and Construction on SANS 62271-100 clause 5.105, and its Figures 1, 2, 3, 4, 5, 6 and 7.,. The rated opening time, break-time, closing time, open-close time, reclosing time, close-open time and pre-insertion time (where applicable) of the circuit-breaker offered shall be stated in Schedule B.

NOTE The break-time determination shall be as per calculation method given in IEC TR 62271-306.

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3.2.24 Nameplates

a) The circuit-breaker nameplate shall contain the necessary information specified in SANS 62271-100 subclause 5.10 and the following:

- Eskom Transmission contract number and purchase order number
- Eskom Transmission GA drawing number and its applicable Eskom material (SAP) number
- Rated single-phase short-circuit breaking current - where applicable (refer to 3.1.9)
- Rated pressure gauge values (please indicate if Absolute or if Relative)
- Circuit-breaker classification (Class M/ C/ E/ S)
- Insulation creepage distance (creepage to ground, and where applicable, creepage across twin-interrupter unit)

b) The operating device nameplate shall contain the necessary information specified in SANS 62271-100 and the following:

- Trip-coil rated voltage, current, d.c. resistance (at 20 ^{0}C)
- Close-coil rated voltage, current, d.c. resistance (at 20 ^{0}C)
- Trip-coli resistance (ohmic value)
- Clos-coil resistance (ohmic value)
- Motor rated voltage and current (starting peak current and nominal running current)
- Operating device classification (Class M);
- Operating Mechanism Energy (kilo-Joules)

NOTE: These values shall be the nominal values (with tolerances) according to the routine test parameters.

c) Circuit-breakers tested in accordance with SANS 62271-302 for controlled switching should make specific reference to SANS 62271-302 on their nameplates. The nameplates of circuit-breakers intended for controlled closing should indicate the rated making window in accordance with SANS 62271-302.

d) The nameplates and their fixings shall be weather-proof and inherently corrosion-resistant. They shall be either engraved aluminium or stainless steel and are subject to approval by Eskom Transmission. All the letters and figures on the nameplates shall be permanently marked. The nameplates shall be securely fastened to the equipment in a reliable manner as in 3.2.12 g) (requirement for labels). The method used shall be stated in Schedule B. The nameplate material offered shall be stated in Schedule B.

e) Where applicable, duplicate nameplates of the CTs shall be attached to the inside of the operating mechanism enclosure front access door in order for them to be read from ground level. The details on the nameplates shall be in accordance with NRS 029.

f) The actual ratings to which the circuit-breaker has been type-tested (and not merely the values specified) shall be displayed.

3.2.25 Tools and spares

a) A full set of operating tools necessary to carry out all mechanical (manual) operations of the circuit-breaker shall be supplied with each circuit-breaker (e.g. racking handle, spring charging handle, etc.). A full list of operating tools shall be provided with the tender documentation (refer to 3.2.26.1). If additional sets of operating tools are required, this will be specified in Schedule A.

b) All operating tools shall be fitted on the inside of the front access door of the operating mechanism enclosure.

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c) A detailed list of standard tools required for minor maintenance shall be supplied with the tender documentation (refer to 3.2.26.1). Where applicable, the following tools are required for minor maintenance:

- slow operating device(s);
- hoses and fittings for draining and filling with SF6 gas or other insulation and/or arc-extinguishing medium; and
- other tools which may be required (e.g. contact alignment tools, insulation and/or arc-extinguishing medium density meter checking device).

d) Should the circuit-breaker require additional specialised tools for major maintenance purposes, a full list of specialised maintenance tools shall be provided with the tender documentation (refer to 3.2.26.1).

e) A full list of spares required for maintenance shall be provided with the tender documentation (refer to 3.2.26.1).

f) The Supplier shall provide the written letter with the tender documentation that states that in case of the design obsolescence, they shall notify Eskom Transmission and present all spares manufacturing drawings and specification (i.e. metal, Bill of material, masses) for the maintenance spares required for circuit-breaker life expectancy.

3.2.26 Documentation requirements

3.2.26.1 The documentation to be submitted with tender documentation

The Supplier shall provide the following documentation with the tender documentation:

a) completed technical schedule B for each circuit-breaker size. The technical Schedule B shall not be left blank. Where numerical values (e.g. rated values, dimensions, etc.) or specific information is required, the actual value/information offered shall be stated. In such cases, use of the words "COMPLY", "TBA", etc. is not acceptable;

b) a full set of general arrangement (GA) drawings showing the following minimum information:

i. manufacturer's drawing number and revision number. Provision shall be made on each sheet for an Eskom Transmission-allocated drawing number as well as for the Eskom Transmission contract number and material (SAP) number - for population after awarding of the contract;

ii. a descriptive title of the drawing (e.g. "400 kV 3150 A 1-pole Operated Circuit-breaker General Arrangement");

iii. critical dimensions such as overall dimensions, structure dimensions (mounting details), phase to phase spacing, phase to phase and phase to earth air clearances, working clearance, height of lowest part of insulation above ground, height of top of operating mechanism enclosure above ground (maximum 2,000 mm), height for personnel perform duties on ground level (indications, counter readings, manual operation), operating mechanism enclosure dimensions, overall height, width and depth of circuit-breaker, etc.;

iv. properly annotated drawing with a complete list of major components (bill of materials);

v. details of main terminals including dimensions of the fixing holes, terminal hole spacing, plate thickness and maximum permissible forces (loads) on main terminals (with directions) expressed in Newtons (N);

vi. details of the main earthing terminal and operating mechanism enclosure earthing terminal;

vii. mass of circuit-breaker in kilograms (kg), which shall include the empty mass, mass and description of heaviest component, total mass of circuit-breaker ready for service and mass of filling medium;

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viii. any special trenches or steelwork required between phases (showing interpole cabling requirement and depth in mm);

ix. the steel support structure dimensioned outline and general arrangement;

x. the steel support structure label mounting holes;

xi. in the case where the steel support structure is designed by the manufacturer, the steel support structure earthing terminal;

xii. the concrete foundation dimensioned outline, design detail and general arrangement;

xiii. mounting and fastening arrangement for the circuit-breaker support structure onto the foundation including the minimum required length and diameter of foundation holding down bolts as well as the relative position of levelling nuts, spacers, washers, etc. in relation to the base plate;

xiv. maximum torque required for the foundation holding down bolt nuts used to secure the support structure base plate (Nm);

xv. static and dynamic forces (loads), centre of gravity - refer to 3.2.26.1 0.

xvi. relative location of circuit-breaker poles, base frame, operating mechanism enclosure(s), grading capacitors (where applicable) and closing resistors (where applicable);

xvii. location of all enclosure doors and handles;

xviii. location and annotation of control facilities (gas filling/evacuation points, SF6 density monitoring device with its environmental protection shelter/cover, etc.);

xix. location and layout of LV control cable gland plates;

xx. insulation and/or arc-extinguishing medium pressure and quantity requirements; and

xxi. location of nameplate on circuit-breaker;

c) for all external insulation (i.e. post-insulators, circuit-breaker chamber insulators, bushings, etc.) and where applicable, grading capacitors - - each sheet with Eskom Transmission-allocated drawing number as well as for the Eskom Transmission contract number and material (SAP) number, detailed drawings showing the insulator material, shed profile dimensions including shed and insulation body/core diameters, shed spacing, creepage distance and dry arcing distances, etc.;

d) drawings showing the generic layout of all the nameplates (circuit-breaker, operating device(s), CTs) in accordance with 3.2.24. Provision shall be made for an Eskom Transmission-allocated drawing number as well as for the Eskom Transmission contract number - for population after awarding of the contract;

e) generic auxiliary and control circuit schematic wiring diagrams for the circuit-breaker. Provision shall be made on each sheet for an Eskom Transmission-allocated drawing number as well as for the Eskom Transmission contract number and material (SAP) number - for population after awarding of the contract.

i. Where applicable, clear indication on the wiring schematic drawings where the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) integrates;

ii. Where applicable, a complete set of as-to-be built drawings for the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device);

f) a general arrangement drawing of the operating mechanism enclosure. Provision shall be made on each sheet for an Eskom Transmission-allocated drawing number as well as for the Eskom Transmission contract number and material (SAP) number - for population after awarding of the contract;

g) drawing showing the cross section of general operating principle of the main contact system (breaking chamber) of the offered circuit-breaker. Provision shall be made on each sheet for an Eskom Transmission-allocated drawing number as well as for the Eskom Transmission contract number and material (SAP) number - for population after awarding of the contract;

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h) full list of spares required for maintenance (refer to 3.2.25 e) and section 3.5.1);

i) full list of operating tools (refer to 3.2.25 b));

j) detailed list of standard tools required for minor maintenance (refer to 3.2.25 c));

k) detailed list of additional specialised tools for major (specialised) maintenance (refer to 3.2.25 d));

l) full list summary of type-tests as well as copies of type test reports and/ or certificates (refer to 3.3.1.2);

m) generic routine test certificates for the circuit-breaker (refer to 3.3.1.2 b));

n) transport, storage, installation, operation and maintenance instruction manuals (refer to section 9);

o) training material (refer to section 3.7); and

p) generic quality inspection and test plan (QITP)

q) the submission, where applicable, of the following additional information:

i. premature failures experienced in service of similar design circuit-breakers supplied elsewhere by the manufacturer, together with the recommended modifications (refer to 3.2.2 g));

ii. where applicable, details of any special equipment required to view all circuit-breaker status indications and make necessary readings from the ground level (refer to 3.2.5 f) and 3.2.11);

iii. details of corrosion protection and lubricants offered (refer to 3.2.7 d));

iv. measures taken to prevent flange corrosion (refer to 3.2.7 e));

v. where applicable (i.e. dead-tank circuit-breakers), details of the internal faults (internal arc) behaviour of the circuit-breaker (refer to 3.2.9 d))

vi. details of the arrangements offered to maintain insulation and/or arc-extinguishing medium pressure in the system when the circuit-breaker or a pole (or the density monitoring device) is removed or replaced (refer to 3.2.13 h) bullet point 11);

vii. details of all insulation and/or arc-extinguishing medium pressure devices, including drawings, manufacturer's specifications, performance and test data, details of production tests and a quality control programme (refer to 3.2.13 h) bullet point 16);

viii. information on how to verify the condition of grading capacitors during circuit-breaker life (refer to 3.2.17);

ix. information required for electronic controller (controlled switching device/ Point-on-Wave (PoW) switching device) (refer to 3.2.20);

x. information about the timing events for PD timers (refer to 3.2.21);

xi. quality control plans and quality inspection test plan (QITP) indicating all inspection hold points (refer to 3.4.2 c));

xii. details of equipment requiring maintenance or attention during storage (refer to 3.4.5 0);

xiii. a written commitment from the Supplier regarding the submission of the maintenance digital Video record (portable format e.g. USB memory stick) (refer to 3.5.2); and

xiv. applicable to 132 kV circuit-breakers, all required OEM documentation of the mitigation of switching transients for their circuit-breaker design to cope within Eskom Transmission (refer to 3.1.2, 3.1.5, 3.1.7, 3.1.13 and Annex F)

xv. spares availability philosophy (refer to 3.5.3.2).

3.2.26.2 The documentation to be delivered with each circuit-breaker

Unless otherwise specified in Schedule A, the manufacturer shall submit the following documentation with each circuit-breaker delivered to Eskom Transmission:

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a) an auxiliary and control circuit schematic wiring diagram of the circuit-breaker. Where applicable, A complete set of as-built drawings for the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) is to be submitted.

b) a complete set of routine test certificates;

c) a commissioning and hand-over test sheet; and

d) one set of transport, storage, installation, operation and maintenance instruction manuals.

NOTE: In addition to the documents supplied with the circuit-breaker, all documents shall be made available in electronic format for publication on the Eskom Transmission internal equipment database.

3.2.26.3 Storage of supplied documents

The above documents supplied with the circuit-breaker shall be stored in the documentation pocket on the inside of the circuit-breaker operating mechanism enclosure front access door.

NOTE: In addition to the documents supplied with the circuit-breaker, all documents shall be made available in electronic format for publication on the Eskom Transmission internal equipment database.

3.2.26.4 Documents to be supplied upon awarding or contract

The Supplier shall submit the following documentation to the contract manager and relevant Eskom Transmission switchgear equipment specialist upon awarding of a contract:

a) circuit-breaker analyser data required for condition monitoring (refer to 3.5.5);

b) detailed scope of works (job plan) for each type of prescribed maintenance intervention;

c) detailed work instructions (task manual) for each type of prescribed maintenance intervention; and

d) detailed works reports (check sheet) for each type of prescribed maintenance intervention.

e) quality inspection and test plan (QITP) in accordance with Eskom Transmission quality requirements documentation.

f) for guide for the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device), a complete set of drawings, commissioning guide, settings guide, application guide, training material, test procedure document to be used during FAT (including factory routine testing) and its maintenance documentation.

3.2.27 Packaging and preservation requirements

a) The OEM will be required to demonstrate if there are different packaging currently implemented for existing customers and Eskom Transmission requirements. Each circuit-breaker shall be “unit-packed” (one unit per package). In other words, the components making up a complete circuit-breaker shall be delivered to site in one or more packing containers which shall contain only the component for one complete individual circuit-breaker.

NOTE: Eskom Transmission will not accept equipment if the various components of the different circuit-breakers are delivered in the same packing containers.

b) All circuit-breaker components shall be packed in containers (e.g. wooden crates) that are suitable for transport and storage over long periods (for up to 18 months). Refer to Eskom Transmission Quality documentation and subclause f) below on how to handle preservation.

c) Durable waterproof packaging shall prevent damage to the circuit-breaker components during transportation and storage on site and shall be such that suitable ventilation is allowed in order to minimise condensation.

d) The packaging shall be able to withstand impact loadings of at least 18 kN. The mechanical strength of the packaging shall not be dependent on the strength of the top cover, i.e. it shall be possible to remove and subsequently replace the top cover without losing any mechanical strength of the packaging.

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e) Where more than one crate is used per circuit-breaker, each crate shall be clearly and sequentially marked in order to identify each crate as belonging to a specific circuit-breaker (e.g. “CRATE 1 of 3”, “CRATE 2 of 3”, etc.).

f) Eskom Transmission will review the markings that are currently being implemented on the packaging for safe handling of the product. Preservation markings, instructions will be required on the packaging and the necessary provisions provided for storage conditions. Each container/crate shall be clearly marked with a durable label using an indelible font at least 30 mm high indicating the following information:

- Eskom Transmission order number;
- Eskom Transmission SAP number;
- short circuit-breaker description (including the rated voltage, normal current, rated short-circuit breaking current, auxiliary d.c. control voltage; specific creepage; “1P” or “3P”) ;
- manufacturer’s name (i.e. make of circuit-breaker);
- manufacturer’s circuit-breaker product designation/code (i.e. type of circuit-breaker);
- manufacturer’s serial number(s);
- contents of the crate (i.e. a parts list);
- the crate number (e.g. “CRATE 1 of 2”, “CRATE 2 of 2”);
- the crate overall dimensions (in mm); and
- total mass of each crate (e.g. “TOTAL MASS: 1000 KG”);
- pictograms / symbols showing correct storage and stacking instructions for crates

g) Exposed shafts, bearings and machined surfaces shall be treated with a temporary anti-corrosive coating.

h) Loose components or components that are subject to damage from exposure to dust or water shall be packed in hermetically sealed plastic bags.

i) All components shall be clearly marked. Components that are physically impossible to mark shall be individually packed and the packaging shall be marked.

j) Fork-lift lifting points shall be provided on the packaging, where applicable. These points shall be braced as though it were a lifting pallet (for mechanical support during lifting activities).

k) A readily accessible (i.e. without the need to remove / disturb the external packaging) external temporary 230 V a.c. supply connection point for the heater circuit during storage shall be provided and wired to the Eskom Transmission side of the terminal strip in the factory. This shall consist of an electrical cord wired to a screw-type connection block for the connection of the temporary a.c. supply used during storage. Heater connections shall be designed in such a manner so as not to cause a hazardous situation when energised. No internal wiring should need be modified to remove the temporary supply leads. The connection point shall be labelled “230 V AC HEATER CONNECTION: CONNECT IF STORED > 2 DAYS” or similar.

l) A non-resettable impact recorder/ detector shall be provided and located in such a position so as to record/detect the acceleration of the circuit-breaker body and not the packaging.

m) Where applicable, the circuit-breaker shall be transported with a positive gas pressure of maximum 150 kPa.

n) A copy of the BOM shall be provided with the delivery note for each circuit-breaker supplied in order to allow the recipient to confirm that all items on the BOM have been delivered, and for record purposes.

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3.3 Tests

3.3.1 General

a) Manufacturer's testing capabilities

The manufacturer shall be fully responsible for performing or having performed all the required tests as specified. Suppliers shall confirm the manufacturer's capabilities in this regard when submitting tender documentation. Any limitations shall be clearly stated. The Supplier shall be responsible for all costs related to testing.

3.3.1.1 Witnessing of tests

Eskom Transmission reserves the right to be present at the OEM factory manufacturing and testing facilities for any of the tests specified for the circuit-breakers, this includes the FAT witnessing of the first circuit-breaker manufactured according to the Eskom Transmission standard specification. The Supplier shall ascertain the sequence of tests required in each particular case and whether witnessing of tests is required, and, after completion of all preliminary tests, shall then give Eskom Transmission sufficient, agreed upon, advanced notice of the firm date when the circuit-breaker and associated apparatus will be ready for the witnessing of testing. The electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) shall form part of the testing.

NOTE: Where applicable, the minimum required notification period for overseas travel from South Africa is 12 weeks.

Eskom Transmission shall be notified as soon as possible of all test failures and corrective measures. This shall take the form of abbreviated reports that shall, upon request, be supported by more detailed reports. It is desirable that Eskom Transmission is notified of test failures to allow in situ inspection if desired.

3.3.1.2 Test certificates and reports

a) Type test reports and/or certificates together with each complete summary of type test (in English) shall be supplied with the tender documentation (refer to 3.2.26.1). The type test reports and/or certificates and the summary of type tests shall be in both printed copy and in electronic Portable Document Format (PDF). The type test reports shall be in electronic Portable Document Format (PDF).

i. The type test certificate which is the proof of official accreditation shall have the official signatures of the accredited test laboratory where the type-tests were performed which is responsible for its validity and contents. The type test certificate shall contain a record of series of type-tests carried out strictly in accordance with the IEC standard. It shall contain essential drawings and the equipment tested.

ii. Where the Supplier and OEM are using the type test certificate and type test report beyond that particular equipment that was type tested, to indicate that the other equipment types with their different ratings are covered by the type test certificate and type test report, a separate official signed off letter on the company's letterhead shall be supplied by the Supplier with the tender documentation. This letter shall clearly state all particular tests and the tested parameters that are extrapolated form the type test certificate and type test report.

iii. The summary list of type-tests indicating the following:-

- The type test performed,
- The IEC standard it was type tested on,
- The type test report document number;
- The date of type test performed
- The Test Facility where the type test was performed, the Test facility accreditation authority.

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b) Generic routine test certificates/reports shall be supplied with the tender documentation (refer to 3.2.26.1) in electronic format (pdf). The test certificate shall indicate (make provision for) the tests performed, results, identification of the equipment tested, etc. The format of the test certificate/report shall make provision for approval by an authorised Eskom Transmission representative.

c) One hardcopy of the routine test certificates/reports shall be supplied with each circuit-breaker and stored in the documentation pocket inside the operating mechanism enclosure. In addition to the hardcopy, the routine test certificates/reports shall be made available in electronic format and submitted to Eskom Transmission.

3.3.2 Type and routine test requirements

a) The manufacturer shall perform a complete set of type tests for each circuit-breaker design offered. It shall be noted that as a minimum the circuit-breaker offered shall have passed the list of type tests in accordance with SANS 62271-100 that are marked under Table 11 as Mandatory type tests, without which the offered circuit-breaker shall not be taken to further consideration by Eskom Transmission. The type test certificates and reports shall be submitted for review during the tender or product evaluation stage. The type test reports shall be according to SANS 62271-100. All type test done on IEC60056 shall not be accepted. If any type testing is carried out during awarded contract period, Eskom Transmission shall be invited as a witness.

NOTE: If, in the opinion of Eskom Transmission, repeat or new type-tests are necessary, the cost of these tests will be taken into account in the evaluation of tenders. In such a case, Eskom Transmission may request the supplier to submit details of the cost of carrying out each applicable type test.

b) The circuit-breaker shall be type tested in accordance with SANS 62271-100 and shall include the following tests:

- equipment insulation level (SANS 62271-100 subclause 6.2); dry lightning impulse withstand voltage test (BIL or LIWL) (SANS 62271-100 subclauses 6.2.6.2 and 6.2.7.3), (for bushings on the dead-tank circuit-breaker - SANS 60137 subclause 8.3);
- Dry power frequency withstand level voltage tests (PFWL) (SANS 62271-100 subclause 6.2.6.1 and 6.2.7.2), (for bushings on the dead-tank circuit-breaker - SANS 60137 8; 9.3 & 8.1);
- Wet power frequency voltage withstand level (PFWL) test (SANS 62271-100 subclause 6.2.2), (for all bushing < 300kV (for bushings on the dead-tank circuit-breaker) - SANS 60137 subclauses 8; 9.3 & 8.1);
- dry switching impulse withstand level voltage test (SIWL) (SANS 62271-100 subclause 6.2.7.2), (for bushings rated for U_r ≥ 300kV (for dead-tank circuit-breaker) - SANS 60137 subclause 8.4);
- wet switching impulse withstand test (SIL) (SANS 62271-100 subclause 6.2.2), for bushings rated for U_r ≥ 300kV (SANS 60137 subclause 8.4) (for dead-tank circuit-breaker);
- temperature rise and measurement of resistance of circuits (SANS 62271-100 subclauses 6.5 and 6.4); temperature rise test (for bushings on the dead-tank circuit-breaker) (SANS 60137 subclause 8.7);
- current withstand - main circuit (SANS 62271-100 subclause 6.6);
- circuit-breaker short-circuit making and breaking capacities (SANS 62271-100 subclauses 6.102 to 6.106); verification of thermal short-time withstand current (for bushings on the dead-tank circuit-breaker) (SANS 60137 subclause 8.8);
- critical current tests (where applicable) (SANS 62271-100 subclause 6.107);
- single-phase tests (for Un >_ 66 kV) (SANS 62271-100 subclause 6.108);
- double earth fault tests (for Un ? 132 kV) (SANS 62271-100 subclause 6.108);

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- short-line fault tests (for class S2 circuit-breakers and Un >_ 66 kV) (SANS 62271-100 subclause 6.109);
- out-of-phase making and breaking tests (applicable if an out-of-phase rating is assigned) (SANS 62271-100 subclause 6.110);
- capacitive current switching tests (SANS 62271-100 subclause 6.111);
- switching of shunt reactors (for Un >_ 66 kV) (SANS 62271-110);
- electrical endurance tests (for class E2 circuit-breakers) (SANS 62271-100 subclause 6.112);
- circuit-breaker mechanical operation (SANS 62271-100 subclauses 6.101.2.1 - 6.101.2.3);
- circuit-breaker extended mechanical endurance tests (for class M2 circuit-breakers) (SANS 62271-100 subclause 6.101.2.4);
- radio interference voltage tests (for Un >_ 132 kV) (SANS 62271-100 subclause 6.3);
- verification of the protection (IP coding) (SANS 62271-100 subclause 6.7) and, in the case of dead-tank circuit-breakers, verification of the protection (IP coding and mechanical impact test) (SANS 62271-203 subclause 6.7);
- tightness test (SANS 62271-100 subclause 6.8); (for dead-tank circuit-breakers) SANS 62271-203 subclause 6.8;
- EMC tests (SANS 62271-100 subclause 6.9) - where applicable; (SANS 60137 subclause 8.6) (for bushings on the dead-tank circuit-breaker);
- X-radiation test procedures for vacuum interrupters (SANS 62271-100 subclause 6.11);
- static terminal load tests (for Un >_ 66 kV) (SANS 62271-100 subclause 5.106);
- cantilever load withstand test (SANS60137 subclause 8.9) (for bushings on dead-tank circuit-breakers);
- additional tests on auxiliary and control circuits (SANS 62271-100 subclause 6.10);
- proof tests for enclosures (compartment/ metallic tank) (for dead-tank circuit-breakers) (SANS 62271-203 subclause 6.103);
- internal pressure test on gas-filled, gas-insulated and gas-impregnated bushings (SANS 60137 subclause 8.11) (for dead-tank circuit-breaker);
- test under conditions of arcing due to an internal fault (for dead-tank circuit-breakers) (SANS 62271-203 subclause 6.105);
- insulator tests (for dead-tank circuit-breakers) (SANS 62271-203 subclause 6.106); and
- corrosion test on earthing connections (for dead-tank circuit-breakers) (SANS 62271-203 subclause 6.107).
- all type-tests applicable to CT's (for dead-tank circuit-breaker);

c) Time-current curves of the electrical tripping and closing circuits shall be provided, both for normal operation, and in the event that the tripping/closing plunger is prevented from moving. The resolution of the function times shall be clearly indicated in the test reports.

d) The circuit-breaker shall be routine tested in accordance with SANS 62271-100 and shall include the following tests:

- dielectric test on the main circuit (SANS 62271-100 subclause 7.1);
- partial discharge measurement (SANS 62271-100 subclause 7.1.101) (SANS 60137 subclauses 8 & 9.4) (for dead-tank circuit-breaker);

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- dry power frequency withstand voltage tests for bushings (SANS 60137 subclauses 8 & 9.3) (for dead-tank circuit-breaker);
- measurement of dielectric dissipation factor (tan δ) and capacitance at ambient temperature (SANS 60137 subclauses 8 & 9.1) (for dead-tank circuit-breaker);
- tests on auxiliary and control circuits (SANS 62271-100 subclause 7.2);

NOTE: In the case of switchgear supplied from an overseas OEM where the wiring of auxiliary and control circuits is done locally, the tests on auxiliary and control circuits are to be done locally as part of the local factory acceptance testing (refer to 7.1).

- measurement of the resistance of the main circuit (SANS 62271-100 subclause 7.3);
- tightness test (SANS 62271-100 subclause 7.4 / SANS 62271-203 subclause 7.4 (for dead-tank circuit-breakers)); (SANS 60137 subclause 9.8) (for bushings of the dead-tank circuit-breaker);
- design and visual checks (SANS 62271-100 subclause 7.5 / SANS 62271-203 (for dead-tank circuit-breakers) / SANS 60137 (for bushings on dead-tank circuit-breakers));
- pressure tests of enclosures (for dead-tank circuit-breakers) (SANS 62271-203 subclause 7.101); and
- Internal pressure test on gas-filled, gas-insulated and gas-impregnated bushings (SANS 60137 subclause 9.6) (for dead-tank circuit-breaker);
- mechanical operating tests on circuit-breaker (SANS 62271-100 subclause 7.101).
- all factory routine tests applicable to CT's (for dead-tank circuit-breaker);
- all factory routine tests applicable to CT's (for live-tank circuit-breaker combined with CT's (also known as COMBO design);

e) The following characteristics, in addition to those specified in SANS 62271-100, shall be measured and recorded during the mechanical operating tests:

- closing and opening speeds;
- timing tests on each type of auxiliary switch contact in relation to the main contacts (including relative timing between main and auxiliary contacts ("a" contact and "b" contact) of single-pole operated circuit-breakers when operated simultaneously);
- where applicable, settings of pressure switches / gas density monitoring devices; and
- time-current curves of the electrical tripping and closing circuits for normal operation. The resolution of the function times shall clearly be indicated on the test reports.

f) Where applicable, circuit-breakers intended for operation with intentionally non-simultaneous poles shall be tested in accordance with SANS 62271-302 (performance verification tests and parameter definition tests for controlled switching applications).

g) Insulators of the offered switchgear equipment shall meet Eskom Transmission requirements (refer to 3.2.9 a) i. and ii, and **Table 7**.

h) Where applicable, CTs shall be tested in accordance with IEC 6189, as applicable.

i) Insulators of the ceramic type shall be tested in accordance with SANS 62155 and SANS 60815-2. Insulators of the offered switchgear equipment shall meet Eskom Transmission requirements (refer to **3.2.10** a)

j) Insulators of the silicone rubber composite type shall be tested in accordance with SANS 61462 and SANS 60815-3. Insulators of the offered switchgear equipment shall meet Eskom Transmission requirements (refer to **3.2.10** a)

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3.3.3 Tests after installation on site (pre-commissioning tests)

a) Commissioning checks and a test programme (as determined by the manufacturer) shall be carried out in accordance with SANS 62271-100 subclauses 10.2.101 and 10.2.102 for all circuit-breakers. The test programme shall be incorporated into the circuit-breaker inspection and test plan. This shall include checks after installation, mechanical tests and measurements, checks of certain specific operations and electrical tests and measurements.

b) Electrical tests shall include, but are not limited to, the following:

- measurement of the steady-state contact resistance of the main circuit; and
- measurement of the dynamic contact resistance of the main circuit.

c) The measurement of the time quantities shall be done at nominal and minimum coil control voltage.

Measured time quantities (timing tests) shall include both the main contact times and the auxiliary contacts (“a” contact and “b” contact). The test report shall show clearly the operating times and duration of the main contact and its auxiliary contact switch (“a” contact and “b” contact) in relative to the main contacts, including relative timing between main and auxiliary contacts of single-pole operated circuit-breakers when operated simultaneously;

NOTE: The measured times for nominal and minimum coil control voltage should be within ± 5 % of the times, as specified on the circuit-breaker pass sheet supplied by the OEM.

d) For each measurement of the operating time, a recording shall be made of each individual operating coil current - namely close, trip I and trip II. The resolution of the function times shall be clearly indicated in the test reports.

e) During the measurement of the re-charging time of the closing spring, the peak motor current in the spring charging process shall be measured as well as the continuous motor current. Measurements shall be made both at the nominal and minimum control voltage.

NOTE: The results should be within ± 2 % of the circuit-breaker pass sheet results supplied by the OEM.

f) For the recording of the mechanical travel characteristics, travel curves for each phase shall be recorded. The location of the travel transducers on the circuit-breakers shall be clearly indicated in the test report. The following measuring results shall be provided:

- the total travel (in mm)
- the over-travel (in mm)
- the rebound (in mm)
- the under-travel (in mm)
- the contact penetration (in mm)
- moving-contact or operating rod position at the time of make or break
- anomalies which are evident from the trace
- the average speed on closing (in m/s)
- the average speed on opening (in m/s)
- “a” contact and “b” contact

g) For the measurement of the steady-state contact resistance of the main circuit, a d.c. current of at least 100 A shall be used. The dynamic contact resistance shall be measured during a close and open operation of the circuit-breaker. This shall be done for each main contact separately. A detailed diagram of the measurement set-up shall be given (sketched) in the pre-commissioning test report. If any difficulties have occurred during erection or commissioning, this shall be clearly stated in the pre-commissioning test report. The results shall be given in pQ and the resolution shall be at least 1 pQ.

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h) Reasons for differences between the results of the tests made on-site and the results of the tests as they were carried out at the OEM's works (the circuit-breaker pass sheet) shall be clearly stated and corrections shall be made.

i) Where applicable, circuit-breakers intended for operation with intentionally non-simultaneous poles shall be tested in accordance with SANS 62271-302 subclause 10.101 (commissioning of circuit-breakers for controlled switching applications)

j) The results of pre-commissioning tests after installation on site shall be documented, signed off and a copy of the results included with the switchgear documentation for hand-over as part of the quality process. All tests may be witnessed by Eskom Transmission. Refer to 3.4.7.2 for further information on the pre-commissioning test report.

3.4 Design reviews, Manufacturing, Transport, Storage, Installation, pre-Commissioning and After-sales Technical Support

a) Eskom Transmission reserves the right to perform Design Reviews inspect assessment with the potential Supplier that Eskom Transmission selects on the procurement process, before start of manufacturing and testing of the Eskom Transmission specified circuit-breaker.

NOTE: Where applicable, the minimum required notification period for overseas travel from South Africa is 12 weeks, preferably few days after the Supplier has been selected by Eskom Transmission.

b) The Design Reviews shall be performed by Eskom Transmission with the Supplier and at the OEM manufacturing and testing facilities relating to the circuit-breaker type design offered. Amongst other points of reviewing the offered design, it shall entail a thorough confirmation to ensure complete compliance with this Eskom Transmission standard specification and Technical Schedules A & B, and the approved manufacturer's drawings with the Eskom Transmission standard interface drawings.

c) Eskom Transmission reserves the right to inspect any ordered circuit-breaker before shipment, or at any stage of manufacture and testing. This inspection, including Factory Acceptance Testing of the first of manufactured Eskom Transmission circuit-breaker, shall entail inspection checks to ensure complete compliance with this Eskom Transmission standard specification and Technical Schedules A & B, and the approved manufacturer's drawings with the Eskom Transmission standard interface drawings.

3.4.1 General

The manufacturing, transport, storage, installation and pre-commissioning of switchgear and controlgear, as well as their operation and maintenance in service, shall be carried out in accordance with the instructions given by the OEM.

The Supplier shall provide instructions for the transport, storage, installation, operation and maintenance of the equipment according to the requirements set out by the OEM (refer to 3.2.26.1).

3.4.2 Inspection of manufacturing facilities and circuit-breakers

a) Eskom Transmission reserves the right to perform design review inspect assessment at the OEM manufacturing and testing facilities relating to the circuit-breaker type design offered - both before and at any time during manufacturing and testing.

b) Eskom Transmission reserves the right to inspect any ordered circuit-breaker before shipment, or at any stage of manufacture and testing. This inspection, including Factory Acceptance Testing of the first of manufactured Eskom Transmission circuit-breaker, shall entail a thorough check to ensure complete compliance with this Eskom Transmission standard specification and Technical Schedules A & B, and the approved manufacturer's drawings with the Eskom Transmission standard interface drawings.

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c) With the tender documentation (refer to 3.2.26.1), the Supplier shall submit the quality control plans and quality plans and quality inspection test plan (QITP) to Eskom Transmission, indicating all inspection hold points. Eskom Transmission may add the necessary inspection hold and/or witness points for Eskom Transmission or its appointed representative. The supplier shall make due allowance for these activities in the manufacturing programme and, to avoid delays, shall give sufficient, agreed upon, advanced notice of the date of inspection. Eskom Transmission will not accept late delivery on the basis of inspection delays.

NOTE: Where applicable, the minimum required notification period for overseas travel from South Africa is 12 weeks.

d) Any deviations in the circuit-breaker design shall be pointed out in accordance with the tendered deviation schedule and the type test certificates provided for the specific unit design. No clearance will be given where there is no satisfactory evidence of the relevant type test certificates, where such tests are required.

e) Clearance shall be obtained before dispatching the equipment. This clearance shall be confirmed on the routine test certificates. No clearance shall be given where there are any outstanding defects resulting from Factory Acceptance Testing (FAT) or from this inspection.

3.4.3 Conditions during transportation

For the requirements on transportation, handling, storage and preservation the Supplier shall refer to Refer to the Eskom Transmission standard (240-53902499).

a) Conditions can be expected to be onerous during transport, storage and installation. Adequate precautionary measures shall be provided for the packaging and protection of sensitive components such as insulating parts and operating mechanisms during transport, storage and installation (including corrosion of exposed parts).

b) Vibrations and impacts during transport shall also be mounted. Refer to 3.2.27 l) for the requirements for non-resettable impact recorders.

c) The supplier shall demonstrate - either by testing or through previous satisfactory experience - that the equipment complies in this respect. Testing may include the following:

- shipping test: this test shall cover all the conditions to be encountered during transportation from factory to the designated site, including loading/off-loading from one mode of transport to another;
- vibration test: this test may be used to supplement actual shipping tests to check for unexpected shortcomings in the equipment and packaging; and
- weather-proof test: this test may demonstrate the adequacy of the packaging to prevent ingress of moisture and water from weather or sea conditions.

d) If the design of the equipment is mature, and the equipment has previously been shipped under similar conditions, the above tests may be waived at Eskom Transmission's discretion.

3.4.4 Transportation and off-loading

For the requirements on transportation, handling, storage and preservation the Supplier shall refer to Refer to the Eskom Transmission standard (240-53902499).

a) Refer to 3.2.26.4 for the requirements for packaging for transportation and storage.

b) The Supplier shall be responsible for the transportation and off-loading of the equipment on site. Off-loading includes transportation from the point of off-loading the equipment after transportation to the point of installation.

c) The Supplier shall provide his own means of off-loading at the point of installation.

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3.4.5 Storage and preservation

For the requirements on transportation, handling, storage and preservation the Supplier shall refer to refer to the Eskom Transmission standard (240-53902499) and the Quality requirements documentation.

a) If any equipment requires maintenance or attention during storage, this shall be clearly stated in the contract and Eskom Transmission's attention shall be drawn to this fact. This information shall be submitted with the tender documentation (refer to 3.2.26.1) as well as with orders upon awarding of a contract.

b) At the time of off-loading at an Eskom Transmission facility, the Supplier has the responsibility to ensure that the necessary steps are taken by Eskom Transmission to ensure satisfactory storage.

c) Where heaters need to be energised, a clearly marked electrical connection point (refer to 3.2.27 k)) shall be provided to enable Eskom Transmission to supply power to the heaters.

d) The Supplier shall implement proper storage and handling (de-stuffing) procedures, which should always be part of site delivery documentation. A copy of the storage and handling procedures shall be made available to Eskom Transmission for acceptance (refer to 3.2.26.1). This shall indicate the maximum recommended period of storage, as well as recommended actions to be taken if a longer storage period (preservation) is required.

e) The Supplier shall provide the storage and preservation protocol from the OEM at tendering stage for Eskom Transmission evaluation, namely site requirements, spares requirement and stores facility requirement.

3.4.6 Installation

a) Unless otherwise specified and agreed (e.g. where OEM certified training and/or supervision is provided), the Supplier shall be responsible for the installation and pre-commissioning of the equipment. This includes the supply of all installation tools, lifting tackle and test equipment.

NOTE: for voltages up to 400 kV (also 550 kV rating), Eskom Transmission shall provide the standard steel support structures under a separate internal contract/order (unless otherwise specified). The details of the Eskom Transmission standard steel support structures shall be shared with the successful Supplier, to confirm this will be adequate for their equipment design snd ensure that their equipment interfacing connection points fit, and in case of modifications needed then the Supplier and OEM factory makes provision for the recommended adaptors on their scope of supply.

b) Installation includes mounting and securing the equipment and its support structure onto the concrete support foundation, leveling of the switchgear, filling of gas (other insulation and/or arc-extinguishing medium), where applicable.

c) For each type of circuit-breaker, the installation instructions provided by the supplier (refer to 3.2.26.1) according to the OEM's instructions shall at least include the items listed below:

- unpacking and lifting instructions: all information required for unpacking and lifting safely shall be given, including details of any special lifting and positioning devices that are necessary;
- assembly: when the switchgear is not fully assembled for transport, all transport units shall be clearly marked. Drawings showing the assembly of these parts shall be provided with the switchgear;
- mounting: instructions for mounting the common base frame, poles, operating device(s) and auxiliary equipment shall include sufficient details to enable site preparation to be completed. These instructions shall also indicate:
  - i. the total mass of the equipment, inclusive of insulation and/or arc-extinguishing medium;
  - ii. the mass of insulation and/or arc-extinguishing medium; and
  - iii. the mass of the heaviest part of the apparatus to be lifted separately if it exceeds 100 kg;

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- qualification of personnel: all personnel employed by the Supplier who are involved in the installation and pre-commissioning of the circuit-breaker shall be trained and accredited by the OEM. Proof of this accreditation shall be included in the quality control plan and shall be submitted to Eskom Transmission for approval prior to installation and pre-commissioning of equipment by the individuals concerned; and
- final installation inspection and testing: instructions shall be provided for inspection and testing after the switchgear and controlgear has been installed and all the interfacing connections have been completed. These instructions shall include the following:
  - i. procedures for carrying out any adjustment that may be necessary to achieve correct operation;
  - ii. recommendations for any relevant measurements that should be made and recorded to help with future maintenance decisions; and
  - iii. instructions for final inspection and testing.

d) The Supplier shall be responsible for ensuring the training and accreditation of persons employed for the installation and pre-commissioning of switchgear.

e) During the performance of the work at the substation site, the Supplier shall comply with all the relevant statutes, regulations, bylaws and codes, as well as all the safety and quality requirements pertaining to the work. The Supplier shall provide all apparatus including safeguards and personal protective equipment (PPE), including a Fall Arrest System (FAS), necessary for the performance of the work.

f) Installation tools / equipment and debris shall be removed from site when installation is completed.

g) Where a.c. power supplies cannot be made available to the Supplier for installation and pre commissioning purposes, the Supplier shall be responsible for providing his own a.c. power supply (e.g. generator) for the installation and pre-commissioning of switchgear.

3.4.7 Pre-commissioning

3.4.7.1 Testing of each circuit-breaker after installation

Each circuit-breaker shall be tested after installation in accordance with 3.3.3. This is to assure proper installation and that no damage occurred during transportation. The pre-commissioning tests shall be witnessed by an appointed Eskom Transmission switchgear official or representative. To facilitate the testing, adequate d.c. power supplies, test equipment and suitably qualified and accredited personnel shall be provided by the Supplier.

NOTES

a) For reasons of compatibility with Eskom Transmission's on-site test equipment, one of the following types of equipment shall be used to measure/record the time quantities and travel characteristics:

- Elcon - SA10 Instrument, Sweden
- Programma Elektrik AB - TM 1600 or TM 1800 Instrument, Sweden.

b) The software used shall be compatible with any one of the above instruments, and will be specified when ordering the circuit-breaker. The choice may depend on where the circuit-breaker will be used.

3.4.7.2 Pre-commissioning test report

The circuit-breaker pre-commissioning test report shall be submitted to Eskom Transmission, comprising the following parts:

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3.4.7.2.1 Required measurements records

a) after the measurements at the substation site, a hand-written pre-commissioning test report shall be handed over to the appointed Eskom Transmission switchgear official or representative. Any special note that is on the OEM operation and maintenance instruction manual and/or test protocol shall be incorporated by the Supplier on this report, e.g. “Activate anti-condensation heaters”;

b) within 3 weeks after the pre-commissioning tests, the Supplier shall submit an official report to Eskom Transmission (two hardcopies); and

c) an electronic copy of the official report shall be provided on a CD for each individual circuit-breaker. The software used shall be compatible with one of the types of test equipment mentioned above. Reports shall be in .pdf or Microsoft Word (.doc) format.

3.4.7.2.2 Measured values

All the measured values shall be clearly stated in the report as well as the following:

a) test/measuring equipment information/data:

- make and type of instruments;
- serial numbers of instruments;
- methods of triggering;
- measuring methods;
- the accuracy of the instruments; and
- calibration certificates of the measuring instruments used;

b) the circuit-breaker data:

- make and type;
- serial numbers of poles and operating mechanisms;
- rated voltage, normal current and short-circuit breaking current;
- the name of the substation and section;
- circuit-breaker identification and application;
- date of commissioning; and
- date and time of testing/measuring.

3.4.7.2.3 Clear copies attached to the official report

Clear copies of the complete printouts of the timing, travel characteristics and dynamic main contact resistance measurements shall be attached to the official report. The names of all parties concerned shall be clearly stated in the report. If the measured values differ from the values as they were measured at the manufacturer's works, an interpretation shall be given and, if Eskom Transmission deems it necessary, the deviation shall be corrected by the Supplier. If the circuit-breaker is found to be faulty during the tests, a fault report shall be completed in addition to the pre-commissioning test report.

3.4.7.3 The switchgear and controlgear shall be subject to a final inspection by Eskom Transmission

The switchgear and controlgear shall be subject to a final inspection by Eskom Transmission after pre-commissioning in accordance with the approved quality control plan.

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3.4.7.4 Final inspection to hand-over

After the final inspection, the final commissioning of the plant is performed and the hand-over documents shall be provided to Eskom Transmission by the Supplier.

3.4.8 Safety related data (where applicable)

All liquids or chemicals used during installation shall be supplied with Material Safety Data Sheets (MSDS).

3.4.9 Requirements for pressure vessels (where applicable)

Circuit-breakers, which are subject to the provisions of the Occupational Health and Safety Act regarding pressure vessels, shall be provided with certificates for the associated pressure vessels. These certificates shall be issued by an independent inspection authority approved by Eskom Transmission. The costs of such an inspection authority appointment shall be borne by the Supplier. The Supplier shall supply to the appointed inspection authority calculation sheets, design drawings and welding procedures of all pressure vessels for approval before manufacture commences. In addition, copies of sub-orders for bought-out vessels or works orders (if manufactured internally) shall be supplied to the appointed authority. Sufficient proof shall be provided that all welders employed in the fabrication of pressure vessels are adequately qualified and that their qualifications are valid.

3.4.10 After sales technical support

The Supplier shall provide locally based technical switchgear specialist support on a full time basis for the duration of the contract, of both the circuit breaker, and where applicable, its electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device). The Supplier shall provide details at tendering stage and upon contract awarding. If the Supplier fails to provide the technical switchgear specialist support during the life of the awarded contract, Eskom Transmission shall raise non-conformities and also escalate the lack of addressing this to contract management to resolve.

3.5 Inspection and maintenance

3.5.1 General

The effectiveness of maintenance depends mainly on the way instructions are prepared by the OEM and implemented by Eskom Transmission. The Supplier shall supply maintenance information in the form of OEM operation and maintenance instruction manuals, OEM test plan/ speed calculation datum points (for closing and opening circuit-breaker operation) field service bulletins and digital Video record (portable format e.g. USB memory stick) material covering the following aspects:

a) Extent and frequency of maintenance:

For this purpose, the following factors shall be considered:

i. switching operations (accumulated switching amperage);

ii. total number of operations (a graph showing the maximum number of guaranteed operations as a function of short-circuit breaking current shall be provided as well as the maintenance and time required to restore the circuit-breaker once the accumulated switching amperage limit has been reached);

iii. environmental conditions;

iv. measurement and diagnostic tests for condition monitoring ; and

v. full maintenance analysis FMECA as per details below:-

- The Supplier with their OEM factory shall prepare the FMECA datasheets for the offered circuit-breaker type design and this shall be submitted with the tender documentation. This FMECA shall provide the details of the maintenance analysis to indicate the reasoning as to the identified maintenance activities and logistics requirements.

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b) Scope of work to be performed:

It shall include the following:

i. recommended place for the maintenance work (indoor, outdoor, in factory, on-site, etc.);

ii. procedures for inspection, diagnostic tests, examination overhaul;

iii. reference to drawings;

iv. reference to part numbers or standard kit of parts;

v. tools required, including special equipment or tools;

vi. precautions to be observed (e.g. cleanliness and possible effects of harmful arcing by-products);

vii. lubrication procedures; and

viii. cleaning materials.

c) Graphical information:

Detailed drawings and sketches of the circuit-breaker components, with clear identification (part number and description) of assemblies, sub-assemblies and essential components. Expanded detail drawings, which indicate the relative position of components in assemblies and subassemblies, are expected as a preferred illustration method. Graphs and similar means of portraying important information shall also be included.

d) Specified operational values:

Values and tolerances pertaining to which, when exceeded, make corrective action necessary, for example:

i. pressure levels (where applicable);

ii. operating times and contact velocities;

iii. resistance of the main current carrying circuits;

iv. insulation and/or arc-extinguishing medium characteristics (e.g. the SF6 purity, dew point, acidity, etc.);

v. quantities and quality of gas;

vi. grading capacitor condition;

vii. contact condition (including contact dimensions);

viii. torque settings for fasteners; and

ix. important dimensions.

e) Specifications for materials:

This includes warnings of known non-compatibility of materials.

i. fluid; and

ii. cleaning and degreasing agents.

f) Tools, lifting and access equipment:

A list of standard and specialised tools shall be provided with description of their application and associated part number.

Tests after the maintenance work: All tests shall be clearly described and shall include the parameters to be observed.

g) Spare parts:

Description, reference number, quantities and advice for storage.

h) Time estimates:

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Estimated time required to carry out maintenance activities.

i) Detailed information:

This relates to the recommended makes and types of transducers (linear or rotary) to facilitate the measurement of travel curves. Such transducers (as well as the brackets, fittings and so forth that are needed to apply them on the circuit-breaker) are part of the special maintenance tools for the circuit-breaker. The OEM operation and maintenance instruction manual shall show clearly how the transducer, together with any brackets, fittings, etc, shall be mounted and applied on the circuit-breaker.

3.5.2 Maintenance Digital Video recording

It is anticipated that maintenance intervals for the circuit-breakers will be very long, e.g. several years. Consequently, it is essential that the OEM operation and maintenance instruction manual be supplemented and supported by a maintenance-orientated video recording. The digital Video recording shall be converted into a suitable portable format e.g. USB memory stick. A written commitment from the Supplier regarding the submission of the maintenance digital Video recording shall be provided with the tender documentation (refer to 3.2.26.1). The actual digital Video record (portable format e.g. USB memory stick) shall be supplied after awarding of the contract following approval of the OEM operation and maintenance instruction manual by Eskom Transmission. Copies of the digital Video record (portable format e.g. USB memory stick) shall be issued to the contract manager and relevant technical switchgear equipment specialists.

The maintenance digital Video recording shall provide a record of the maintenance requirements and procedures for the equipment supplied, this shall include the commissioning and maintenance of the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device). The digital Video recording and related OEM operation and maintenance instruction manuals shall be detailed enough to enable a trained maintenance crew (with some general knowledge of the equipment) to perform all inspections and maintenance required on the equipment. It is anticipated that the OEM operation and maintenance instruction manuals will list what maintenance is required, while the digital Video recording will show how such maintenance is achieved.

The maintenance digital Video recording shall cover routine inspection, minor maintenance, major maintenance (overhaul/ intrusive inspection) and repairs (upon breakdown) of all equipment requiring such work, as well as some trouble-shooting techniques (repairs upon emergency breakdown) and tips. It shall explain the normal operation of the equipment in sufficient detail for the maintenance crew to be able to differentiate between normal and abnormal equipment performance. The digital Video recording shall concentrate on equipment maintenance and repairs (upon breakdown), shall not include any unnecessary sales or publicity material. Since the topics to be covered are extensive and complex, it may be considered an advantage to present the results in definite sections, covering the various aspects or portions of the equipment.

These sections may be on separate digital Video recordings or if consolidated into a single digital Video recording, there shall be adequate indexing to permit quick access to the desired section. For each piece of equipment requiring maintenance, the maintenance digital Video recording shall show:

- the tools, equipment and materials required to perform the maintenance, especially any special tools;
- the tests required prior to maintenance operations to record the status of the equipment and/or to indicate the areas requiring maintenance/re-adjustment;
- the disassembly steps, including any marking of positions required prior to disassembly, any discharging of pressure and/or stored energy;
- the disassembly, removal, replacement and re-assembly of any sub-components requiring scheduled maintenance/replacement;
- the re-assembly, realignment and re-installation of all components, including any lubrication of moving parts;
- a brief summary of the evacuation, refilling and leak testing of the re-assembled equipment;
- the testing of the re-assembled equipment, including acceptable values and tolerances of the measured/tested parameters; and
- some trouble-shooting methods if the required tolerances are not achieved.

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The trouble-shooting portion of the maintenance digital Video recording shall record the normal/expected values of equipment performance, plus techniques and tips to analyse the cause of any abnormalities, and how to correct them.

3.5.3 Spares

3.5.3.1 General

Spares will normally be purchased at the same time that orders are placed for circuit-breakers. The Supplier shall provide a list of the minimum recommended spares (refer to e)) together with prices in the pricing schedules for the circuit-breakers concerned.

NOTE: Delivery to any of the specified destinations should remain valid for the duration of the contract period and be subject to the same Contract Price Adjustment formula as applied to the circuit-breakers.

3.5.3.2 Availability of spares

The Supplier (who represents the OEM), shall be responsible for ensuring the continued availability of spare parts required for maintenance for a period of not less than 25 years from the date of discontinuation of the switchgear and controlgear.

Spares required under emergency breakdown conditions shall be readily available with a maximum lead time of 24 hours from date of purchase order. The Supplier shall state the lead time offered in Schedule B. This excludes spares required for scheduled maintenance.

The Supplier upon contract awarding shall carry the following spares and shall be readily available locally (in South Africa) within a minimum of 24 hours (up to a maximum of 14 days), when Eskom Transmission emergency requires to restore the circuit-breaker for its network:

- trip coils;
- close coils;
- spring charging motors;
- contactors and relays; and
- SF6 density monitoring devices (If applicable, other insulation and/or arc-extinguishing medium).
- electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device)

The Supplier shall undertake to supply to Eskom Transmission all the necessary replacement parts for the circuit-breaker throughout its expected service life. If the manufacture of the specific make and type of circuit-breaker (or any of its replacement parts) is discontinued, Eskom Transmission shall be advised by the Supplier in writing.

Written advice (relating to discontinuation) shall also be provided for parts of the equipment that the Supplier obtains from a third party (sub-supplier). In this situation, the Supplier shall supply the following information to Eskom Transmission:

- all design data;
- all material characteristics and parameters;
- all testing information (parameters, equipment, methods, criteria, etc.);
- all manufacturing information; and
- all relevant working drawings and information.

This information shall be supplied to Eskom Transmission in a legible and acceptable format in English when notice of discontinuation of the circuit-breaker or any of its replacement parts is given. In this case, Eskom Transmission will be able to make alternative arrangements to obtain the necessary replacement parts. Another option is to pool spare parts: the Supplier shall state his/her spares availability philosophy with the tender documentation (refer to 3.2.26.1).

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3.5.3.3 Identification of spares

Spares shall be identified by a unique number and cross-referenced in the OEM operation and maintenance instruction manual. Large spares such as poles and operating shafts shall be packed in separate cases, clearly labelled and consigned to Eskom Transmission. Such large spare items shall be provided with a metal label bearing the appropriate identification.

A parts list shall be provided with each consignment of spares, clearly identifying each item by description, identification number and quantity supplied. The contract number shall appear on the packaging containing spares.

3.5.3.4 Packaging, preservation and storage of spares

For details on how to handle preservation, the Supplier shall refer to the Quality documentation requirements. Care shall be taken to ensure that spares are protectively packed for satisfactory long-term storage. Maintenance spares will usually be stored indoors.

3.5.3.5 D.C. supply voltage conversion kits

In accordance with this standard specification subclause 3.2.22 h) the d.c. supply voltage "conversion kits" shall be kept locally by the Supplier in South Africa for the duration of the contract to ensure that they are readily available as and when required. Separate conversion kits shall be made available that are able to convert from 110 V d.c. to 220 V d.c. or from 220 V d.c. to 110 V d.c.

3.5.4 Modifications to circuit-breakers during their service life

If, during the normal service life of a circuit-breaker supplied, Eskom Transmission requires to be notified about a necessary modification, a field Service Bulletin shall be issued to the Eskom Transmission contract manager and relevant technical switchgear equipment specialists giving details of the modification and the reason for it. Suitable training and parts shall be supplied to Eskom Transmission within 30 days of any modification required for all circuit-breakers supplied to Eskom Transmission. All concessions shall be approved by Eskom Transmission.

3.5.5 Condition monitoring of circuit-breakers

The Supplier and OEM factory shall provide practical and innovative methods to improve the reliability and maintainability of the circuit-breaker installation. This shall include offering Eskom Transmission the on-line condition monitoring and/or integrated diagnostic devices which meets the minimum requirements of the Eskom Transmission standard (240-1489922148), and achieves the following functions:

- accumulated interruption amperage values (per pole);
- contact wear (per pole), and nozzle wear;
- continuous measurement of SF6 gas or other insulation and/or arc-extinguishing medium density, the instrumentation for which will provide information enabling early warning of insulation and/or arc-extinguishing medium leaks and planned outages for refilling or repairs;
- analyser for SF6 gas quality and decomposition products (with alarms); and
- continuous monitoring, recording and alarm signalling of the mechanical operating characteristics of the circuit-breaker.

The on-line condition monitoring and/or integrated diagnostic device shall be IEC61850 protocol compliant.

All information required to carry out condition monitoring of circuit-breakers (including, but not limited to, specification sheets, speed calculation points, travel curve values, etc.) shall be provided by the Supplier and OEM for each type of circuit-breaker. This information shall be given to the Eskom Transmission contract manager and relevant technical switchgear equipment specialist upon awarding of the contract.

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3.6 OEM Operation and Maintenance Instruction Manuals

3.6.1 General

Transport, storage, installation (erection), operation, maintenance, testing and breakdown fault-finding information shall be submitted in the form of OEM operation and maintenance instruction manuals (refer to 3.2.26.1 and 3.2.26.2) for the circuit-breaker and where applicable, also its associated CT. These OEM operation and maintenance instruction manuals shall be in English and provided in the following formats:

- hard copy A4 form; and
- electronic copy (pdf) form copied onto an appropriate portable digital medium such as USB memory stick and Compact Disc (CD).

The OEM operation and maintenance instruction manual and contents shall be approved by Eskom Transmission. The approval process shall be initiated immediately upon contract award and completed within three months. The onus shall be upon the Supplier to meet this programme. If further material is required, then this shall be subject to negotiation.

3.6.2 Content

The OEM operation and maintenance instruction manual(s) shall cover transport, storage, installation, operation, maintenance (minor maintenance, condition-based maintenance and major maintenance), testing and breakdown fault-finding, and shall fulfil the following requirements:

- the OEM operation and maintenance instruction manuals shall be written in English only;
- it shall be specifically compiled for the circuit-breaker with which it has been supplied, and where applicable, also for its associated CT;
- torque wrench settings, clearances, settings and other important information shall be listed, e.g. the typical operating times, speed curves and tolerances in synchronism;
- it shall give a clear description of the operation, and the diagrams, photos and description shall be easily read together;
- routine inspection, minor and major maintenance procedures shall be given together with a list of lubricants, recommended spares and/or special tools and so on, required for these activities;
- it shall contain high-quality diagrams and photos showing details of operating components of the circuit-breaker, which also identify and list separately each component making up the diagram;
- seals and gaskets requiring replacement during major maintenance (overhaul/intrusive inspection) and repairs (upon breakdown) shall be detailed and the Suppliers of these components, together with the part number(s), shall be listed; and
- the names and addresses of suppliers of lubricants, oils, gases, compounds and so on shall be listed.

One set of sample OEM operation and maintenance instruction manual(s) shall be supplied to Eskom Transmission with the tender documentation (refer to 3.2.26.1) for approval. After approval, the requisite number of OEM operation and maintenance instruction manuals shall be supplied.

Suitably trained and qualified personnel shall install, operate, maintain and repair the equipment with the aid of the manufacturer's operation and maintenance instruction manuals and digital Video record aids (portable format e.g. USB memory stick). The OEM operation and maintenance instruction manuals shall contain at least the following information (where applicable):

General

- title page: title of equipment, equipment ratings, contract and order numbers, Supplier's reference numbers. This information shall also appear on the outside of the binder and on the first page;
- table of contents: the OEM operation and maintenance instruction manual shall be sectionalised and numbered sequentially;

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- equipment make and type to which the OEM operation and maintenance instruction manuals apply;
- list of all drawings, by number and title;
- description and summary of circuit-breaker operation;
- full details of method adopted for anti-pumping;
- where applicable, details of interlocking between phases;
- where applicable, details of auto-reclosing arrangements;
- schematic wiring diagram of circuit-breaker; and
- where applicable, full details of all valves, including information regarding materials of valves and valve seats. If materials such as synthetic rubber or other equivalent types are used, the method of bonding or clamping these materials shall be given.

Transport, handling and storage instructions (also long-term storage requirements for preservation)

- packaging requirements;
- transport instructions;
- transport instructions
- storage instructions: indoor, outdoor and special information for equipment storage; and
- the measures required to make sure all the manufacturer's transportation and storage requirements are met (also long-term storage requirements for preservation);.

Installation instructions

- complete step-by-step instructions and detailed drawings, including alignment, installation and dimensional tolerances for preparing the equipment for service;
- inspection procedures before and after unloading, pre-installation tests, gas-filling and monitoring procedures;
- the levels of expertise required for the construction team;
- a man-hour estimate for the installation work required on site;
- a list of special equipment and tools required for unloading and positioning components of the circuit-breaker on site; and
- tolerances for field assembly.

The Supplier shall supply a digital Video record (portable format e.g. USB memory stick) to supplement installation information given in the OEM maintenance instruction manual. This visual information may be provided separately or may form part of the maintenance digital Video record required.

Testing

- functional testing, dielectric testing, controlled switching testing, operating instructions, operating limits and starting-up instructions (complete with sketches or drawings); and
- a separate set of record sheets, showing measurements and tolerances for each test for separate items of equipment.

Inspection and maintenance, including condition-based maintenance

- the OEM operation and maintenance instruction manual shall contain the typical contents as described in 3.6.2.

Dismantling, repair (upon failure or intrusive maintenance), settings inspection and lubrication

- instructions for dismantling the equipment, as well as repair instructions and settings of critical clearances and adjustments, complete with photographs and sketches or drawings;

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- special tools shall be clearly described;
- guide to inspection frequency;
- all gaskets, seals and o-rings which have to be replaced during scheduled maintenance or after a specified period, shall be identified;
- lubrication chart and schedule (including component quantities). Lubricants shall be clearly identified. If no lubrication is required, it shall be clearly stated;
- procedures for the discharge of stored energies in the mechanical and electric systems;
- procedures for the safe disposal of decomposed SF6 gas products shall be described; and
- trouble-shooting procedures shall be provided.

Spare parts

- spare parts list, including quantities and manufacturer's part numbers. Spare part numbers shall be cross-referenced with drawings in the OEM operation and maintenance instruction manual;
- drawings (sectional or "exploded" views, etc.) of the equipment/sub-assemblies shall identify every component (excluding standard bolts, nuts, washers, etc.) referenced to the spare parts list, including component description and manufacturer's part number; and
- delivery times for recommended spare parts shall be stated.

Drawings for equipment

- a complete set of approved drawings specific to the equipment being supplied. The drawings shall show dimensions and tolerances of the major components and assemblies. Details of the drawings required are given in 3.2.26.
- a complete set of approved drawings for the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device)

3.7 Training

The Supplier shall provide with tender documentation the details of the first-hand training of an international standard on the supplied equipment by OEM accredited instructors, and this shall be available for the duration of the contract. The OEM supplied equipment that is covered by the offered training and its material shall include the circuit-breaker with its the insulation and/arc-quenching medium, and where applicable, it's electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) and on-line condition monitoring and/or integrated diagnostic devices.

For new contracts or once-off order/turnkey, the Supplier shall ensure that:

- technical equipment training is offered upon first delivery (or installation). In the case of the long-term contract awarded, the Supplier shall rollout technical equipment training first-off delivery (installation) to each of the Eskom Transmission grids (at provincial level) for the duration of the contract.
- this training shall cover storage, packaging (unpackaging), handling, assembling, installation, setting/ adjustments, pre-commissioning testing, handing-over, condition-based maintenance inspection tests (tolerance setting verification and adjustments), and the aspects of dismantling and disposal. The Supplier shall provide details of this training with tender documentation.
- This training shall also provide electronic controller (Controlled Switching Device/ Point-on-Wave switching device) training as a line item on the contract. This training shall cover the design, application, operation, settings, commissioning and maintenance of the device, including any applicable software. (Refer to Annex G)
- Upon contract award, the Supplier shall prepare training material documentation (in English) with guidance of Eskom Transmission in terms of the details covered.

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The intrusive major maintenance (servicing) and breakdown repairs shall be specialized training to be conducted at the OEM factory. Its scope shall include product design aspects, drawings, parts, quality assurance, assembling, testing and disassembling inspections, repairs and testing. The Supplier shall provide details of this training with tender documentation. Eskom Transmission shall arrange with the Supplier to receive this intrusive technical equipment training as and when the need arise.

Refer to **Annex G** for the switchgear training requirements from original equipment manufacturers. The supplier shall provide with the tender documentations, the detailed training programme in accordance with this standard specification.

3.8 Safety, health, environment, and quality

Refer to Eskom Transmission documentation issued for SHEQ requirements in order to comply with this circuit-breaker specification.

All facets of this tender must comply with Occupation Health and Safety Act (OHS Act) No 85 of 1993 – Construction and Electrical Machinery Regulations.

The Supplier shall insist on safe handling of the insulation and/arc-extinguishing medium in accordance with the international standards (SANS/IEC 62271-4 and NRS 087), during all stages of transportation, delivery, off-loading, installation, testing and repairs of the circuit-breakers that are specified by Eskom. Transmission. Acceptable leakage rates shall be within these international standards and SANS/ IEC 62271-100 when the circuit-breakers enter Eskom Transmission service up to the years of the acceptable 1st alarm stage. Upon any deviation of tested leakage rate as per international standard, Eskom Transmission shall raise non-conformances to the Supplier and their OEM factory to investigate and resolve.

3.9 Technical submission minimum tender returnables

3.9.1 Minimum tender returnables of the offered circuit-breaker

In order for the Supplier's technical tender submission to be considered for performing evaluation by Eskom Transmission evaluators or its appointed representative, the submission shall contain these minimum technical tender returnables in accordance with Eskom Transmission Technical Evaluation Criteria (240-180000573):-

i. Completed Technical A & B schedules

ii. Type test reports

iii. Drawings (General Arrangement Outline, Wiring Schematic and Nameplate)

iv. OEM Operation and Maintenance Instruction Manuals

Should the Supplier not submit the above-mentioned minimum technical returnables documentation, the Eskom Transmission evaluators or its Representative shall consider the technical submission unresponsive and not proceed with further technical evaluation, thus that technical submission is disqualified.

Eskom Transmission shall perform technical evaluation in accordance with Eskom Transmission Technical Evaluation Criteria (240-180000573).

3.9.2 Minimum tender returnables of the offered circuit-breaker insulation/arc-quenching medium

For the offered SF6 gas circuit-breaker, the Supplier shall submit the following minimum tender returnables in order for Eskom Transmission to perform technical evaluation of the SF6 gas. Refer to the SF6 gas specification (240-151122225) for the Eskom Transmission requirements for the SF6 gas. Similarly, for the offered non-SF6 (SF6-free) circuit-breakers of alternative environmental-friendliness low Global Warming Potential (of low GWP of 1 or less, or low CO2e), the Supplier shall submit the minimum tender returnables with the tender documentation in order for Eskom Transmission to perform technical evaluation of the insulation and/or arc-quenching medium.

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i. Clause-by-clause responses that answers to the subclauses of the Eskom Transmission specification (240-151122225).

ii. Certificate of compliance to Class 1 (issued by the authority that performed tests);

iii. Technical data specification sheet of the cylinder;

iv. Certificate of gas purity (of compliance to IEC 60376);

v. Documented proof (evidence) of colour code marking used to comply with Protea as SANS 10019;

vi. Photo (evidence) of cylinder stamping evidencing compliance with the requirements of SANS 10019;

vii. Certificate of compliance with BS341-3 (for valve outlets and connections);

viii. Valid Test Certificate of hydrostatic testing (issued by the authority that performed tests);

4. Authorization

This document has been seen by:

Name and surname	Designation
Bheki Ntshangase	Senior Manager Substation Equipment & Diagnostics
Jabulani Cebekhulu	Chief Engineer, AM SED (AIS Care Group Convener)
Rodger Peense	HV Manager, Western Grid; (Switchgear Work group Convener, HV Plant Manager's Forum – Switchgear representative)
Matome Matlhadisa	Transmission HV Plant Corporate Consultant

5. Revisions

Date	Rev.	Compiler	Remarks
Feb 2023	1	S Nkosi	Final authorised official document
Dec 2022	0.5	S Nkosi	Circulated for comments to interested and affected parties.
Nov 2022	0.4	S Nkosi	Re-arrange the document and updated referenced details.
Oct 2022	0.3	S Nkosi	Remove Annex C and Annex D
Sept 2022	0.2	S Nkosi	Combine Transmission requirement for all circuit-breakers including COMBO, Training, insulation medium (SF6 and SF6-free/ non-SF6), new technologies
Sept 2022	0.1	S Nkosi	New document applicable to Eskom Transmission only with its 240-numbering, which is a departure from **240-56063756 Rev 6**
Sept 2015	6	S. Nkosi	**240-56063756 Rev 6:** Final Document for Authorisation

6. Development team

The following people were involved in the development of this document as well as previous revisions of this standard specification. The original document was compiled by Transmission and Distribution switchgear representatives.

- Sphiwe Nkosi Substation Equipment & Diagnostics, Asset Management, Transmission
- Jabulani Cebekhulu Substation Equipment & Diagnostics, Asset Management, Transmission

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7. Acknowledgements

The Compiler acknowledges the contributions to this new document and all those who contributed on the last 240-56063756 Rev 6, 240-56030489, 240-46425564, 240-124520996 Rev 1 and 240-56065202

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Annex A – Supplier and Eskom Transmission responsibilities

The responsibilities of Eskom Transmission and the Supplier of the switchgear and associated equipment shall be as defined below.

A.1 Supplier's responsibilities

The Supplier shall be responsible for, but not limited to, the following:

a) upon submission of a tender, the submission of a complete set of technical documents as required by this standard specification (refer to subclause 3.2.26 for documentation requirements), this shall be in paper print, Adobe PDF copy and all the technical schedules A and B shall also be submitted in a copy of the Microsoft Excel format.. The tender shall state clearly all deviations (if any) in the Deviation schedule and in Schedule B (if applicable). Deviations will be evaluated by Eskom Transmission and the outcome will be communicated, in writing, to the Tenderer;

   i. The Supplier, as indicated in subclause 3.9, shall also read the Technical Evaluation Criteria standard (240-180000573) and provide with tender documentation all the minimum technical tender returnables in order for the technical documentation to be evaluated by Eskom Transmission. Failing to provide information called by this standard specification and the Technical Evaluation Criteria standard (240-180000573) shall render the technical submission disqualified for technical evaluation.

b) submit with tender documentation the written technical documentation that warns Eskom Transmission on the limitations of their OEM factory offered circuit-breaker design with regards to switching transients and insulation withstand. The Supplier and the OEM shall provide the suitable solution to apply in Eskom Transmission network for the purpose of protecting the circuit-breaker design from premature failure not to achieve its designed life expectancy. Such proposed solution shall form part of that particular offered circuit-breaker, in order for Eskom Transmission to factor accordingly.

c) all testing and recording of results required by this standard specification as well as the OEM's own protocols using accredited personnel including the use of approved and calibrated test equipment. Type testing shall be carried out in accordance with the relevant IEC product standards. All testing shall be done at accredited local test facilities (SANAS accredited – e.g. SABS) or accredited international testing authorities (e.g. KEMA/CESI/IPH);

d) in the case of inspection at the factory of circuit-breakers for use on systems with nominal voltages up to and including 765 kV, the erection of a completely functional prototype at the Supplier's own premises under direct supervision of the OEM for a comprehensive evaluation by Eskom Transmission before erecting on site. Unless otherwise agreed by Eskom Transmission;

e) ensuring equipment is in an acceptable and safe working condition during all phases of transportation from factory to site, storage until the point of official handing over;

f) all necessary arrangements for factory routine testing and/or acceptance testing (FAT), transporting and off-loading at the most convenient point (if applicable), as well as for transporting and off-loading at the ultimate destination. Eskom Transmission will only accept delivery to the destination specified at the time of placing the order – unless otherwise negotiated. Shafts, bearings and machined surfaces exposed during transport and storage shall be treated with a temporary anti-corrosive coating;

g) provision of OEM accredited installation and pre-commissioning services for all on-site work;

h) the supply of all documentation relevant to the circuit-breaker including factory routine test results. Records shall be available during the pre-commissioning (on-site) testing phase;

i) when required, the supply of a fully complete circuit-breaker assembled, installed, pre-commission (on-site) tested and ready for handover (including, where applicable, controlled switching systems);

j) where necessary (i.e. in the absence of an on-site a.c. power supply), the supply of an a.c. power supply (e.g. generator) for the installation and pre-commissioning of switchgear;

k) the supply of all conductor clamp main terminals on the supply and load side;

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l) the supply of all necessary auxiliary equipment, including operating mechanisms, control, monitoring and protective devices, installed in suitable operating mechanism enclosures;

m) the supply of all auxiliary and control wiring and terminations for the circuit-breaker, including inter-pole cabling and cabling to the central control enclosure(s). For single-pole operated circuit-breakers the wiring shall be done in the factory. No additional inter-pole wiring on site is allowed;

n) the supply of all electrical and mechanical interconnections between the elements of the circuit-breaker – made to Eskom Transmission's approval;

o) the supply of all fixing bolts, fasteners and adapter plates – excluding the bolts required for fixing support structures to concrete foundations (which are to be supplied by Eskom Transmission);

p) where applicable, the first filling of the insulation and/or arc-extinguishing medium to the OEM's rated value;

q) when specified on the specific Technical Schedule A & B, the supply of the steel support structures for the circuit-breaker;

r) when required, testing and recording of results required by this standard specification as well as the OEM's own protocols using accredited personnel including the use of approved and calibrated tools and test equipment;

s) provision of all training in accordance with this standard specification (refer to **3.7** and **Annex G**) by OEM accredited trainers;

t) submit FMECA datasheets for each offered circuit-breaker type design;

u) provide the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) with associated equipment and documentation to Eskom

v) where applicable, any modifications required during the circuit-breaker service life; and

w) any other responsibilities as specified in this document.

A.2 Eskom Transmission's responsibilities

Eskom Transmission shall be responsible for the following:

a) the supply of the relevant standard(s) or specification(s) and completed Schedule A's with the enquiry;

b) the evaluation of all equipment offered and documentation supplied with a tender. This includes the compilation of an evaluation report summarising the outcomes of the evaluation;

c) when required, subject to Eskom Transmission discretion, perform the Design Review inspection assessment of the offered circuit-breaker at the relevant OEM manufacturing facilities before any first manufacturing of Eskom Transmission specified circuit-breaker;

d) when required, subject to Eskom Transmission discretion, perform the Factory Acceptance Testing (FAT) of the offered circuit-breaker upon first-of manufacturing at the relevant OEM manufacturing facilities;

e) when required, the assessment and evaluation of the relevant transport, storage and preservation, installation and pre-commissioning facilities;

f) the approval of all drawings submitted by the Supplier (e.g. general arrangement, nameplate, schematic wiring, etc.), and provide the Supplier with Eskom Transmission standard wiring interface drawings and the standard steel support structure drawings;

g) the approval of all other documentation provided by the Supplier (e.g. OEM operation and maintenance instruction manuals, training material, inspection and testing plans after installation, etc.);

h) the supply of a heater connection point for long term storage;

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i) the provision of concrete foundations and the standard Eskom Transmission circuit-breaker steel support structure;

where applicable when specified upfront, the approval of the circuit-breaker steel support structure and provide the concrete foundations;

j) the stringing and clamping of main conductors;

k) the supply and installation of the control cabling to the circuit-breaker operating mechanism enclosure;

l) the supply and installation of all control, metering, relaying and annunciation equipment remote from the circuit-breaker;

m) specifying (at the time of placing the order) whether the steel support structure for the circuit-breaker is required to be supplied by the Supplier;

n) if necessary, provide suitable storage facilities where circuit-breakers are to be stored for extended durations prior to installation due to unplanned delays; and

o) the witnessing and approval of the first complete circuit-breaker delivered, installation and pre-commissioning.

p) where applicable, the insulation and/or arc-extinguishing medium for filling to the OEM's rated value;

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Annex B – Technical Schedule A & B (Generic typical example)

Add appendix detail here or remove if not required.

TECHNICAL SCHEDULES A & B FOR 6,6 kV to 765 kV OUTDOOR CIRCUIT-BREAKERS
SAP: 0666781 BKR 132 kV 3150 A 40 kA 3P 31 220 VDC non-SF6 (SF6-free) low GWP of 1 or less

Schedule A: Purchasers specific requirements
Schedule B: Guarantees and technical particulars of equipment offered

1	2	3		4	5
Item	**Clause of 240-180000572**	**Description**		**Schedule A**	**Schedule B**
1		**Item and system description** BKR 132 kV 3150 A 40 kA 3P 31 220 VDC non-SF6 (SF6-free) low GWP of 1 or less			
1,1		• SAP No			xxxxxxxxxx
1,2		• Buyers Guide Drawing		non-SF6 (SF6-free) CB employs environmental-friendly medium of low GWP of 1 or less (low CO2e)	
1.3		• Circuit-breaker application		Line/Cable/Bus/ Transformer	xxxxxxxxxx
1.4		• Nominal system voltage (U_n)	kV	132	xxxxxxxxxx
1.5		• System voltage range	pu	0,9 to 1,1	xxxxxxxxxx
1.6		• System earthing (effective/non effective)		Non-effective	xxxxxxxxxx
2		**Ratings**			
2,1		• Rated voltage (U_r)	kV	145	
2,2		• Number of phases on system		3	
2,3		• Rated short-duration power-frequency withstand voltage (U_d) - Phase-to-earth and between phases	kV	275	
2,4		• Rated short-duration power-frequency withstand voltage (U_d) - Phase-to-earth and between phases - under Wet conditions as per SANS 62271-1 cl. 6.2 ($U_r \leq 245$kV)	kV	xxxxxxxxxx	

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Annex C– Material and Corrosion Protection information

Below is the **Table C1** that details the Eskom Transmission requirements that need to be completed by the Supplier and their OEM factory, for each offered circuit-breaker design

Table C1: Material and Corrosion Protection Information

This information is required to be completed by the Supplier for each offered circuit-breaker design type		
Eskom Transmission specified requirements	**To be completed by the Supplier**	**Completed Example (*guide by Eskom Transmission*)**
Item or part Description		*Support bracket*
Drawing number		*DEMO1*
Material type		*EN8*
Material grade		*(BS 970 080M40)*
Type of corrosion protection		*HD galvanising*
Minimum thickness of protective coating		*85 micro*
Verification tests carried out on coating e.g. Thickness with thickness gauge		*6 measurements along profile*
Expected life of coating (Industry/marine)		*Marine = 5 years Industry = 8 years*
Maintenance frequency of protection coating		*Repair installation damage on commissioning and thereafter once a year*
Maintenance type of protection coating		*Patch repair with Zincfix*
Bi-metallic corrosion prevention		*Coat both sides*
Crevice corrosion prevention		*Seal with crevice with Zincfix*
Item or part weight in Kilogram		*7kg*
Field experience		*Equipment used at coast in*
Remarks/General comments		*Debris, scratches and indentation have been removed prior to*

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Annex D – Requirements for wiring of switchgear for Eskom Transmission

This Annexure ensures a standardised approach and philosophy for the design and wiring of outdoor circuit-breaker control and auxiliary circuits and, where applicable, associated instrument transformers.

1. Wiring of switchgear for Eskom Transmission

The requirements for control and auxiliary circuits shall be in accordance with the relevant parts of SANS 62271-1, SANS 62271-100 and the requirements of this Eskom Transmission standard specification. Where conflicting requirements exist, the requirements of this standard shall take precedence.

a. The convention applied to schematic wiring diagrams and the requirements of this standard shall be that limit switches, pressure switches, relay contacts etc. are shown assuming the following reference conditions:

- circuit-breaker main contacts are open;
- springs are discharged;
- gas compartments are without pressure (where applicable);
- relay coils are de-energised;
- no a.c. or d.c. supplies are connected;
- earthing switches not applied (where applicable); and
- disconnectors in the closed position (where applicable).

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

b. The interface for all switchgear wiring to Eskom Transmission shall be via terminal strips in accordance with the applicable Eskom interface drawing. All terminal strips shall be located in the mechanism enclosure.

c. For circuit-breakers with 3 operating mechanisms (1P): In case where the design of the switchgear makes use of multiple mechanisms to operate the individual poles (e.g. single pole operated three mechanism circuit-breakers), the mechanisms shall be wired in a master-to-slave configuration. The connections between the slave mechanisms and the master mechanism shall be pre-wired and tested in the factory. The central operating mechanism enclosure (master) shall form the single access point for the Eskom Transmission control cables from remote equipment.

NOTE: Eskom Transmission will connect all control cables to the master mechanism enclosure.

d. The closing and opening devices (coils), mechanism motors and motors contactor coils to be supplied with the switchgear shall be suitable for operation at either 110 V d.c. or 220 V d.c. as specified in Schedule A of the relevant equipment specification. It shall be possible to change the d.c. control voltage at which the switchgear operates by only replacing the opening and closing coils, mechanism motors and motor contactor coils.

NOTES

- Switchgear shall only be required to operate at one d.c. control voltage i.e. the closing and opening devices; mechanism motors and motor contactor coils to be supplied with the switchgear are required to be suitable for operation at either 110 V d.c. or 220 V d.c. as specified in the relevant equipment specification.
- The use of resistors to achieve voltage reduction of the control voltage is not acceptable.
- Unless specifically stated in the specific switchgear tender, it will be assumed that the unit prices of the switchgear will remain the same irrespective of the d.c. control voltage.

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e. All d.c. MCBs shall be rated for use on 220 V d.c. systems (i.e. rated at 250 V d.c.).

f. The 110 V or 220 V d.c. and 230 V a.c. power supplies required for the switchgear will be provided by Eskom Transmission via the terminals allocated in accordance with The Eskom Transmission interface drawing.

g. Power supplies will be provided from the protection schemes located in the control room or yard junction box. The protection schemes include a 10 A (curve C) 2-pole or 1-pole and neutral MCB for a.c. circuit protection and a 16 A (curve B) 2-pole MCB for d.c. circuit protection. The MCBs are in accordance with SANS 60947-2. Any additional MCBs provided for switchgear LV circuit protection or isolation shall discriminate with these upstream MCBs. Provision shall be made for each sub-circuit dedicated to a particular function (e.g. heater circuit, racking motor circuit, mimic indication circuits, spring charging control circuit, etc.) to be locally isolated from the incoming supply without the need to disconnect any wires.

h. MCBs shall comply with the requirements of SANS 60947-2 and IEC 60898 (Parts 1 and/or 2 as appropriate). In particular:

- breaking capacities shall be in accordance with IEC 60898 (Icn/Ics) and SANS 60947-2 (Icu = Ics) and shall be at least 5 kA;
- the utilisation category shall be ‘A’ (SANS 60947-2);
- the maximum service voltage shall be at least VN + 20%;
- the pollution degree shall be ‘3’ or higher (SANS 60947-2);
- the MCB shall be suitable for isolation (SANS 60947-2); and
- the protection curve shall be ‘B’ for DC MCBs and C for AC MCBs (SANS 60947-2 and IEC 60898).

i. 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.

j. Motor contactors shall comply with SANS 60947-4-1, and shall be rated to break the maximum motor current.

1.1 Circuit-breaker spring charging motor control circuits

a. The motor control circuit shall include thermal overload and short-circuit protection via a suitably rated MCB.

b. 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.

c. Automatic re-charging of closing springs shall be provided by means of an interlock arranged via normally-closed spring limit switch contacts.

d. In addition to the spring limit switch contacts required for motor control, spare contacts of the type and quantity specified the Eskom Transmission interface drawing shall be provided. One of the normally-open spring limit switch contacts may be used for sequential starting of spring charging motors in the other poles or circuit-breakers. The rating of this contact shall be adequate for such duty. If the rating of this contact is not adequate, a control contactor that is under command of this contact shall be provided.

e. In the case of motor control circuits for multiple mechanism breakers, sequential re-charging of springs shall be applied to limit the maximum simultaneous current drawn by the motors.

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1.2 Circuit-breaker control circuits

1.2.1 Closing control circuit

a. 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.

b. The circuit-breaker shall close correctly when an electrical closing pulse of 100 ms duration is applied to the closing coil.

c. When closing all phases simultaneously, the total power drawn by the closing coil(s) of the circuit-breaker shall not exceed 500 W for three-pole operated single mechanism circuit-breakers and 1500 W for single-pole operated three mechanism circuit-breakers (i.e. 500 W per mechanism) unless otherwise approved.

d. For closing coils rated less than 200 W, the closing coils shall not operate if a 10 µF capacitor, charged to 1,5 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.

e. Each closing coil shall be wired in series with the following contacts:

- a normally-closed control contact, to allow closing only when the circuit-breaker is open.
- 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.

f. 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.

1.2.2 Tripping control circuits

a. 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. Satisfactory operation shall be possible at, but not lower than, 70 % of the nominal supply voltage measured at the coil terminals.

b. Each circuit-breaker shall be equipped with two shunt-tripping coils 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 operate correctly when energised independently or simultaneously.

c. 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.

d. When tripping all phases simultaneously, the total power drawn by the tripping coil(s) of the circuit-breaker shall not exceed 500 W for three-pole operated single mechanism circuit-breakers and 1500 W for single-pole operated three mechanism circuit-breakers (i.e. 500 W per mechanism) unless otherwise approved.

e. For tripping coils rated less than 200 W, the tripping coils shall not operate if a 10 µF capacitor, charged to 1,5 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.

f. A normally-open auxiliary switch control contact shall be provided in series with the tripping coil to interrupt the tripping control circuit current when the circuit-breaker is open.

g. Tripping 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.

1.2.3 Anti-pumping

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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.

1.3 Heater control circuits

a. Suitably rated electric heaters shall prevent moisture from condensing and being deposited inside the mechanism enclosures. Heaters shall maintain a dew-point greater than the ambient temperature and shall circulate the air constantly to all parts of the enclosure.

b. Heaters shall be placed 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.

c. The electrical supply for heaters shall be single-phase 230 V a.c.

d. The total power drawn by heaters shall not exceed 400 W (per mechanism enclosure), unless otherwise approved. Where multiple heaters are applied the first 100 W shall be permanently connected. The heater power drain larger that 100 W shall be switched via a pre-set thermostat or humidistat to prevent the mechanism enclosure from overheating.

e. Heater circuits shall not be equipped with local isolating switches, but shall be protected by a single-pole and neutral MCB with gang operation of the two poles.

f. The heaters shall be equipped with suitable temperature-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 accordance with the Eskom Transmission interface drawing.

g. A readily accessible (i.e. without the need to remove external packaging) 230 V a.c. external temporary supply connection point for the heater circuit during storage shall be provided and wired to the Eskom Transmission side of the terminal strip in the factory. This shall consist of an electrical cord wired to a screw-type connection block for the connection of the temporary a.c. supply used during storage. No internal wiring should need to be modified to remove the temporary supply leads.

1.4 Ancillary functions

1.4.1 Auxiliary switches

a. Auxiliary switches shall faithfully reproduce 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 the Eskom Transmission interface drawing. Auxiliary switch contacts shall reproduce main contact timing to acceptable limits approved by Eskom. If possible, auxiliary contact timing shall permit adjustment within limits to be provided by the supplier at the time of tendering.

b. All spare auxiliary contacts shall be wired independently to the terminals in accordance with the Eskom Transmission interface drawing. The use of auxiliary relays to multiply the number of auxiliary contacts is not acceptable.

c. Auxiliary switch contacts shall be protected against ingress of dust particles to degree IP 55 in accordance with SANS 60529. Where Eskom Transmission 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.

1.4.2 Spring limit switches (SLS)

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a. Spring limit switches shall faithfully reproduce the charge status of the mechanism spring.

b. A normally-open spring limit switch contact of each mechanism shall be used to block an electrical close operation.

c. 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.

1.4.3 Condition monitoring contacts

a. A normally-open auxiliary contact shall be provided for the purposes of condition monitoring. This contact shall faithfully reproduce the main contact position.

b. The condition monitoring contacts shall be wired to the terminals provided in accordance with the Eskom Transmission interface drawing.

1.4.4 Auxiliary and control relays

All auxiliary and control relays shall be standard products that are freely available on the commercial market and shall be labelled in accordance with the schematic wiring diagram for the circuit-breaker. The location of the label shall be on the backing plate where the relays are fixed in order to retain the labelling should the relay be changed during the switchgear's lifetime.

1.4.5 Operation counters

a. 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.

b. 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.

1.5 Circuit-breaker control circuit interlocks

1.5.1 Spring charging motor control circuit interlocks

a. 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. This is to prevent possible injury to the operator should the motor start running while the manual charging handle is inserted onto the mechanism.

b. When the spring charge handle is inserted into the mechanism, a circuit-breaker unhealthy alarm status shall be activated.

c. A direct means to achieve the following functions shall be provided:

- the closing operation shall be possible only when the closing spring is fully charged;
- the closing spring can only be released when the main contacts are fully open; and
- a device shall be employed to block overcharging of the closing spring when the manual charging facility is employed.

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

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a. SF_6 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 two stages as follows:

- on reaching the non-urgent alarm / warning level (i.e. only gas replenishment is necessary).
- on reaching the lockout level (i.e. circuit-breaker to be taken out of service).

NOTES

- It shall be possible to verify the correct operation of gas density/pressure switches in situ without having to disconnect wiring or having to perform gas-handling operations on the switchgear.
- The use of pressure switches without temperature compensation for the initiation of these functions will not be permitted.

b. The contacts of these switches, on reaching these levels, shall operate relays, which in turn shall provide:

- electrically separated normally-closed contacts for alarm indication purposes (Low Gas Alarm); and
- lockout alarm level: contacts which shall be wired into all tripping and closing control circuits to block the operation of the switchgear.

c. The blocking contacts for the tripping control circuits and the alarm contacts for the auxiliary circuits shall be derived directly from the density meter or pressure gauge and not via auxiliary relays. Blocking/enabling of the tripping control circuits shall not be dependent on the presence of the auxiliary d.c. supply.

d. The blocking contact for the close control circuit shall share a common actuator to the low gas block indication auxiliary circuits (i.e. all three contacts shall be derived directly from the density meter or pressure gauge, or all three shall be derived from the same auxiliary relay).

e. Where auxiliary relays are used to multiply the alarm or blocking 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.

1.6 Alarm circuits

Three alarm circuits shall be provided for:

- ***Circuit-breaker not healthy common alarm:***

  This alarm shall monitor and indicate an abnormal state of the switchgear. This alarm is activated under any of the following conditions:

  i. motor over-run protection is activated, or

  ii. spring charging motor control circuit MCB trips , or

  iii. manual spring charge handle left engaged in the mechanism.

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

- ***Low gas alarm:*** This alarm shall monitor and indicate the level of SF_6 gas inside the switchgear.

  This alarm is activated under the following conditions:

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i. non-urgent or warning alarm level

ii. lockout alarm level

- ***Switchgear heater alarm:***

  This alarm shall monitor and indicate the status of the heater circuit(s). 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.

1.7 Wiring, terminal blocks and terminal strips

1.7.1 General wiring requirements

a. Enclosure wiring shall be to IP 2X of SANS 60529 ensuring no contact with hazardous parts with a finger.

1.7.2 Terminal blocks and terminal strips

a. Each mechanism enclosure shall be provided with not less than 6 spare terminals.

b. The arrangement of the terminal strips in the mechanism enclosure shall facilitate the entry of the incoming control cables in the bottom-entry configuration.

c. The terminal blocks shall be of the screw clamp, spring loaded insertion type. The terminal width of 10 mm is preferred. Terminal widths less than 8 mm will not be accepted. The terminal blocks shall be capable of accepting back-to-back insulated hook blade lugs without damaging or deforming the lugs. Only Eskom Transmission accepted terminal blocks shall be used.

d. Control cabling applied by Eskom Transmission to interface with the circuit-breaker will be multi-core, PVC insulated, single-wire armoured and PVC sheathed in accordance with SANS 1507-3.

e. The terminal strip spacing shall be such that the person cabling the circuit-breaker can easily access the terminals to insert the wiring. The spacing shall be such as to accommodate a ferrule of length up to 20 mm.

f. Trunking shall be provided on both sides 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 x 60 mm trunking is preferred.

g. In general and where applicable, all wiring is to be stripped of as much slack as possible so as to leave maximum trunking space for Eskom Transmission wiring.

1.7.3 Wiring, terminations and identification

a. 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.

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b. Wiring for CTs and motor control circuits shall be carried out using stranded copper conductor with a minimum nominal cross-sectional area of 2,5 mm2.

c. Wiring for control and other auxiliary circuits shall be carried out using stranded copper conductor with a minimum nominal cross-sectional area of 1,5 mm2.

d. All a.c. wiring (including CTs, heater circuit, etc.) shall be black in colour. Earth wires shall be green/yellow. All other d.c. wiring shall be grey.

e. 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.

f. All wires shall be terminated using suitable 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.

g. Secondary cabling (e.g. inter-pole cabling) provided by the manufacturer shall be UV-stable and shall preferably be run in the ground, in which case steel wire armoured cable shall be used. In the case where Eskom Transmission steel support structures are provided, all inter-pole secondary cabling shall be run in the ground, unless otherwise approved by Eskom.

h. Where applicable, wiring shall be routed in the corners of compartments, avoiding any screw studs or sharp objects that protrude into the compartment.

i. Where applicable, 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.

j. Where applicable, 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).

1.7.4 Standard terminal strip layout

a. The terminal strips used for interfacing with external cabling shall be numbered, and interfacing wires ferruled in accordance with the Eskom Transmission interface drawing.

b. If a particular function/alarm is not applicable, then the required terminals shall be provided but shall be left unwired. Alternative functions/alarms shall not be wired to standard terminals designated for another function/alarm.

c. Any spare status, spring limit switch and/or alarm contacts available in addition to the basic requirements of the Eskom Transmission interface edraing shall be wired to additional terminal blocks.

1.8 Schematic wiring diagrams and layout drawings

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a. All diagrams and drawings shall be labelled and annotated in English.

b. 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 60617and shall include a key to any abbreviations or device codes used.

c. 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, fuses, etc.)

d. 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.

e. A general arrangement drawing of the mechanism enclosure shall be provided showing the relative positions of the terminals strips, gland plates, contactors, coils, motor, MCBs, heaters, overall dimensions, etc. The drawing shall clearly show the space (clearance) provided on either side of the terminal strips for easy access to insert the wiring.

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Annex E – Technical A & B Schedule for electronic controller (Controlled Switching Device/ PoW switching device) (Generic typical example)

Electronic Controller (Controlled Switching device/ Point on Wave switching device - (POW relay) for 132 kV (and below) circuit-breaker type 1P (3-mechanisms) 110V DC or 220V DC						
Item	**Spec/ clause**		**Description**		**Schedule A**	**Schedule B**
1			**Device design details**			
1,1		•	Controlled switching device electronic controller complies to IEC 61850-5 © IEC:2003(E) (p.31) protocol compliant	Y/N	Yes	
1.2		•	Controlled switching device electronic controller complies with Eskom standard philosophy - ST 240- 75566441	Y/N	Yes	
1.3		•	Controlled switching device electronic controller complies IEC 62271-100 standard	Y/N	Yes	
1.4		•	Controlled switching device electronic controller complies to the Eskom circuit-breaker standards - 240-56063756	Y/N	Yes	
1.5		•	Controlled switching device electronic controller manufactured to which standard(s)		xxxxxxxxxx	
1.6		•	Manufacturer of controlled switching device		xxxxxxxxxx	
1.7		•	Design type of controlled switching device		xxxxxxxxxx	
1.8		•	Country of manufacturing		xxxxxxxxxx	
1.9		•	Device operating software type		xxxxxxxxxx	
1.10		•	Device operating software version		xxxxxxxxxx	
1.11			Device operating software:			
			Different supplier circuit breaker application	Y/N		
			Application on Shunt Capacitor Bank & Shunt Reactors	Y/N		
			Duty: Opening, closing or opening&closing	Y/N		
			Adaptive mode	Y/N		
			Use circuit breaker data to setup switching program	Y/N		
1.12		•	Minimum expected life-span of the operating software	Years	xxxxxxxxxx	
1.13		•	Minimum expected life-span of circuit-breaker Controlled switching device	Years	xxxxxxxxxx	

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1.14		•	Device operating Algorithms:			
			Busbar VT and circuitbreaker auxiliary contacts	Y/N		
			Busbar VT and device current transformers	Y/N		
1.15		•	Relay life contact (N/C contact), to indicate the health of the relay. To be used for alarming purposes.	Y/N		
2			**Circuit-breaker ratings**			

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Annex F – Surge capacitors used for mitigation of switching overstress on 132 kV CB of the MTS feeders

1. Surge capacitors used for mitigation of switching overstress on 132 kV circuit-breakers installed on the Eskom Transmission's MTS feeders

This addresses the requirement to install the surge capacitors in order to mitigate the switching transients, that may overstress the circuit-breakers which are installed on the 88 kV and 132 kV Eskom Transmission's main transmission substation (MTS) – applicable to the candle-stick single interrupter gap (breaking chamber) design circuit-breakers.

Eskom Transmission main transmission substation (MTS) on some 132 kV and 88 kV substations is characterised by high fault level (large MVA transformation on a busbar where 132 kV breaker is installed), about 30% and above of the rated short-time withstand current or breaking capacity of the circuit-breaker, and in some short line fault (SLF) switching cases, may show increased switching transients (RRRV upon ITRV).

The substations (MTS) that record permanent sustained faults incidents (long duration faults) on 88 kV and 132 kV network have been observed that some of this type circuit-breakers, especially of the auto-puffer arc-quenching principle, including those of double-motion tend to fail to clear the fault current or take too long to clear. Most of these faults are classified by the SANS/IEC 6221-100 as Short Line Faults (SLF). The candle-stick single interrupter gap (breaking chamber) design circuit-breakers that are SF6 gas insulated have been observed affected by the severity of such. It has been noted when the circuit-breaker receives and executes the first trip command to clear or during the course of executing the ARC, that the fault clearing prolongs, which results in Busstrip operation and in some case Buszone protection triggered. Some of these failure incidents have caused interruption of supply to Eskom customers. The catastrophic failure incidents of the circuit-breaker interrupter poles have been recorded that present an undesirable risk to safety of personnel when porcelain violently explodes, and this can damage the adjacent equipment.

The recommendation to install surge capacitors came from the results of the switching studies performed on the 132 kV Witkop Nhluvuko No1 feeder circuit-breaker whereby the steepness of the ITRV, namely the Rate of Rise of Recovery Voltage (RRRV) of the Initial Transient Recovery Voltage (ITRV) was found to exceed (almost double) the SANS/IEC 62271-100 standard (3 kV/µs) [69]. The circuit-breaker gets stressed by the steepness of the ITRV (the RRRV) that exceeds its rated parameters as per SANS/IEC, and this affects the contact-gap thermal recovery and can lead to reignition which if the arc-quenching is not successful to clear that fault current, could result in circuit-breaker failure.

Eskom Transmission has had different application of surge capacitors on the 132 kV (near FCLR in Sol substation), where a simulation study [70] performed showed a need of this mitigation solution so that the mechanical switching device can cope with TRV's generated upon reactor switching application. Also this mitigation applied recently at 400 kV (near Busbar Reactor for Medupi TSS) [71]. These cases are treated as project specific, and not necessary on the wider application explained earlier. So, these types of surge capacitor application will always be treated separately from time to time when a simulation study proposes the mitigation solution and the particular rating required.

1.1 General requirements for surge capacitors

Where applicable, the Supplier shall indicate the offered circuit-breaker design limitations and then provide mitigation details for the purpose of protecting the offered circuit-breaker design from premature failure not to achieve its designed life expectancy. It is incumbent of the Supplier and OEM to provide details at tender stage of mitigation methods details, in this case to offer surge capacitors to be installed with their circuit-breaker design.

Eskom Transmission shall indicate on Schedule A the requirement for details offered circuit-breaker's switching transients (TRV and ITRV), and the Supplier shall state in Schedule B the tested ratings

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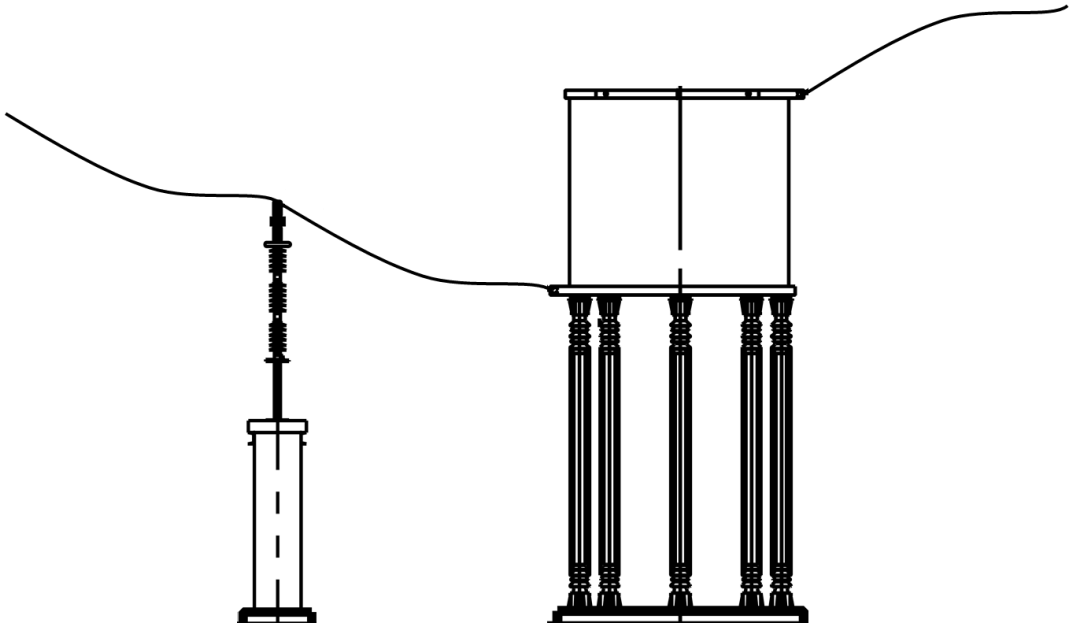

Figure E1: Typical arrangement of the surge limiting capacitor (shown near Reactor)

a. The surge capacitors shall have a steady state and transient voltage ratings that are applicable.

b. The capacitors shall comply with the rated capacitance values specified in Schedule A. The tolerance of +10%, -0% on the capacitor ratings shall be acceptable to Eskom Transmission.

c. Any solution offered shall comply with environmental requirements, for instance, the capacitors shall be free of PCB.

d. The external insulation of the capacitor should be conventional silicon rubber with a creepage distance as specified in Schedule A and shed profile meeting the minimum requirements of SANS 60815 for pollution class e (very heavy).

e. The Supplier shall provide all outline drawings, with mounting details (to Eskom Transmission standard drawing – 0.54/8829) and type test reports.

NOTE: According to the Eskom Transmission Engineering Instruction (240-180000036), these surge capacitors are applied on the feeders as it enters that MTS, as the overhead line enters the surge arrestor. To optimise, preferably surge capacitors shall be mounted sharing the same steel support structure or if the surge capacitor does not fit due to size, then install it using the Eskom standard Medium Equipment Support (MES) steel structures. (0.54/8829).

The clauses of this Eskom Transmission standard specification (240-180000572) shall also be applicable to the surge capacitors offered.

1.2 Type and Routine Tests Requirements

The routine and type tests shall be performed in accordance with SANS 60358-1 on one unit of each type and rating.

1.2.1 Routine tests

The following are tests are routine tests in accordance with SANS 60358-1. For details, reference should be made to the relevant subclauses:

a) Tightness of equipment (9.1);

b) Capacitance and tan δ measurement at power-frequency (9.2.1);

c) Power-frequency withstand test (9.2.2);

d) Measurement of partial discharges (9.2.3);

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e) Resistance measurement if resistance(s) is (are) mounted inside the equipment (9.2.5).

f) Power-frequency withstand test on low voltage terminal if applicable (9.2.4);

1.2.2 Type tests

The following tests are type tests in accordance with SANS 60358-1. The electrical routine tests have to be performed before and after the type test at 100% test voltages. For details, reference should be made to the relevant sub-clauses:

a) Chopped impulse test for a.c. equipment (10.1.2.2);

b) Power frequency withstand voltage wet test for outdoor type equipment for a.c. voltage for the voltage range Um < 300 kV (10.2.1);

c) Switching impulse test under wet conditions for a.c. voltage range ≥ 300 kV (10.2.2);

d) EMC radio interference voltage (RIV) tests, if applicable (10.3);

1.3 Transportation, Installation, Commissioning, Spares, Tools, Training and Maintenance inspection

The clauses of this Eskom Transmission standard specification (240-180000572) shall also be applicable to the surge capacitors offered.

OEM installation operation and maintenance instruction manual(s) shall cover transport, storage, installation, operation, maintenance, testing and breakdown fault-finding repairs

1.4 Documentation

The clauses of this Eskom Transmission standard specification (240-180000572) shall also be applicable to the surge capacitors offered.

Details of post insulators [material type, classification, dimensions, creepage distance, withstand voltages (power frequency, switching and lightning), mechanical strength, shed profile, top and bottom PCDs]

Technical Schedule A & B (Surge capacitor) (Generic typical example)

TECHNICAL SCHEDULES A & B FOR SURGE CAPACITOR USED WITH 132 kV OUTDOOR CIRCUIT-BREAKER MTS

THIS TECHNICAL SCHEDULE A & B FORMS PART OF SPECIFICATION 240-180000572 ANNEX E SURGE CAPACITOR USED ON 132 kV CIRCUIT-BREAKER FOR MTS 30 nF SURGE CAPACITOR PER PHASE.

SCHEDULE A: PARTICULARS OF ESKOM TRANSMISSION'S REQUIREMENTS AND

SCHEDULE B: SUPPLIER'S GUARANTEES OF TECHNICAL PARTICULARS OF EQUIPMENT OFFERED.

WHERE XXXXX IS INDICATED, THE SUPPLIER MUST COMPLETE IN SCHEDULE B.

Technical specifications				
Item	**Description**	**Units**	**Schedule A**	**Schedule B**
1	**Delivery and off-loading**			
1.1	Delivery to:		Eskom Stores	
1.2	Delivery effected upon		Purchase Order	
1.3	Off-loaded from transport vehicle by Supplier	Yes/No	Yes	

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1.4	Transferred to intended operation position (subject to Eskom Order placed)	Yes/No	Yes	
1.5	Installation	Indoor/ Outdoor	Outdoor	
2	**Quantity**			
2.1	Capacitors		12	
2.2	Spares (optional units)		4	
3	**Site installation (erection) and testing**			
3.1	To be installed and tested ready for service	Yes/No	Yes	
3.2	Training to perform installation and testing to be offered to Eskom Transmission employees	Yes/No	Yes	
3.3	Documentation for handling, storage, site installation, testing and maintenance inspection to be supplied to Eskom transmission	Yes/No	Yes	
4	**Environmental information**			
4.1	Altitude above sea level	m	1800	
4.2	Ambient temperature			
4.2.1	• Maximum	° C	45	
4.2.2	• Minimum	° C	-10	
4.2.3	• Maximum average daily temperature variation	° C	20	
4.3	Relative humidity			
4.3.1	• Minimum	%	50	
4.3.2	• Maximum	%	96	
4.4	Solar radiation			
4.4.1	• Solar radiation (on a clear day at noon)	W/m^2	1 100	
4.4.2	• Solar radiation (maximum)	W/m^2	2 600	
4.5	Wind force (loading)	m/s	34	
4.5.1	• Wind force (loading) (maximum)	Pascals/ ms^{-1}	1200/40	
4.6	Pollution			
4.6.1	• Type		Industrial/ Marine	
4.6.2	• Classification (IEC 60815)	SPS class	“e” (very Heavy)	
4.6.3	• Climatic conditions		Rain/dry/ hail/high UV radiation	
4.7	Seismic level	g	0.3	
5	**System Details**			

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5.1	Nominal system voltage (U_n)	kV	132	
5.1.1	Maximum system voltage (U_m)	kV	145	
5.2	Temporary overvoltages			
5.2.1	• For 10 min	kV	1.05 U_m	
5.2.2	• For 1 min	kV	1.25 U_m	
5.2.3	• For 5 s	kV	1.5 U_m	
5.2.4	• For 1 s	kV	1.75 U_m	
5.3	Nominal system frequency	Hz	50	
5.4	Number of phases		3	
5.5	Maximum short-circuit current level at 132 kV: Symmetrical	kA	40	
5.6	Interval between fault conditions	hr	N/A	
5.7	Frequency of short circuit application / year		N/A	
5.8	Number of switching operations / day		N/A	
6	**Type**			
6.1	Application		Mitigation of the TRV's overstress on 132 kV CB installed on the MTS	
6.2	Phases (mounting)	1Ø/3Ø	1Ø	
6.3	Does it come with support pedestal insulator base	Yes/No	xxxxxx	
7	**Capacitor Rating**			
7.1	Rated frequency	Hz	50	
7.2	Rated insulation level			
7.2.1	Rated voltage	kV	145	
7.2.2	Rated Power Frequency Withstand Voltage (PFWL) ($\boldsymbol{U_s}$)	kV	275	
7.2.3	Rated Lightning Impulse Withstand Voltage (LIWL) or (BIL) ($\boldsymbol{U_p}$)	kV	650	
7.3	Rated continuous (/ power frequency) current (I_N)	A	xxxxxx	
7.4	Rated capacitance (per phase)	nF	30	
7.4.1	tan δ measurement at power-frequency (Loss angle or Dielectric dissipation factor) (with its tolerance)		xxxxxx	
7.5	Minimum Polarisation Index (acceptable to put into service)		xxxxxx	
7.5.1	Polarisation Index (unacceptable to put in service – i.e. remove from network)		xxxxxx	
7.6	Measurement of partial discharges		xxxxxx	

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	Resistance measurement if resistance(s) is (are) mounted inside the equipment	Ohms	xxxxxx	
7.6	Natural frequency of capacitor/ reactor combination	Hz	xxxxxx	
7.7	Losses	W	xxxxxx	
7.8	Dielectric fluid		xxxxxx	
	Insulating foil		xxxxxx	
8	**Capacitor details**			
8.1	Model (Type designation)		xxxxxx	
8.2	Manufacturer		xxxxxx	
8.3	Country of manufacture origin		xxxxxx	
8.4	Expected life-span (minimum) of the surge capacitor with its support base insulator	years	> 40	
8.5	Minimum clearance between base of insulators and ground level	mm	2500	
8.6	Details of conductor, main HV terminals		xxxxxx	
8.6.1	• Conductor types		Bull (Single/ Twin)	
8.6.2	• Main HV terminal (pad/ stem) to Eskom clamping arrangement by Supplier and OEM	Yes/ No	Yes	
8.6.3	• Main HV terminal (pad/ stem)		xxxxxx	
8.6.4	• Maximum permissible loading on main HV terminals (with directions) expressed in	N	xxxxxx	
8.6.5	• Mass of one capacitor	kg	xxxxxx	
8.7	Capacitor dimensions and mounting details			
8.7.1	• Mounting details to be provided by Supplier/ OEM	Yes/ No	Yes	
8.7.2	• Connection (parallel to surge arrestor)	Attached/ mounted separately	Mounted Separately	
8.7.3	• Diameter	mm	xxxxxx	
8.7.4	• Height	mm	xxxxxx	
8.8	Dimensions of unit including support insulator pedestals			
8.8.1	• Diameter	mm	xxxxxx	
8.8.2	• Height	mm	xxxxxx	
8.8.3	Details of top PCD	mm	xxxxxx	
8.8.4	Details of bottom PCD	mm	xxxxxx	

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9	**Capacitor external insulation**			
9.1	Insulation level (BIL)	kV peak	650	
9.2	60s power frequency withstand voltage	kV rms	275	
9.3	Minimum Electrical Clearance (Un = 132kV) (Phase-To-Earth)	mm	xxxxxx	
9.4	External Creepage (minimum)	mm/kV	31	
9.5	Material	Ceramic (Porcelain)/ Silicon	Silicon	
9.6	Shed profile		xxxxxx	
9.7	Compliance to all clauses of this standard specification (240-180000572), where applicable	Yes/No	Yes	
10	**Support pedestal insulator (if offered design requires)**			
10.1	Material	Ceramic (Porcelain)/ Silicon	xxxxxx	
10.2	Type designation		xxxxxx	
10.3	Minimum creepage distance	mm	4495	
10.4	60s power frequency withstand voltage	kV rms	275	
10.5	Insulation level (BIL)	kV peak	650	
10.6	Steady mechanical load factor		xxxxxx	
10.7	Compliance to all clauses of this standard specification (240-180000572), where applicable	Yes/No	Yes	
11.	**Deviations**			

Clause	**Description of deviation**	**Proposed alternative**	**Accept/Reject**

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Annex G – Requirements for Switchgear Training from Suppliers and their OEM's

1. Switchgear Training from Suppliers and their OEM's

With respect to switchgear training for Eskom Transmission (Tx), it seeks to address skills upon various challenges experienced with the installation, testing commissioning, operating, maintenance, failure conditions and intrusive maintenance and repairs of switchgear equipment. This aims to positively impact the entire life cycle stages of switchgear plant, ensuring that it stays in service as per designed life expectancy. The trained Eskom Transmission switchgear personnel working on the equipment shall not negatively impact the warranty of the switchgear.

This is an Eskom Transmission standard training approach that all contracted Suppliers and their OEM's for switchgear are required to comply with, together with the development of the standardized training material.

This addresses the standardized approach to switchgear training from Switchgear Suppliers and Original Equipment Manufacturers (OEM's), and provides clarity to what it entails.

1.1 General Training Requirements

a. The Supplier and its OEM shall provide the OEM accredited instructors to give first-hand training of an international standard on the supplied equipment, and where applicable, including the electronic controller (Controlled Switching Device/ Point-on-Wave switching device).

b. For new contracts, a switchgear unit of the first delivery (installation) at the Grid shall be targeted by the Supplier and their OEM to provide local non-intrusive switchgear technical training within the contractual lead time, for training and quality assurance purposes. This shall form part of tender submission for switchgear contracting.

   However, for switchgear intrusive specialized training, that can be conducted at the OEM factory, with details submitted to Eskom Transmission upfront during tender submission. The pre-requisite for the higher-level training shall be the successful completion of the preceding level.

c. Switchgear training material written in English, shall be developed by the Supplier and their OEM, and submitted for approval by Eskom Transmission switchgear Task Team and Care group. This material shall be done in accordance with the offered Eskom Transmission specified switchgear.

d. The Supplier shall provide electronic controller (Controlled Switching Device/ Point-on-Wave switching device) training as a line item on the contract. This training shall cover the design, application, operation, settings, commissioning and maintenance of the device, including any applicable software.

e. There shall be a Point on wave device training before the Factory Acceptance Testing.

f. The training and training material shall comprise installation, testing and non-intrusive condition-based maintenance as part of switchgear contract and shall be provided in English.

g. Training shall be made available for the life cycle of the switchgear.

h. The intrusive training (major maintenance internal inspection and repairs upon breakdown) shall be available between the Supplier and OEM when requested by Eskom Transmission, even though this is not part of the switchgear contract phase.

i. Training shall consist of the following:

   1) Approximately 30% theoretical training and theoretical examinations thereof.

   2) Approximately 70% practical training and the practical examinations thereof.

1.2 Non-intrusive switchgear technical training (Install, Tests, Maintenance and Trouble-shooting)

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1.2.1 Description

Training for Eskom Transmission Grid personnel responsible for all aspects of installation, testing, commissioning, breakdown repairs maintenance and scheduled maintenance of switchgear and associated components.

1.2.2 Costs

This training and training material development shall be free issued with the circuit-breaker, and where applicable the surge capacitor. To manage the costs, it shall be deployed by the Supplier and OEM factory during the first installation per South African provincial boundary of CLN's of Eskom Transmission.

1.2.3 Course content covers

The training course content shall cover the following topics:

1.2.3.1 Erection/installation and commissioning testing, and condition-based maintenance inspection

a) Objective

After attending this course, the person(s) will be accredited/certified to install, set, commission and maintain the equipment(s).

b) Duration

As per Supplier and its OEM requirements.

c) Location

Eskom Transmission and Supplier with its OEM shall agree on the location. (This must be stated in the contract.). As part of training rollout during the contract period, Eskom Transmission shall make necessary arrangements for an agreed training venue in consultation with targeted audience.

d) Frequency

To be negotiated as part of the contract. This shall be a once-off training course per trainee. Re-assessment frequency shall be as per OEM requirement.

e) Course content

To be prepared by the local Supplier and the OEM factory then submitted to Eskom Transmission to ensure it meets the Learning and Development (L&D) requirements. Eskom Transmission shall approve the final revision and sign-off the copy that will be shared with Supplier.

f) Target group

- Grid Switchgear Maintenance Specialists
- Technical Support – Grid HV Plant Technical/ Engineering personnel
- Asset Management (SED) Switchgear Equipment Specialists

1.2.3.2 Electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device) – setting (configuring), installation, commissioning, testing and breakdown maintenance (troubleshooting), minor maintenance (non-intrusive, visual inspection)

a) Objective

After attending this course, the person(s) will be accredited/certified to set-up the electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device), installation and commissioning testing the circuit-breaker including all tests confirming correct functionality.

b) Duration

As per suppliers and its OEM requirements.

c) Location

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Eskom Transmission and Supplier with its OEM shall agree on the location, since this will be for circuit-breakers with electronic controller (Controlled Switching Device/ Point-on-Wave (PoW) switching device), of where it has been ordered separately. (This must be stated in the contract.). As part of training rollout during the contract period, Eskom Transmission shall make necessary arrangements for an agreed training venue in consultation with targeted audience.

d) Frequency

This shall be a once-off training course per trainee attended. Assessment for accreditation shall be as per OEM requirement.

e) Course content

To be prepared by the local Supplier and the OEM factory then submitted to Eskom Transmission to ensure it meets the Learning and Development (L&D) requirements. Eskom Transmission (Tx) PTM&C representatives switchgear care group and Switchgear Task Team, shall approve the final revision and sign-off the copy that will be shared with Supplier.

f) Target group

- Grid Secondary Plant (Test department representatives), and
- Engineering PTM&C (Design Application and Technology)
- System Operations (Secondary Plant Operations and Investigations)

1.2 Intrusive switchgear technical training (Major Maintenance and Repairs)

1.2.1 Description

Training and accreditation on intrusive internal maintenance inspection and repairs (overhauling upon breakdown) of switchgear [Also referred to as Major Overhaul Task (MOT) or Major Maintenance]. This training shall be for Eskom Transmission Grid personnel responsible for all intrusive breakdown repairs maintenance and scheduled major maintenance of switchgear and associated components.

1.2.2 Costs

This training and training material development shall be for the circuit-breaker, and where applicable the surge capacitor. The costs implications discussions shall be handled by Eskom Transmission and the Supplier.

1.2.3 Course content covers

The training course content shall cover the following topics:

1.2.3.1 Erection, commissioning, testing, breakdown maintenance (troubleshooting), minor maintenance (non-intrusive, visual inspection)

g) Name of training programme

Major Maintenance/Corrective Maintenance (Intrusive, servicing of equipment).

h) Objective

After attending this course, the person(s) will be accredited/certified to execute breakdown maintenance, minor maintenance and testing (mechanical, electrical and gas analysis or insulation medium analysis).

The OEM factory accredited Trainer will visit the Eskom Transmission accredited/certified Grid Switchgear Maintenance Specialists upon the factory specified validity of their certification/ accreditation nears expiry and requires renewal;

i) Duration

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Training to be provided as and when required.

j) Location

This training and training material development shall be for the circuit-breaker, and where applicable the surge capacitor. The location details discussions shall be handled by Eskom Transmission and the Supplier.

k) Purpose

After attending this course, the person(s) will be accredited/certified to perform intrusive maintenance and conduct training (non-intrusive Level).

l) Frequency

This shall be a once-off training course per trainee attended (Grid Switchgear Maintenance Specialist.). Assessment for accreditation shall be as per OEM requirement. Reassessment shall be as per OEM requirement.

m) Course content

To be prepared by the local Supplier and the OEM factory then submitted to Eskom Transmission to ensure it meets the Learning and Development (L&D) requirements. Eskom Transmission (Tx) switchgear care group and Switchgear Task Team, shall approve the final revision and sign-off the copy that will be shared with Supplier.

n) Target group

- Grid Switchgear Maintenance Specialist that performs maintenance and breakdown repairs;
- Asset Management (SED) Switchgear Equipment Specialists

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