Eskom	Standard	Technology

Title: **SPECIFIC REQUIREMENTS FOR DISTRIBUTION POLE AND GROUND-MOUNTED TRANSFORMERS UP TO 33 KV AND 1 MVA**

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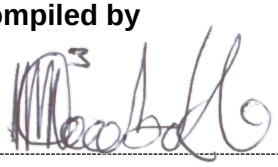

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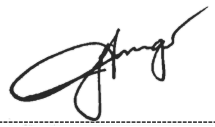

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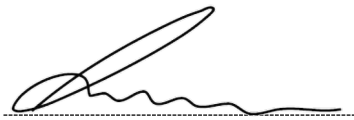

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1. Introduction

This document details specific Eskom requirement for the purpose of designing, manufacturing, and testing of pole and ground-mounted oil filled transformers with primary voltages up to 33 kV and primary ratings up to 500 kVA (pole mounted) and 1 MVA (ground mounted) (Class 0) for application in Eskom distribution systems.

This standard promotes Eskom's drive for transformers with lower losses and a lower carbon footprint. The transformers may be filled with mineral oil or natural ester oil. This requirement will be stipulated at the time of tender. Subsequently, low loss technologies; for example, amorphous cores, improved grade of core steel etc.; will be considered. A total cost of ownership will be calculated by a capitalisation formula specified in this document and used in the tender evaluation to provide a commercial incentive for lower loss designs.

The life expectancy of Class 0 transformers in the Eskom network is 25 years, and the onus is on the manufacturer to ensure that the transformers are designed and built to meet this requirement.

2. Supporting Clauses

2.1 Scope

This standard specifies the requirements for all pole-mounted (sized up to 500 kVA), ground-mounted (sized up to 1 MVA) and SWER, oil-immersed distribution and isolation transformers intended for operation at nominal primary voltages not exceeding 33 kV.

2.1.1 Purpose

This Standard details the specific requirements for pole and ground-mounted transformers up to 33 kV and 1 MVA transformers for application in Eskom Distribution systems.

2.1.2 Applicability

This document shall apply to distribution systems throughout Eskom Holdings Limited Divisions.

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

[1] ISO 9001 Quality Management Systems.

[2] SANS 60076-1 Power Transformers, Part 1: General.

[3] SANS 60076-3 Power Transformers, Part 3: Insulation levels, dielectric tests and external clearances in air.

[4] SANS 60076-5 Power Transformers, Part 5: Ability to withstand short circuit.

[5] SANS 60137 Insulated bushings for alternating voltages above 1000 V.

[6] SANS 60317-0-1 Specifications for particular types of winding wires. Part 0-1: General requirements - Enamelled round copper wire.

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

[8] SANS 780 Distribution transformers.

[9] SANS 876 Cable terminations and live conductors within air-filled enclosures (insulation co-ordination) for rated a.c. voltages from 7.2 kV and up to and including 36 kV

[10] SANS 1213 Mechanical cable glands

[11] SANS 1091 National Colour Standard

[12] 240-75661431 Mineral insulating oils (uninhibited and inhibited) Part 1: Purchase, management, maintenance and testing.

[13] 240-75661043 Services Section 3: Outdoor Low-Voltage Services for Small Power Users and Large Power Users Standard

[14] D-DT-0864, Transformer Plinths for 100 kVA-1000 kVA Transformers

[15] D-DT-3070, Cable glands

[16] D-DT-3088, Neutral surge arrester 6kV 10 kA

[17] D-DT-3202, Warning signs

[18] D-DT-8019, Clamp, cable polypropylene black

[19] D-DT-8027, Rubber grommet

[20] D-DT-8022, Ground-mounted distribution transformers

[21] 240-75655452 Procedure for the Handling and Transportation of Distribution Transformers up to 500kVA and 33kV

[22] 240-75655504,. Corrosion Protection Standard For New Indoor And Outdoor Eskom Equipment, Components, Materials And Structures Manufactured From Steel Standard

[23] 240-142598739 Rescinding Of KIPTS Testing As Mandatory Requirement And Guidance On Technical Standards Applicable For Pollution Related Qualification Of High Voltage Equipment

[24] 240-42837724 Transformer Specification for Amorphous Core Pilot Project

[25] IEC 62730 Tracking and Erosion Testing by Wheel Test and 5000 Hour Test

[26] IEC 62770:2013 Standard; Fluids for electro technical applications - Unused natural esters for transformers and similar electrical equipment.

[27] 240-141429838 Engineering Bulletin Regarding Changes to Pole And Ground Mounted Transformers

[28] 240-151534440 Loss Factors for Procurement Of Transformers (2019 Calculation)

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

[30] IEC 60507 Artificial pollution tests on high-voltage ceramic and glass insulators to be used on a.c. systems

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

The definitions in SANS 780 and NRS 000 apply to this standard. In addition, the following definitions will apply:

Definition	Description
Class 0	Transformers with a power rating ranging from 0.001 MVA to 1 MVA and voltage ratings from 200V to 22kV, including 33kV for Eskom systems.
Psophometer	An instrument that provides a visual indication of the audible effects of disturbing voltages of various frequencies.

2.3.2 Disclosure Classification

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

2.4 Abbreviations

The abbreviations in SANS 780 apply to this standard. In addition, the following abbreviations will apply:

Abbreviation	Description
BIL	Basic Insulation Level
CCITT	Consultive Council for International Telegraphy and Telephony
GMT	Ground Mounted Transformer
IV	Intermediate Voltage
KIPTS	Koeberg Insulator Pollution Test Station
LPU	Large Power Users
LV	Low Voltage
MV	Medium Voltage
ONAN	Oil Natural Air Natural
OU	Operating Unit
SWA	Steel Wired Armoured
SWER	Single Wire Earth Return
U_m	Maximum system voltage in kV
U_n	Nominal primary voltage in kV

2.5 Roles and Responsibilities

All the Eskom employees and/or appointed bodies involved in the procurement of transformers and/or the associated accessories shall ensure that the product meets the requirements of this standard. Any deviation from these requirements shall constitute a non-conformance, unless it was agreed to in advance by a delegated Eskom transformer specialist in writing and is based on sound engineering judgement.

All Suppliers supplying transformers to Eskom must be conversant with the requirements of this standard and shall comply with the requirements. All deviations shall be clearly listed in the deviation Schedule as part of the tender deliverables.

No deviations will be accepted unless approved by Eskom in writing. Suppliers shall ensure that they get clarity where required and that they have all the supporting information or documents necessary to demonstrate compliance with this document.

The Eskom designated Transformer Specialist shall be responsible for ensuring the validity of this document.

2.6 Process for Monitoring

Distribution Technology and Engineering must ensure that this document is updated, renewed and current at all times.

2.7 Related/supporting Documents

This revision cancels and replaces the last published revision of the following documents DSP 34-1627, DSP 34-342, DSP 34-343, DSP 34-344, DSP 34-345 and DSP 34-346.

The Schedules A of the Schedule A and B does not form part of this standard and will be issued as a separate document at the time of tender. In cases of the two documents conflicting, the Schedules A of the Schedule A and B shall take precedence to this standard.

3. Requirement

3.1 General

a) The rated primary and secondary voltages are:

Table 1: Standard Voltage Requirements

1	2
Maximum system voltage U_m [kV]	**Nominal primary voltage U_n [kV]**
<1	<1
3.6	3.3
7.2	6.6
12	11
24	22
36	33
	No-load secondary voltage [V]
Single-phase	242
Dual-phase	± 242
Three-phase	420

b) The SWER voltage requirements are stated in Section 3.2.4.2.

c) Refer to Annex C for unique requirements related to IV transformers rated at 3.3kV.

d) The life expectancy of Class 0 transformers in the Eskom network is 25 years, and the onus is on the manufacturer to ensure that the transformers are designed and built to meet this requirement.

e) This standard shall be read in conjunction with SANS 780 and Eskom's standard shall take precedence in cases of conflicting requirements.

f) The transporting and handling of all transformers should be carried out in accordance with

240-75655452.

g) All transformers must carry a 36-month warranty from the date of manufacture, effective from the date of handover unless otherwise stipulated in the relevant contractual agreement.

h) Transformers shall be hermetically sealed.

i) Transformers shall be of the oil immersed type.

1) Where mineral oil filled transformers are required, the oil shall be compliant with the Class C oil specification as specified in the Eskom standard: 240-75661431.

2) Where natural ester oil filled transformers are required, the oil shall be compliant with the IEC 62770:2013 Standard. Furthermore, the natural ester oil must be biodegradable and non-toxic in water and soil.

j) Oil filling and impregnation of the cellulose insulation must be done under full vacuum. The supplier must provide method statements and documentation to prove that the temperatures, vacuum and impregnation time is suitable for the application. This will be verified by Eskom at the factory accreditation stage.

k) The onus is on the supplier to ensure that all materials used in the manufacture of the transformers are compatible with each other. This requirement is of particular importance in natural ester oil filled transformers.

l) Oil level gauges are not required; however, the supplier must prove that the oil level is sufficient such that it always covers all the live parts adequately for the voltage concerned. The oil level must be suitable for fluctuations in load from no load to 200% and must cater for the drop in oil level when the tank expands. The supplier will be required to prove that this criterion is met at the design review stage via calculations and experimental results.

m) The transformer cooling method shall be ONAN.

n) MV insulation levels (for the transformer windings and connected parts) shall be in accordance with “List 3” as given in SANS 780 Table 3.

o) Winding tapping connections shall be provided (unless otherwise indicated as not required).

p) No overload protection shall be provided.

q) The pole mounted transformer bushings shall comply with the relevant requirements of SANS 60137. The minimum specific creepage distance for all transformer bushings shall be 31mm/kV as specified for “Heavy to Very Heavy” site pollution severity class as per SANS 60815-1.

r) The ground mounted transformer bushings shall comply with the relevant requirements of SANS 876.

s) No optional fittings shall be provided.

3.2 Electrical Requirements

3.2.1 Power Ratings for Pole-Mounted Transformers

Single phase	16 kVA
Dual phase	32 kVA & 64 kVA
Three phase	25 kVA, 50 kVA, 100 kVA, 200 kVA, 315 kVA & 500 kVA

3.2.2 SWER Transformers

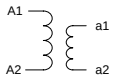
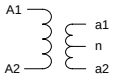
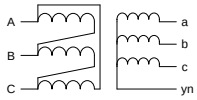
Single phase	16 kVA
Dual phase	32kVA & 64 kVA
Isolation	50kVA, 100kVA, 200 kVA & 400 kVA

3.2.3 Ground-Mounted Transformers

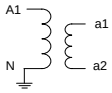
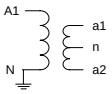
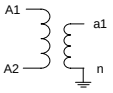
Three phase	100 kVA, 200 kVA, 315 kVA, 500 kVA & 1 MVA.

3.2.4 Winding Configuration

3.2.4.1 Pole and Ground- Mounted Transformers (Excluding SWER):

Single-phase – Primary: Phase-to-phase connected single phase winding • Secondary: Phase-to-phase connected single phase winding	
Dual-phase – Primary: Phase-to-phase connected single phase winding • Secondary: Centre tapped single phase winding	
Three-phase – Primary: Delta or Star connected three phase winding • Secondary: Star or Zigzag connected single phase winding • i.e. Dyn11 or Yzn11	

3.2.4.2 SWER Transformers:

Single-phase – Primary: Phase-to-neutral connected single phase winding • Secondary: Phase-to-phase connected single phase winding	
Dual-phase – Primary: Phase-to-neutral connected single phase winding • Secondary: Centre tapped single phase winding	
Isolation – Primary: Phase-to-phase connected single phase winding • Secondary: Phase-to-neutral connected single phase winding	

The SWER isolation transformer shall be constructed such that the secondary winding (SWER winding) is located on the inside, next to the core and the primary winding is located on the outside, see Figure 1.

SWER single-phase and dual phase transformers primary phase-to-neutral voltage shall be 19 kV.

SWER isolation transformer secondary phase-to-neutral voltage shall be 19 kV.

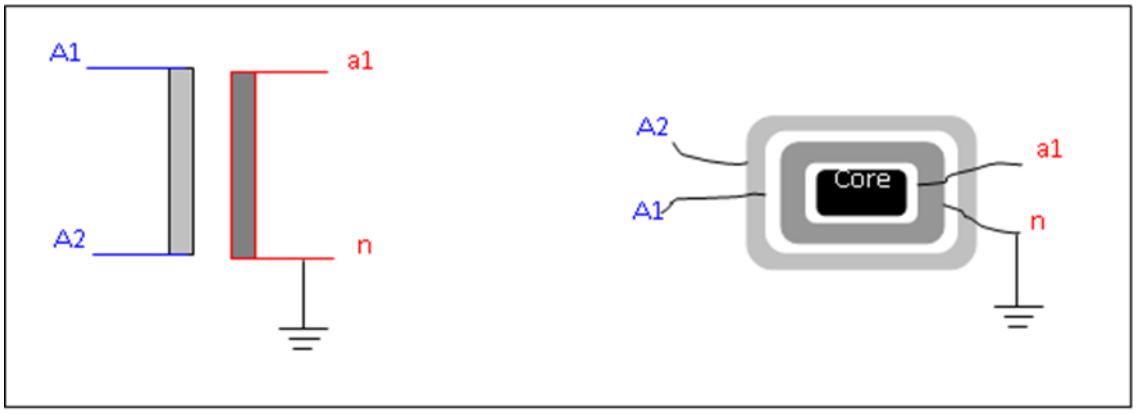


Figure 1: SWER Isolation Transformer Winding configuration

The 19 kV terminal (a1) of the secondary winding shall be connected to the “core-side” of the winding and the neutral terminal (n) shall be connected to the other side of the winding, nearest to the inter-winding insulation, see Figure 2.

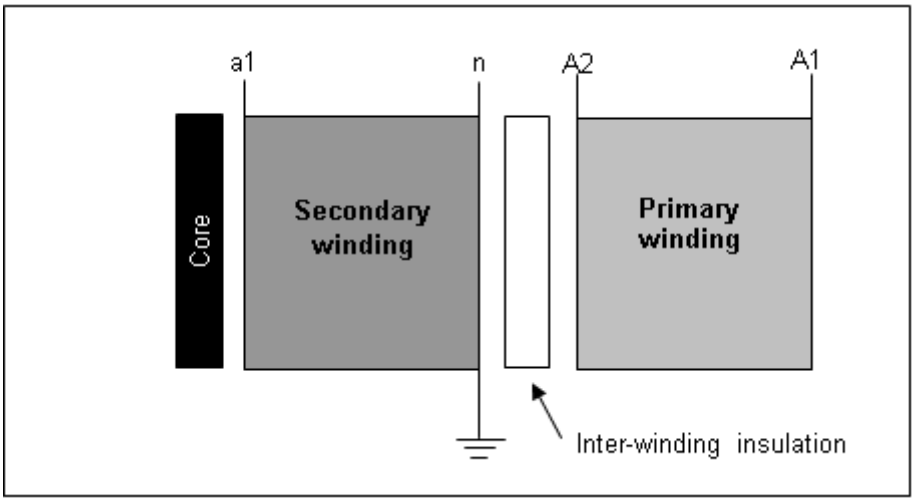


Figure 2: SWER Isolation Terminal arrangement

3.2.5 Insulation Levels

The insulation levels shall be in accordance with Table 2.

Table 2: Standard Insulation Levels

1		2	3	4
Maximum system voltage U_m [kV]		**Nominal primary voltage U_n [kV]**	**BIL [kV]**	**60 seconds power-frequency withstand voltage [kV]**
<1		<1	30	8
3.6		3.3	60	16
7.2		6.6	75	22
12		11	95	28
24		22	150	50
36		33	200	70
		No-load secondary voltage [V]	**BIL [kV]**	**60 seconds power-frequency withstand voltage [kV]**
Single-phase		242	30	8
Dual-phase		± 242	30	8
Three-phase		420	30	8
SWER Isolation	**Line terminal**	33 000 (Note 1)	200	70
	Neutral terminal	-	30	8

Note 1: The rated no-load secondary voltage shall be 19 kV (phase to ground). The 33 000 V stated in the above Table 2 is indicated to stipulate the required BIL.

3.2.6 Transformer Oil, Handling and Oil Impregnation

Transformers shall be of the oil immersed type.

1) Where mineral oil filled transformers are required, the oil shall be compliant with the Class C oil specification as specified in the Eskom Standard: 240-75661431.

2) Where natural ester oil filled transformers are required, the oil shall be compliant with the IEC 62270:2013 Standard.

Every effort must be made to handle and store oil appropriately and according to methods prescribed by the oil supplier. This is especially critical for natural ester oil and the supplier must ensure that there will be no cross contamination of natural ester oil with any other oil at any point in the transformer manufacturing process. Due to the oxidation stability of the natural ester oil, the exposure of the natural ester oil to oxygen must be kept to a minimum. This will be verified by Eskom at the factory accreditation stage.

Oil filling of the transformer and oil impregnation of the cellulose insulation must be done under full vacuum in an autoclave oven. The supplier must provide method statements and documentation to prove that the temperatures, vacuum and impregnation time is suitable for the application. This is a critical process for Eskom and special attention will be paid to this process at the factory accreditation stage.

The onus is on the supplier to ensure that all materials used in the manufacture of the transformer are compatible with each other. This requirement is off particular importance in natural ester oil filled transformers.

3.2.7 Electrical Clearances

Transformers must be designed with sufficient safety margins and clearances to accommodate for the stresses posed by over voltages and fast transients on overhead networks. The manufacturer will have to prove via design reviews that adequate measures have been taken to ensure a robust and efficient design.

The minimum external air clearances between the live metal parts of bushing and the corresponding parts of adjacent bushing and any earthed metal shall be twice the numerical value of appropriate lighting impulse test voltage given in column 3 of Table 2.

3.2.8 Inter-turn Winding Insulation

The wire insulation shall be either enamel or paper insulation.

The enamel wire insulation for 3.3, 6.6,11, 22 and 33 kV windings shall be Grade 3 or better, as defined in the SANS 60317-0-1. Paper tape covered wire for 6.6,11, 22 and 33 kV windings shall have a minimum covering of 0.125 mm, a minimum impulse withstand of 21 kV and a minimum power frequency withstand of 8 kV between turns.

The inter-turn winding insulation stress shall not exceed 5 kV/mm.

3.2.9 Interlayer Winding Insulation

The interlayer stresses shall not exceed 5 kV/mm in any part of the winding. This parameter is an absolute upper limit.

The interlayer stress for the non-tap part of the winding shall be calculated as follows:

$$\boldsymbol{ils} = \frac{\boldsymbol{tpl} \times 2 \times \boldsymbol{vpt}}{\boldsymbol{lit} \times 1000}$$

Where: ils = interlayer stress [kV/mm]

tpl = turns per layer

vpt = volts per turn [V]

lit = layer insulation thickness [mm]

The highest interlayer stress in the tap part of the winding will occur in the layer between tap connections 4 and 5 and when the tapping switch is in position 5, see Figure 3. The interlayer stress for this configuration shall also not exceed 5 kV/mm.

The highest interlayer stress for the non-tap part and tap part of the winding shall be calculated and shall be provided in the tender documentation.

3.2.10 Tap Connections

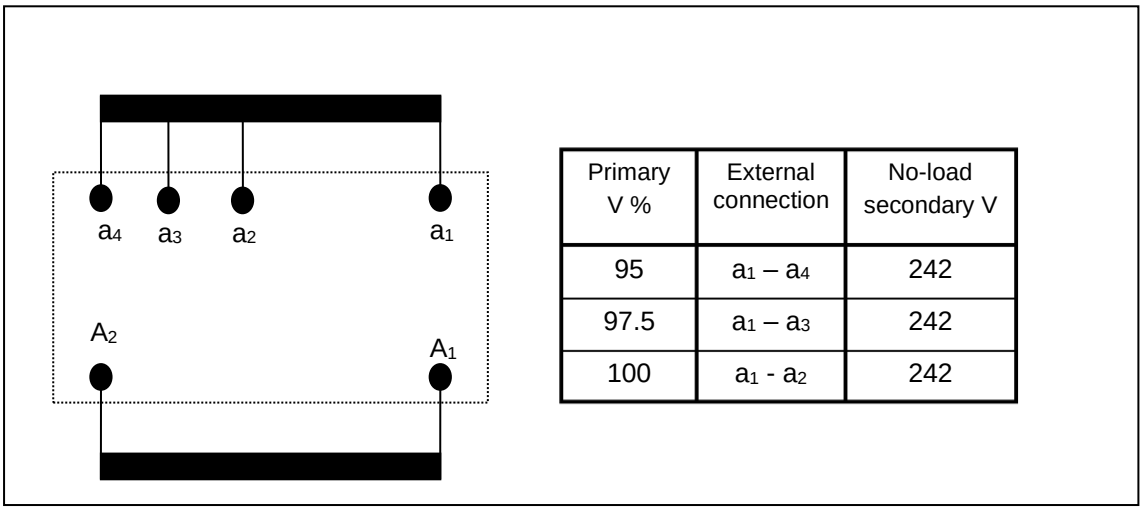
3.2.10.1 The tapping connections shall be in accordance with SANS 780.

3.2.10.2 The LV centre-tap terminal on dual-phase transformers shall have the same current rating and be of the same type as the line terminals.

3.2.10.3 No tap connections shall be provided on SWER isolation transformers.

3.2.10.4 External Tapping Connections

Single-phase transformers shall have a tapping range of 0 %, + 2.5 %, + 5 %, achieved by means of external taps. The external taps and labelling shall be as indicated in Figure 3.



Primary V %	External connection	No-load secondary V
95	$a_1 – a_4$	242
97.5	$a_1 – a_3$	242
100	$a_1 - a_2$	242

Figure 3: Single-phase external tapping connections

3.2.10.5 Off-Circuit Tapping Switch

Three-phase and dual-phase transformers shall have a tapping range of –5 %, –2.5 %, 0 %, +2.5 %, +5 %, achieved by means of an off-circuit tapping switch.

The operation of the off-circuit tapping switch shall be such that by turning the handle clockwise the tap position number is increased, as indicated in Table 3, and the off-circuit tapping switch must be located on the LV side of the transformer tank.

Table 3: Three-phase and dual-phase off-circuit tapping switch connection

1	2	3	4
Tap position number	**Primary voltage %**	**No-load secondary voltage [V]**	
		Three-phase	**Dual-phase**
1	105	420 V	a1 to a2 = 484 and a1 or a2 to n = 242
2	102.5		
3	100		
4	97.5		
5	95		

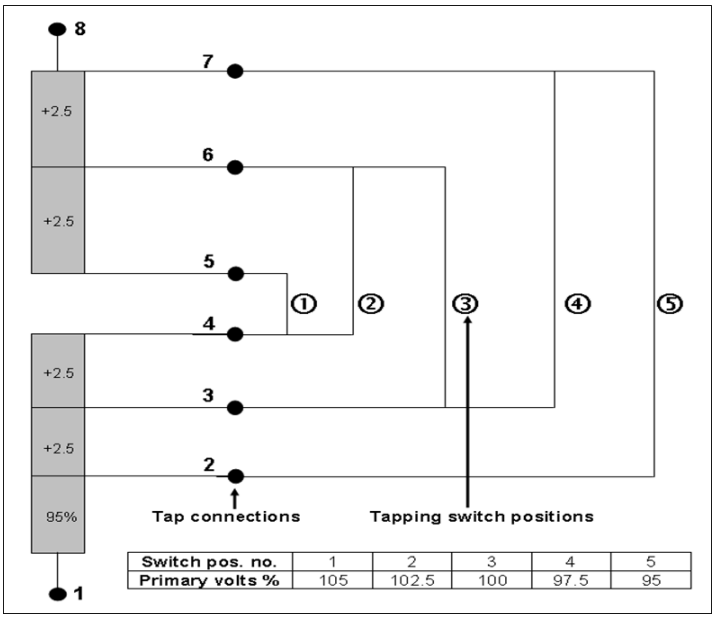


Figure 4: Off-circuit tapping switch connections

Note 2: That the tapping configuration illustrated in Figure 4 is an example. Alternative configurations may also be considered, provided that the necessary details are provided in the tender documentation.

3.2.11 Bushings for Pole-Mounted Transformers

The bushings for pole-mounted transformers shall comply with the relevant requirements of SANS 60137. All insulator housing shed profiles shall conform to SANS 60815, “Selection and dimensioning of high voltage insulators intended for use in polluted conditions”.

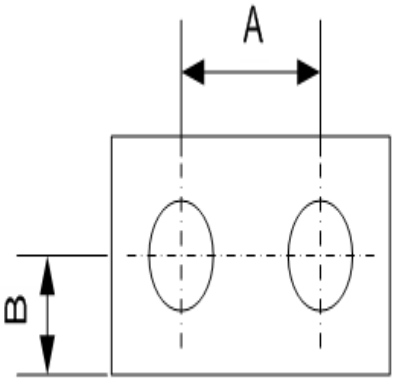
The minimum specific creepage distance for all transformer bushings shall be 31 mm/kV as specified for “Heavy to Very Heavy” site pollution severity class as per SANS 60815.

Lid mounted bushings are not acceptable. All bushings shall be side wall mounted. The bushing design drawings shall indicate the minimum tank wall thickness.

Medium voltage bushings shall be clamped at the base of the bushing. The bushing base clamp applied to the MV bushing must ensure that there is no excessive mechanical load applied to the bushing collar. Clamping forces must be distributed over the area of the bushing collar thereby eliminating point loading.

MV and LV bushing stems must accommodate M12 connection fittings. The connecting end stem and hardware of the LV and MV bushing must be compatible with jumper connecting hardware. Compatibility includes consideration of dimensions and material selection.

The LV bushings for all MV Pole Mounted transformers shall be supplied with a flag. The flag shall have two holes and the dimensions shall be in accordance with Figure 5. Each hole shall be fitted with an M12 set screw, 2 x flat washers, a spring washer and a nut. The set screw lengths shall be 40 mm for the 100 kVA, 200 kVA and 315 kVA transformers and 50 mm for the 500 kVA transformers.



	100 & 200 kVA	315 & 500 kVA
A (min)	25 mm	35 mm
B (min)	16 mm	20 mm

Figure 5: Bushing flag dimensions

3.2.12 Ground-Mounted Transformers: MV and LV Cable termination enclosures and Bushings

3.2.12.1 MV Cable Termination Enclosure

3.2.12.1.1 The MV cable termination enclosure shall be air filled and shall be positioned on the side of the transformer tank.

3.2.12.1.2 Fasteners used to secure the cable termination enclosure gland plate and front cover shall be stainless steel.

3.2.12.1.3 The MV cable termination enclosure shall be in accordance with the requirements of SANS 876 for the termination type given in **Table 4.**

Table 4: Type of MV cable termination in accordance with SANS 876

1	2
Rated voltage (kV)	**Cable termination type (SANS 876)**
12	Type 4
24	Type 4
36	Type 4
Note 3: It is assumed that a three-core MV cable is to be terminated into the cable termination enclosure. (Single-core or three-core MV cables Al and Cu can be terminated).	

3.2.12.1.4 An earthing terminal in accordance with clause 3.3.7 shall be welded to the centre of the side wall of the MV cable termination enclosure at a height of 100 mm from the gland plate.

3.2.12.1.5 The MV cable termination enclosure gland plate shall be removable and designed in such a way that, once removed, the entire bottom of the cable termination enclosure is open i.e., the bottom of the cable termination enclosure shall form the gland plate. The gland plate shall have a pre-drilled/punched cable entry hole of 110 mm diameter that is positioned below the attachment point of the centre phase bushing. The hole shall be fitted with a rubber grommet in accordance with D-DT-8027.

Note 4: The primary function of the rubber grommet is to seal the cable entry into the MV cable termination enclosure.

3.2.12.1.6 Dimensions between bushing centres (i.e. phase-to-phase and phase-to-ground) within the MV cable termination enclosure shall be as indicated in **Figure 7** for all voltage levels.

Note 5:

1) Clearances within the MV cable termination enclosure are based upon the requirements of SANS 876.

2) At 11 kV, 22 kV and 33 kV screened separable connectors shall be used.

3) Unless otherwise specified in Schedule A of the enquiry document, the dimensions of the separable connectors shall be assumed to be as indicated in Figure 6.

3.2.12.1.7 A polypropylene cable support clamp in accordance with Eskom drawing D-DT-8019 shall be provided below the MV cable termination enclosure for supporting the MV cable. The clamp shall be suitable for a cable with outer diameter in the range of 50 - 75 mm. The centre of the clamp (i.e. when a cable of diameter 75 mm is installed) shall be positioned to correspond with the centre of the cable entry hole in the gland plate.

3.2.12.1.8 The depth of the cable box (i.e. front to back) shall be at least 350 mm as indicated in **Figure 7**.

Note 6: The depth of the cable box is specified in order to make provision for the possible installation of surge arresters onto the back of the cable connectors.

3.2.12.1.9 An MV warning sign in accordance with D-DT-3202 shall be fitted to the cover/lid of the MV cable termination enclosure. If pop-rivets are used to attach the sign to the cover, only aircraft pop-rivets will be acceptable. Normal pop-rivets are not acceptable.

3.2.12.2 LV Cable Termination Enclosure

3.2.12.2.1 The LV cable termination enclosure shall be air filled and shall be positioned on the side of the transformer tank.

3.2.12.2.2 Fasteners used to secure the cable termination enclosure gland plate and front cover shall be stainless steel.

3.2.12.2.3 The LV cable termination enclosure shall have one bushing per phase and shall be suitable for the termination of the type and number of cables specified in column 2 of **Table 5**, unless otherwise specified in Schedule A of the enquiry document. The minimum clearance (i.e. 60 mm between live metal phase-to-phase and phase-to-earth), indicated in **Figure 8**, shall be maintained taking into account the lugs, flag orientation (if applicable) and fasteners required to connect the cable to the bushing.

3.2.12.2.4 The LV bushings of transformers rated ≥200 kVA shall be supplied with a copper flag suitable for connection of the number of LV cables specified in **Table 5**. A minimum of two M12 holes shall be provided for the connection of the individual LV cables. Where more than two LV cable lugs are to be terminated per phase, they may be connected to either side of the flag as shown in **Figure 9**. Each hole provided shall be fitted with a suitably dimensioned M12 set screw, nut, washer and spring washer. The current density of flags shall not exceed 2 A/mm^2 for rated currents up to and including 630 A and 1.6 A/mm^2 for rated currents greater than 630 A.

3.2.12.2.5 An earthing terminal in accordance with 3.3.7 shall be welded to the centre of the side wall of the LV cable termination enclosure adjacent to the LV neutral bushing as shown in **Figure 8**.

3.2.12.2.6 A surge arrester in accordance with Eskom drawing D-DT-3088 shall be mounted on the earthing terminal in the LV cable termination enclosure and shall be connected to the neutral bushing terminal. In addition, an electrolytic copper conductor with a cross-sectional area of at least 70 mm^2 shall be fitted in parallel with the surge arrester as shown in **Figure 8** to provide an electrical bridge between the earthing terminal and the LV neutral bushing. The position of the surge arrester and bridging conductor shall not interfere with the connection of the LV cables.

Note 7: According to the Eskom earthing philosophy, if the MV and LV earth electrodes are to be separated on site, the electrical bridge between the earthing terminal and the LV neutral bushing would then be removed as required, and the neutral surge-arrester would become effective.

3.2.12.2.7 A removable, non-conductive gland plate shall be provided as indicated in **Figure 10**. The gland plate shall make provision for the fitting of cable glands by providing pre-punched gland holes suitable for the

termination of the type and number of cables given in **Table 5**. The number and diameter of holes corresponding to the type and size of associated cable glands are given in **Table 5**. The clearance associated with each hole is given in **Table 5**. Where it is indicated that single-core cables are to be used, the gland plate holes shall be aligned with the bushing centres. If the number and diameter of holes to be provided differs from that given in **Table 5** the corresponding details shall be specified in Schedule A of the enquiry document.

Table 5: LV Cable termination arrangement and gland plate hole requirements

Transformer Rating (kVA)	Size and type of LV Cu Cable	Size and type of LV AL Cable	Number of cable gland holes	Cable gland type and size (see D-DT-3070)	Size of gland hole and clearance around hole (mm)
25 kVA	70 mm^2 Cu 4-core PVC/SWA/PVC	120 mm^2 Al 4-core PVC/SWA/PVC	1	Adjustable Mechanical No. 5	Ø 65 mm (hole), Ø 100 mm (clearance)
50 kVA	70 mm^2 Cu 4-core PVC/SWA/PVC	120 mm^2 Al 4-core PVC/SWA/PVC	1	Adjustable Mechanical No. 5	Ø 65 mm (hole), Ø 100 mm (clearance)
100 kVA	70 mm^2 Cu 4-core PVC/SWA/PVC	120 mm^2 Al 4-core PVC/SWA/PVC	1	Adjustable Mechanical No. 5	Ø 65 mm (hole), Ø 100 mm (clearance)
200 kVA	70 mm^2 Cu 4-core PVC/SWA/PVC	120 mm^2 Al 4-core PVC/SWA/PVC	2	Adjustable Mechanical No. 5	Ø 65 mm (hole), Ø 100 mm (clearance)
315 kVA	150 mm^2 Cu 4- core PVC/SWA/PVC	185 mm^2 AL 4- core PVC/SWA/PVC	2	Adjustable Mechanical No. 7	Ø 65 mm (hole), Ø 100 mm (clearance)
500 kVA	150 mm^2 Cu 4- core PVC/SWA/PVC	185 mm^2 AL 4- core PVC/SWA/PVC	3	Adjustable Mechanical No. 7	Ø 65 mm (hole), Ø 100 mm (clearance)
1000 kVA	500 mm^2 Cu 1-core PVC/PVC (unarmoured)	Not applicable	7 (2 per phase, 1 for neutral)	Compression Type A2 No. 5	Ø 50 mm (hole), Ø 85 mm (clearance)

Note 8: The number, type and size of LV cables are based upon the standard LPU meter panel service cable requirements in accordance with DST 240-75661043.

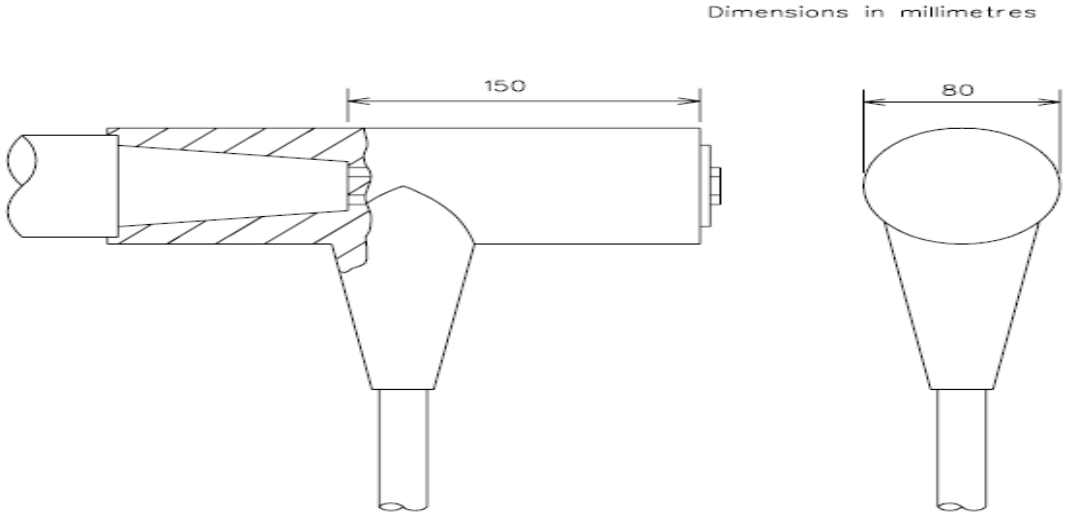


Figure 6: Typical Dimensions for Screened separable Connectors

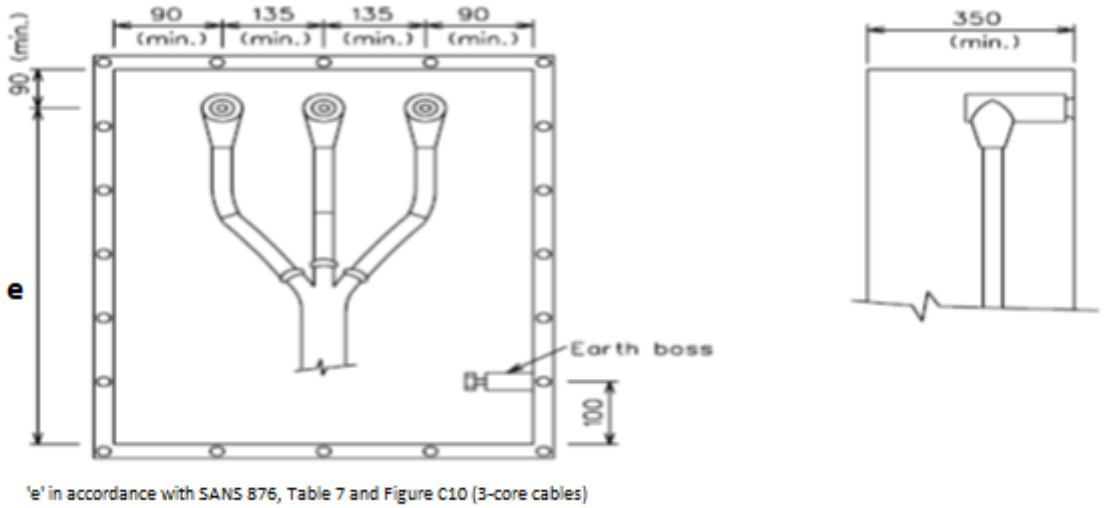


Figure 7: MV cable termination enclosure dimensions

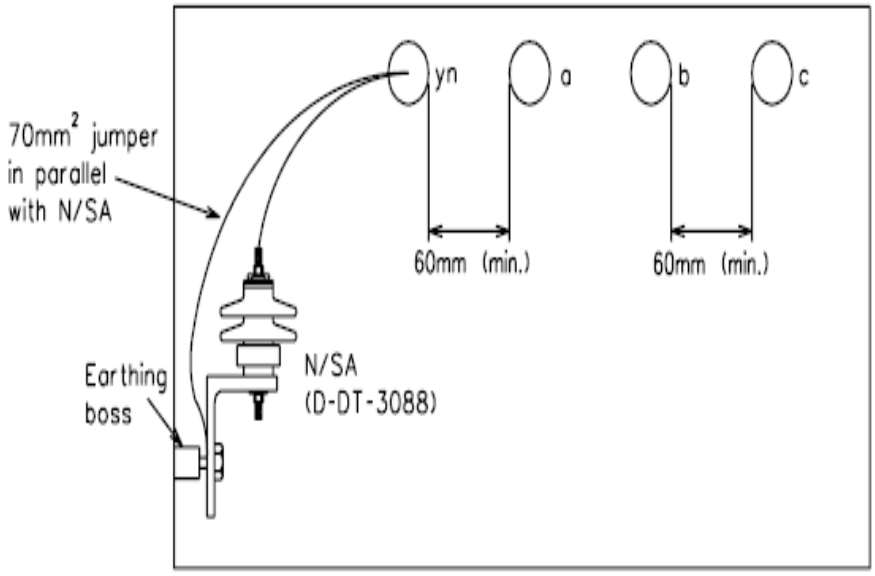


Figure 8: LV cable termination enclosure

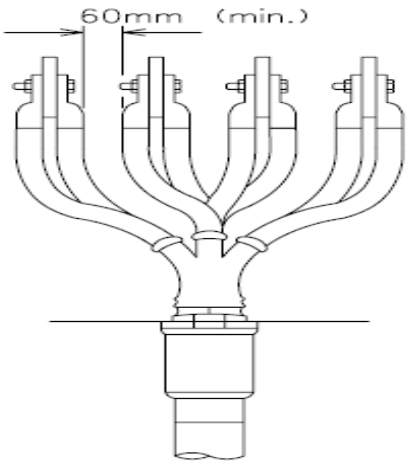


Figure 9: Correct connection of back-to-back LV cable onto a bushing flag

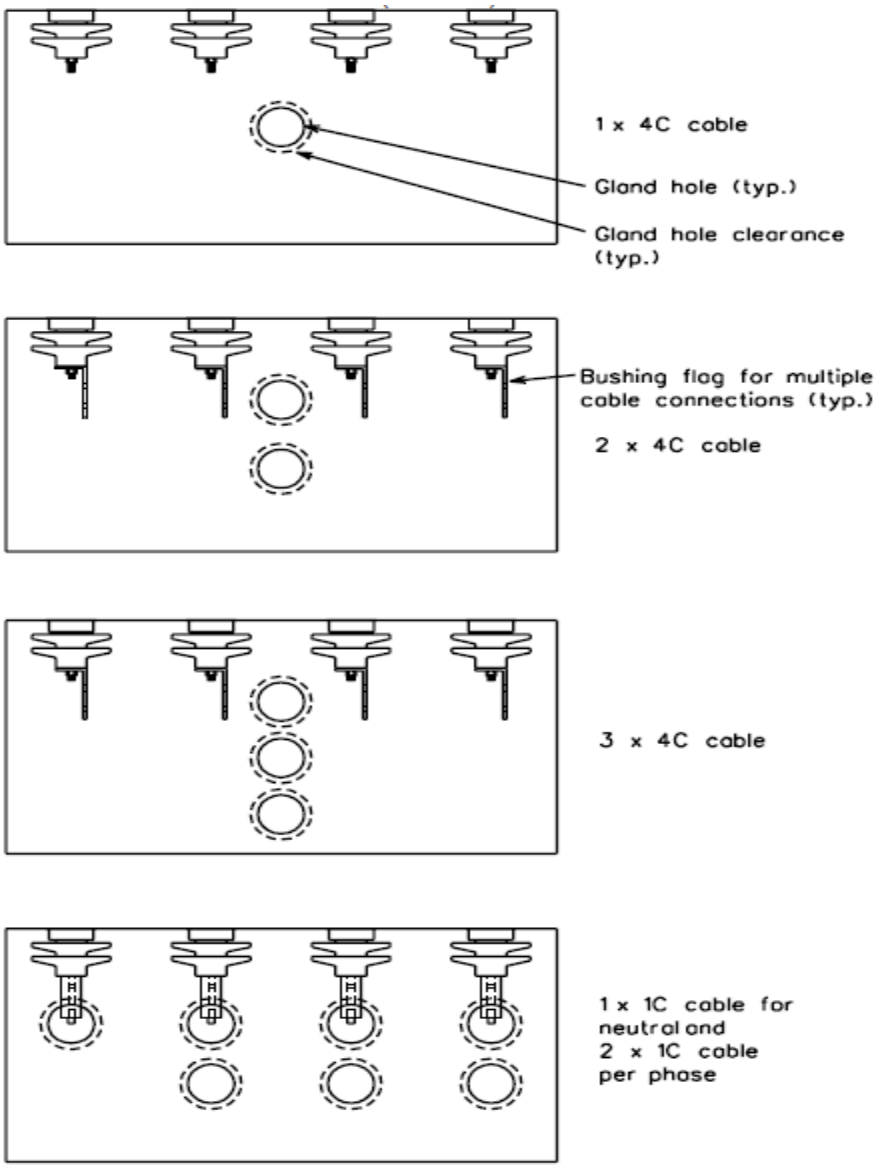


Figure 10: LV gland plate and bushings flag detail

3.2.13 Imbalance

Dual-phase transformers shall be capable of operating continuously with 100 % phase imbalance on the LV winding.

3.2.14 Losses

The following capitalisation formula will be used in the tender evaluation to provide a commercial incentive for lower loss designs.

$$Total\ cost = A + \text{NLLF} \times P_{\text{NL}} + \text{LLF} \times P_{\text{LL}}$$

where:

A = Cost of purchasing the transformer, R

P_{NL} = No-load losses, kW

P_{LL} = Load loss, kW

NLLF = No-load Loss Factor, R/kW

LLF = Load Loss Factor, R/kW

The economic life of a transformer is assumed to be 25 years.

The loss factors are calculated in accordance with the latest version of Eskom engineering instruction 240-151534440. As the loss factors change with the cost of electricity, NLLF and LLF will be confirmed at the tender stage.

Regardless of the use of the capitalization formula, the losses shall not be greater than those given in SANS 780 and Table 6 and Table 7 below.

Table 6: Maximum losses for conventional dual-phase transformers

1	2			3
Power rating kVA	**No-load loss W**			**Load loss W**
	Primary voltage kV			
	Up to 12 kV	**22 kV**	**33 kV**	
32	130	170	190	630
64	210	260	290	1200

Table 7: Maximum losses for SWER transformers

1	2			3
Power rating kVA	**No-load loss W**			**Load loss W**
	Primary voltage kV			
	11 kV	**22 kV**	**33 kV**	
16	-	-	100	400
32	-	-	170	630
64	-	-	260	1200
200	520	600	650	2700
400	910	990	1040	4500

The no-load loss, load loss, percentage impedance and X/R ratio shall be stated in Schedule B of an enquiry document. The load losses and the percentage impedance shall be stated at 75 °C, in accordance with SANS 780.

Losses stated in tender documents must be accompanied with a test report demonstrating the guaranteed loss values are achievable. Eskom reserves the right to implement penalties if guaranteed losses are breached during the contract period.

3.3 Physical Requirements

3.3.1 Constructional Fittings

All units shall be hermetically sealed and as such, the following constructional fittings are **not acceptable**:

- Drain plug.
- Drain valve.
- Oil-filling pipe.
- Conservator.
- Dehydrating breather and breather pipes.
- Oil-level gauge.

3.3.2 Tank, Tank Cover and Radiators

Transformer tanks shall be hermetically sealed and may be either rigid or corrugated. Tank covers shall be welded, bolted covers are not acceptable.

Radiators shall not obstruct the connection path of cables.

Radiator dimensions shall be in accordance with Figure 11.

3.3.3 Transformer Dimensions

The transformer outline dimensions and total mass shall be in accordance with Figure 12.

For pole-mounted transformer up to 200 kVA the Overall Maximum Length (Lo) is to be restricted to allow for platform on an H-Pole structure when radiators are included.

For 315 kVA and 500kVA pole-mounted transformers, D-DT-1864 will apply. Transformer dimensions are to be restricted to allow for mounting accordingly.

3.3.4 Pole Mounting Brackets

Pole-mounted transformers rated at 100 kVA and less shall be designed for single pole mounting and shall be equipped with a top and bottom mounting bracket in accordance with Figure 13. Each bracket shall be supplied with a clamp and two (M20 x 250 mm) threaded rods.

In addition, the top bracket shall be supplied with a (M20 x 350 mm) threaded rod.

Each threaded rod shall be supplied with two nuts, two flat washers and two spring washers. The clamps, threaded rods, flat washers, spring washers and nuts shall be hot dipped galvanized.

Single pole, mounting brackets shall be positioned in accordance with Figure 12. A minimum mechanical clearance of 100 mm between any brackets and/or LV bushings shall be maintained.

3.3.5 Transformer Under Base

All three phase pole-mounted transformers rated at 25 kVA and above shall be designed for platform mounting and shall be equipped with an under base in accordance with Figure 15 .

Ground-mounted transformers must be supplied with skid under bases suitable for installation on concrete plinths of dimensions conforming to per DDT 0864 and see Figure 13.

The overall Length and Width of the Ground-mount Transformer cannot exceed the under base dimensions as stated relevant drawings.

3.3.6 Lifting Lugs

Lifting lugs shall be so fitted and positioned as to permit the complete assembled transformer (filled with oil) to be lifted vertically without the aid of a sling spreader.

The lifting lug hole diameter shall be at least 30 mm. A safety factor of at least 2.5 per lug shall apply.

3.3.7 Earthing Terminals

Earthing terminals shall comprise of a 316 stainless steel or mild steel earth boss, welded to the tank. The boss shall be a minimum of 30 mm deep and shall be fitted with a M12 x 25 mm, 316 stainless steel or galvanized mild steel set screw, washer and spring washer. This is applicable to Pole and Ground-mounted units.

The set screw must be removable to cater for the installation of the earthwire lug. The earth boss and the set screw material must be compatible. Once torqued, the set screwed must not seize in the earth boss.

The earth boss must be painted on all surfaces except the surface with which the earth lug makes contact.

For pole-mounted units:

- One earth terminal shall be located on the primary side of the tank. It shall be in the center of the tank, close to the bottom.
- One earth terminal shall be located on the secondary side of the transformer, between 250 mm and 300 mm below the neutral bushing. The design shall take into account that Eskom will mount a neutral surge arrester, on the secondary earth terminal, see Figure 16 (not applicable to SWER isolation transformers).

For ground-mounted units:

- An earthing terminal shall be welded to the center of the side wall of the LV cable termination enclosure adjacent to the LV neutral bushing as shown in Figure 8.
- On the MV side, the cable termination must be earthed as per Figure 7.

Note 9: According to the Eskom earthing philosophy, if the MV and LV earth electrodes are to be separated on site, the electrical bridge between the earthing terminal and the LV neutral bushing would then be removed as required, and the neutral surge-arrester would become effective.

3.3.8 Surge Arrester Brackets

A surge arrester bracket shall be provided below each MV bushing of all pole-mounted transformers suitable for the application of double or parallel surge arresters.

A single surge arrester bracket shall be provided adjacent to each MV bushing of all ground-mounted transformers.

Two surge arrester brackets shall be provided adjacent to each MV bushing of SWER transformers for the application of double or parallel surge arresters.

The brackets shall be designed to ensure that the applicable arresters, with dimensions as indicated in Figure 17 and Figure 18, can be fitted and still maintain the clearances indicated in Figure 17 and Figure 18.

The brackets shall allow the mounting of a surge arrester spaced sufficiently away from the transformer tank to prevent the tank from interfering with the operation of the surge arrester.

The bracket shall be mounted high enough on the tank such that the bottom of the surge arrestor does not extend below the base of the transformer tank.

Each bracket shall have 14 mm diameter holes. See Figure 17 and Figure 18 for the interfacing dimensions.

NOTE :

1. RADIATORS MAY EXCEED THE MAXIMUM PERMITTED TANK LENGTHS AND WIDTHS, PROVIDED THESE MAXIMUM PERMITTED LENGTHS AND WIDTHS ARE NOT EXCEEDED WHEN MEASURING THROUGH THE TRANSFORMER CENTRE LINE.
2. WHERE THE RADIATOR DIMENSION EXCEEDS Wo (MAX), THE RADIATOR DUCTS MUST BE A MINIMUM OF 100mm FROM A LINE DRAWN ALONG THE WIDTH OF THE TRANSFORMER THROUGH THE CENTRE OF GRAVITY (C.O.G.) SEE FIGURE A1
3. WHERE THE RADIATOR DIMENSION EXCEEDS Lo (MAX), THE RADIATOR DUCTS MUST BE A MINIMUM OF 100mm FROM A LINE DRAWN ALONG THE LENGTH OF THE TRANSFORMER THROUGH THE CENTRE OF GRAVITY (C.O.G.) SEE FIGURE A2.

EXAMPLE : (PLAN VIEW)

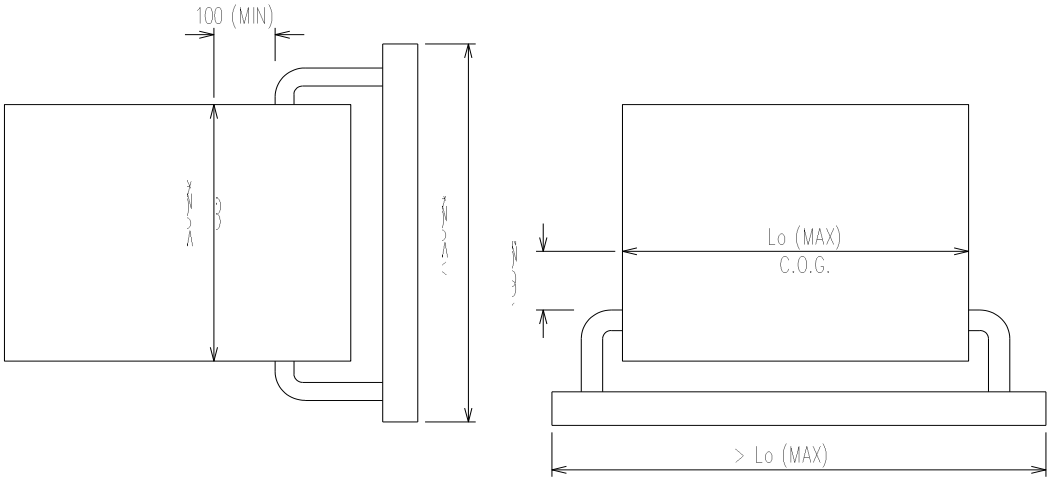
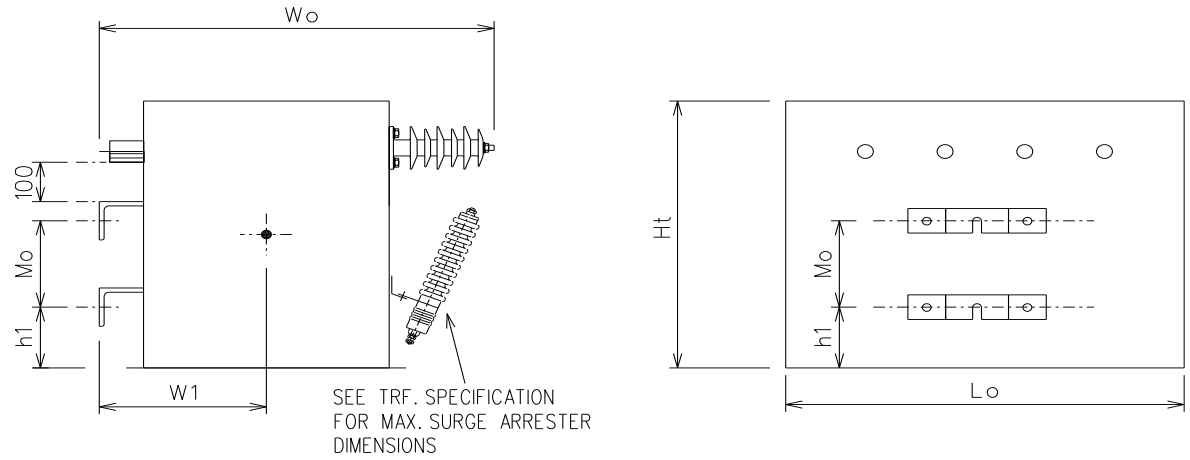
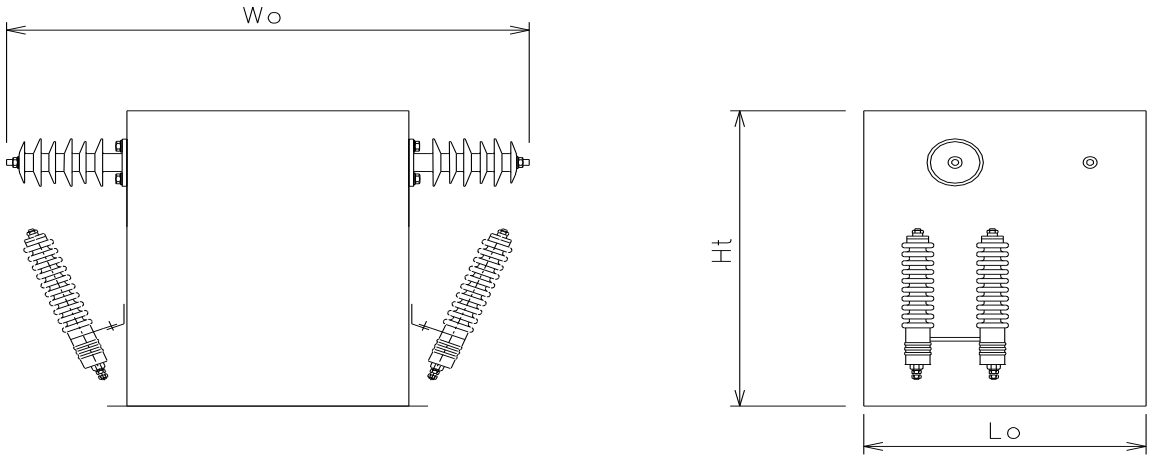


FIGURE A1 FIGURE A2

Figure 11: Radiator dimensions



Single-, Dual- & Three-phase Transformers (Conventional and SWER)



SWER Isolation transformer

Pole Mounted Transformer Dimensions		16 -100 kVA	200 kVA	315 - 500 kVA
VERTICAL POLE HOOKING DISTANCE	Mo [mm]	400	-	-
MAX. VERTICAL BASE-LOWER POLE HOOKING POINT	h1 [mm]	400	-	-
MAX. OVERALL WIDTH (INCLUDING SURGE ARRESTER)	Wo [mm]	1080	-	1800
MAX. HORIZONTAL DISTANCE POLE-HOOKING TO CENTRE OF GRAVITY	W1 [mm]	450	-	-
MAX. OVERALL LENGTH (INCLUDING RADIATORS)	Lo [mm]	1500	1500	1500
TOTAL HEIGHT (MAX.)	Ht [mm]	1500	2000	2000
MAX. OVERALL WEIGHT	[kg]	900	1700	3500

Figure 12: Pole Mounted transformer dimensions

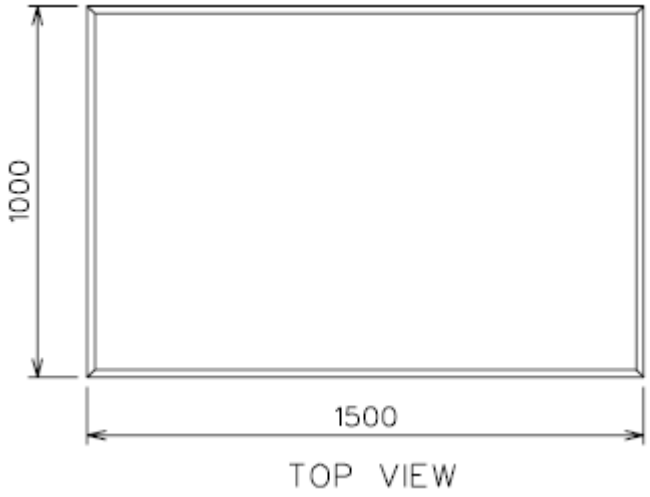


Figure 13: Ground mounted transformer dimensions

Note 10: The overall Length and Width of the Ground-mount Transformer cannot exceed the underbase dimensions as stated in in the diagram above.

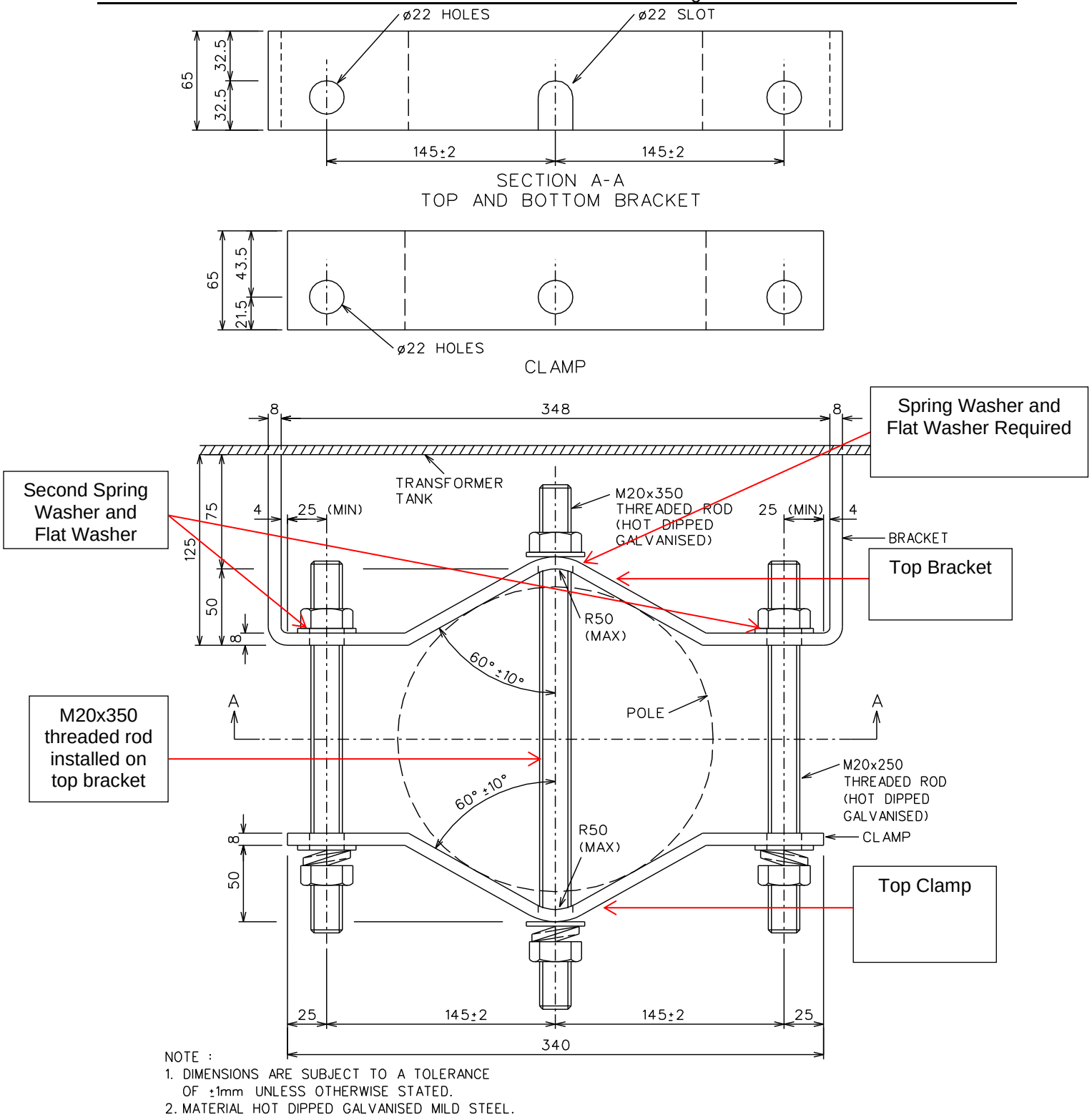


Figure 14: Single pole, mounting bracket

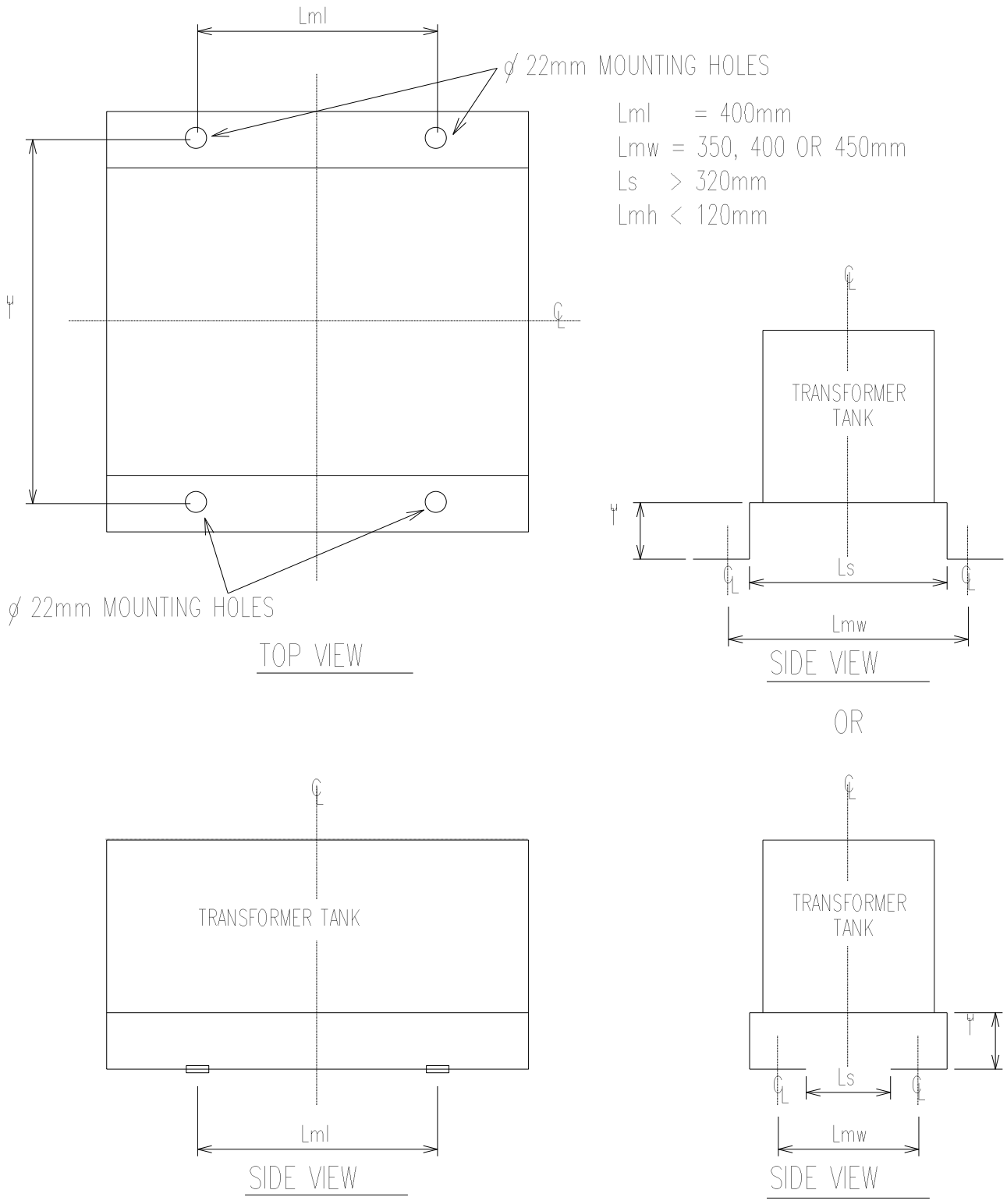


Figure 15: Pole Mounted Transformer under base

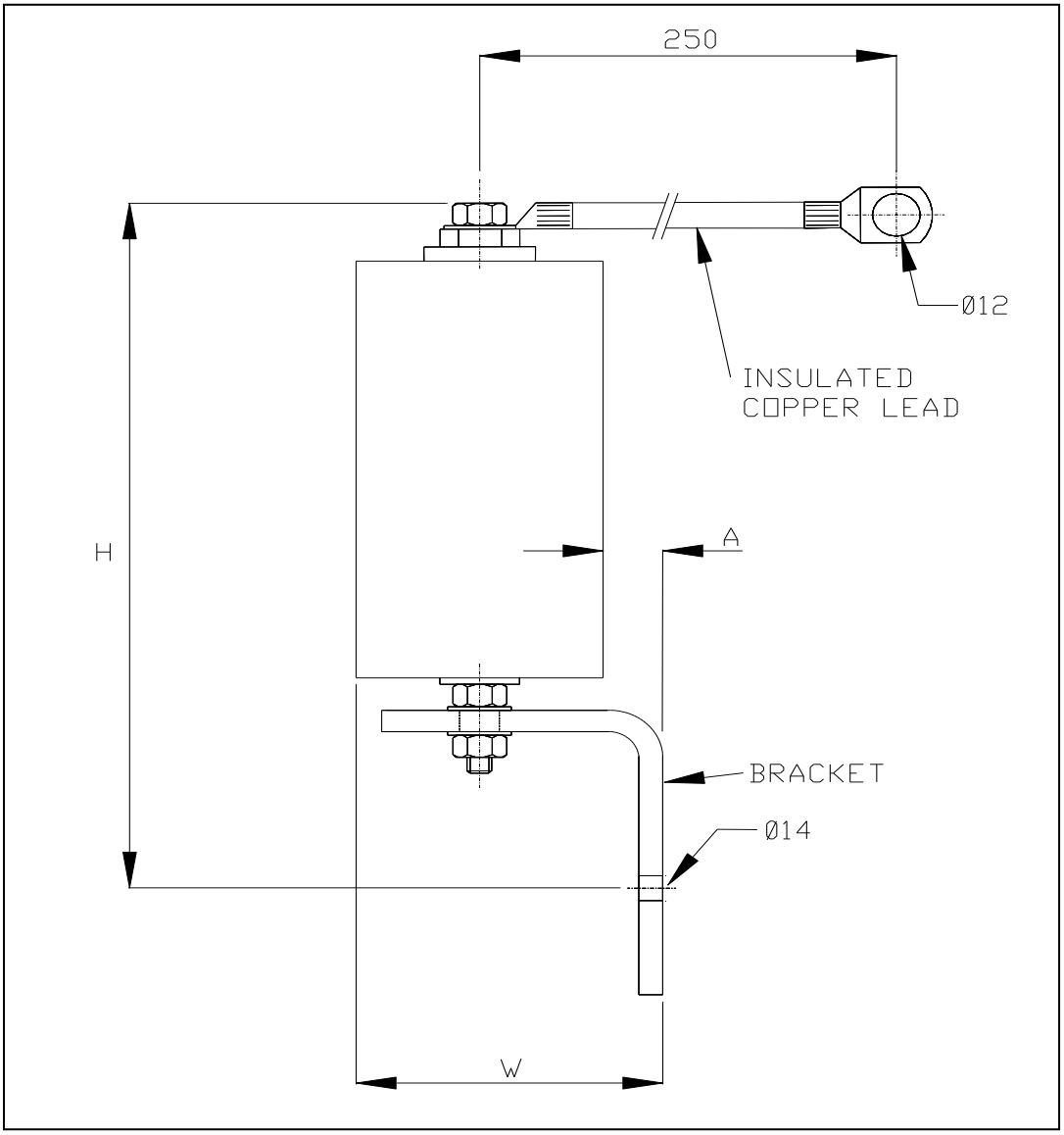
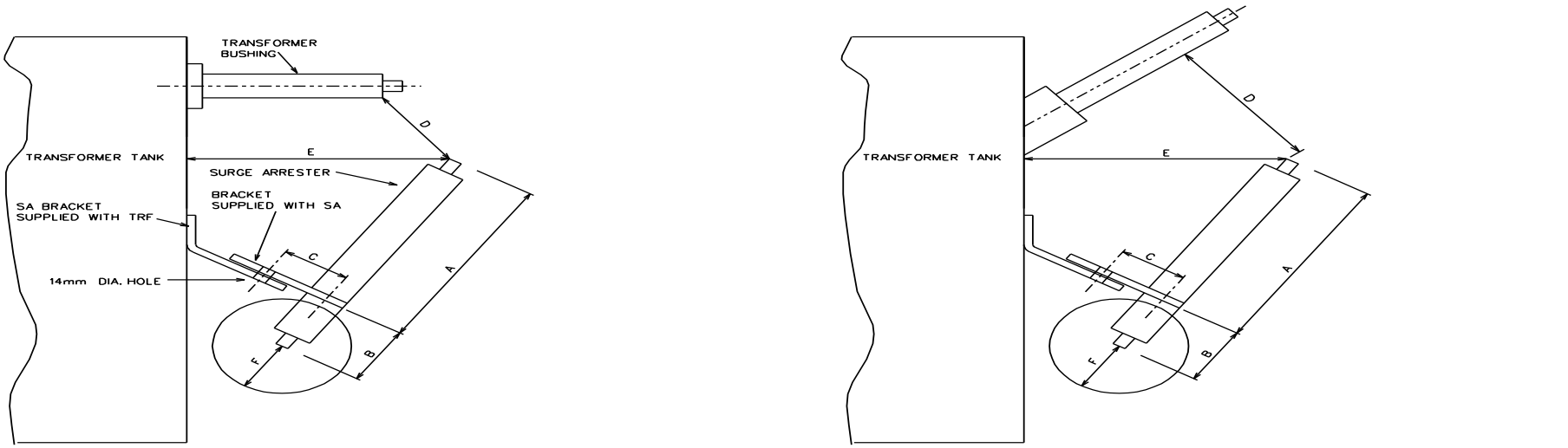
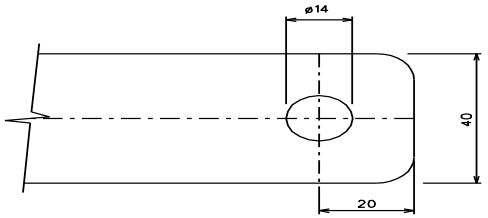


Figure 16: Dimensions of neutral surge arrester

NOTE :

- D - SHORTEST DISTANCE BETWEEN SA LINE TERMINAL AND TRANSFORMER BUSHING.
- E - SHORTEST DISTANCE BETWEEN SA LINE TERMINAL AND ANY EARTHED METAL.
- F - RADIUS SHALL BE CLEAR OF ANY OBJECTS.
- PARAMETERS A, B AND C ARE GIVEN VALUES SPECIFIED BY THE SA MANUFACTURES.
- TRANSFORMERS SHALL BE DESIGNED TO COMPLY WITH PARAMETERS D, E AND F.





NOTE :
THE CONSTRUCTION OF THE BRACKET MAY VARY BETWEEN MANUFACTURERS, BUT THE INTERFACING DIMENSIONS SHALL BE AS SHOWN.

SURGE ARRESTER BRACKET SUPPLIED WITH TRANSFORMER

	11kV	22kV	33kV
A	200-300mm	300-400mm	370-570mm
B (MAX)	75mm	75mm	75mm
C (MIN)	130mm	130mm	130mm
D (MIN)	200mm	200mm	200mm
E (MIN)	190mm	300mm	400mm
F (MIN)	150mm	150mm	150mm

Figure 17: Surge arrester mounting details

Note 11: Double surge arresters must be mounted as depicted in 17 for each arrester applications.

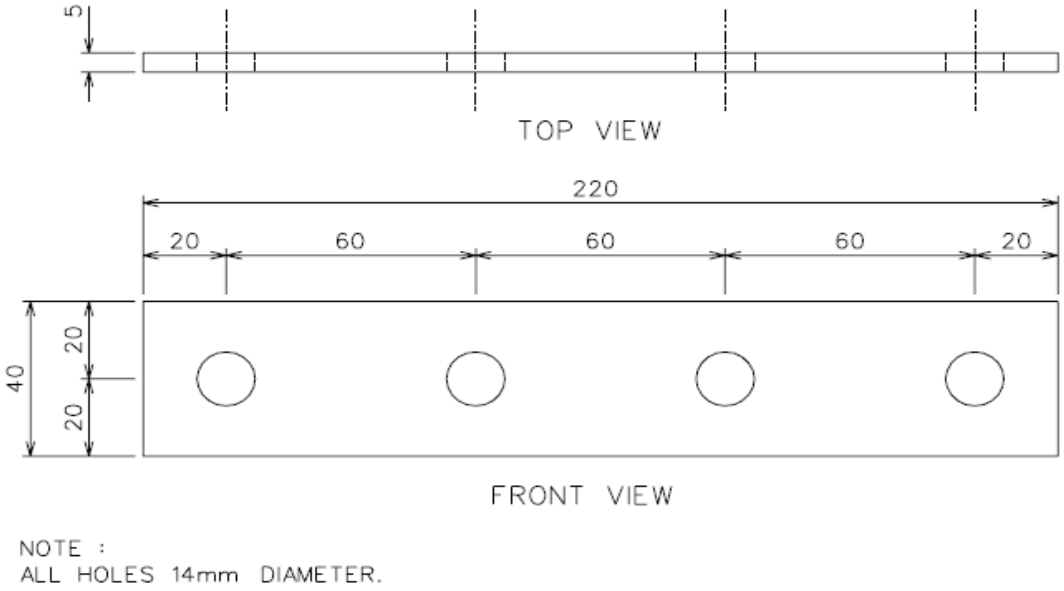


Figure 18: Double Surge Arrester Mounting Bracket

3.4 Corrosion Protection

Corrosion protection shall be in accordance with the latest revision of Eskom specification 240-75655504.

Transformers shall be prepared for coastal applications, which relates to a 'High to Very High' corrosivity rating and a 'C4 to C5' corrosivity category, as defined in Table 2 of 240-75655504. The specific requirements of the corrosion protection must adhere to Table 3 of 240-75655504.

The detailed systems for painting of pole and ground mounted transformers are as follows:

- Transformer tank for COASTAL applications: DS-11; DS-13 + DS-16; DS-14 + DS-16; DS-13 + DS-16; DS-14 + DS-16; or DS-18.
- Radiators for COASTAL applications: DS-12.

The colour of the final coat shall be natural light grey (Colour No. G29 – SANS 1091) for mineral oil and azure blue (Colour No. F05 – SANS 1091) for ester oil.

Eskom may consider alternative corrosion protection offers under the condition that the offer is the same or improved corrosion protection. Any applications for concessions for alternative systems must first be sent to Eskom's designated Transformer Specialist for acceptance. This must be done in writing and the manufacture may only proceed once Eskom has accepted.

3.5 Drawing and Other Documentation Requirements

3.5.1 Pole Mounted Transformers

Single copies of drawings shall be submitted electronically as well as on hardcopy as part of the original tender or design evaluation showing the following detail for pole mounted transformers:

a) Dimensions and abbreviations indicated in Figure 12;

b) Mounting hole dimensions and abbreviations indicated in Figure 15;

c) Surge arrester dimensions and abbreviations indicated in Figure 17 and Figure 18. The relevant clearance should be indicated for the minimum and maximum values of dimension A;

d) Single pole mounting bracket;

e) Terminal arrangement and labelling;

f) Position of tapping switch and tap arrangement;

g) MV tap arrangement;

h) Earthing terminals;

i) Bushing (including base clamp) and flag detail;

j) Rating and diagram plate.

Electronic copies of all type test reports, and mark scheme permits (or application for permits) shall be submitted as part of the original tender.

All electronic documentation shall be in English and submitted in PDF format.

3.5.2 Ground Mounted Transformers

Single copies of drawings shall be submitted electronically as well as on hardcopy as part of the original tender or design evaluation showing the following detail for ground mounted transformers:

a) General assembly (GA) with outline dimensions;

b) Rating and diagram plate layout and details.

c) The general assembly (GA) drawing shall show the following specific details:

d) Position of cable termination enclosures and transformer radiator(s);

e) Position of tapping switch;

f) Position of rating and diagram plate;

g) Position of earthing terminals (tank and cable termination enclosures);

h) MV and LV warning signs with reference to D-DT-3202;

i) MV and LV gland plate design showing gland hole positions, sizes, thickness and material;

j) Position of MV cable entry with rubber grommet and reference to D-DT-8027;

k) Position of MV cable support clamp and reference to D-DT-8019;

l) Distance from MV gland plate to MV bushing centre line;

m) Position of MV and LV bushings and labelling;

n) Distance between bushing centres and between outer bushing centres and cable termination enclosure side walls;

o) The overall height, width and depth of the MV and LV cable termination enclosures;

p) Position of the LV surge arrestor (and reference to D-DT-3088) with parallel 70mm^2 Cu jumper;

q) LV bushing flag details and dimensions.

Electronic copies of all type test reports, and mark scheme permits (or application for permits) shall be submitted as part of the original tender.

All electronic documentation shall be in English and submitted in PDF format.

4. Tests

Failure of a unit to pass any test listed in this section will constitute a non-compliance to this standard.

Notwithstanding the fact that a unit has been type tested, Eskom reserves the right to test any production unit supplied to Eskom before it has been in service and in accordance with tests described below. Compliance criteria for such testing remains the same and a failure will constitute non-compliance with this standard.

Approval shall be obtained from Eskom before any design, manufacturing and/or material changes can be implemented on designs approved by Eskom. Eskom will evaluate the proposed changes and if deemed necessary the manufacturer will be instructed to redo (at their cost) the relevant type tests.

Note 12: Manufacturers should note the deviations from the SANS/IEC standards.

4.1 Test Certificates

Single copies of type test reports, in English, shall be submitted with a tender.

Type test reports shall be arranged in the order shown in clause 4.2 and shall be marked clearly with the identifier and description in 4.2, for example, 4.2 Temperature-rise test. Any additional test reports shall be marked “Additional Tests” and kept separate from the required test certificates.

4.2 Type Tests

The following type tests shall be performed on each design and in accordance with SANS 60076-1 and SANS 780.

4.2.1 Temperature Rise Test

The temperature rise tests shall be performed in accordance with SANS 780 and must comply to the stipulated requirements.

4.2.2 Dielectric Type Test

The dielectric type tests shall be performed in accordance with SANS 780 and must comply to the stipulated requirements. Connections diagrams shall be provided in test reports to confirm compliance.

4.2.3 Tank Stiffness Test

The tank stiffness test shall be performed in accordance with SANS 780.

4.2.4 Corrugated Tank Fatigue Test

The corrugated tank fatigue test shall be performed in accordance with SANS 780 where applicable.

4.2.5 Short-Circuit Withstand Test

Short-circuit withstand type tests shall be performed in accordance with SANS 780 and must comply to the stipulated requirements. Demonstration of ability to withstand the dynamic effects of short-circuit and short-time current.

4.2.6 Pollution Performance Test [23]

Testing must comply with the requirements of 240-142598739. Polymeric insulator housing shall conform to the 1000hr salt-fog tracking and erosion test, contained in SANS 62217, “Polymeric HV insulators for indoor and outdoor use – General definitions, test methods and acceptance criteria” as a minimum or equivalent and the requirements of section 3.3 of 240-142598739.

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

4.2.7 Equivalent Disturbing Current Test

This test is only applicable to SWER transformers.

4.2.7.1 General

The maximum flux density in the core shall be such that, with 105 % rated voltage of sinusoidal waveform applied to the 242 V tap of the secondary winding, the equivalent disturbing current, measured in accordance with 4.2.7.2, shall not exceed the values shown in Table 8.

Table 8: Equivalent disturbing current

1	2
Power rating, kVA	**Equivalent disturbing current, [mA] At 105 % of rated voltage**
16	100
32	200
64	400

4.2.7.2 Measurement of Equivalent Disturbing Current

The equivalent disturbing current determined from the transformer magnetizing current is numerically equal to the voltage reading obtained from a psophometer (having characteristics defined by the CCITT for commercial circuits) when its terminals are connected across a 0.2 mH inductor having a d.c. resistance of less than 0.02 Ω. The inductor is connected in series with the 242 V tap of the secondary winding, see Figure 19.

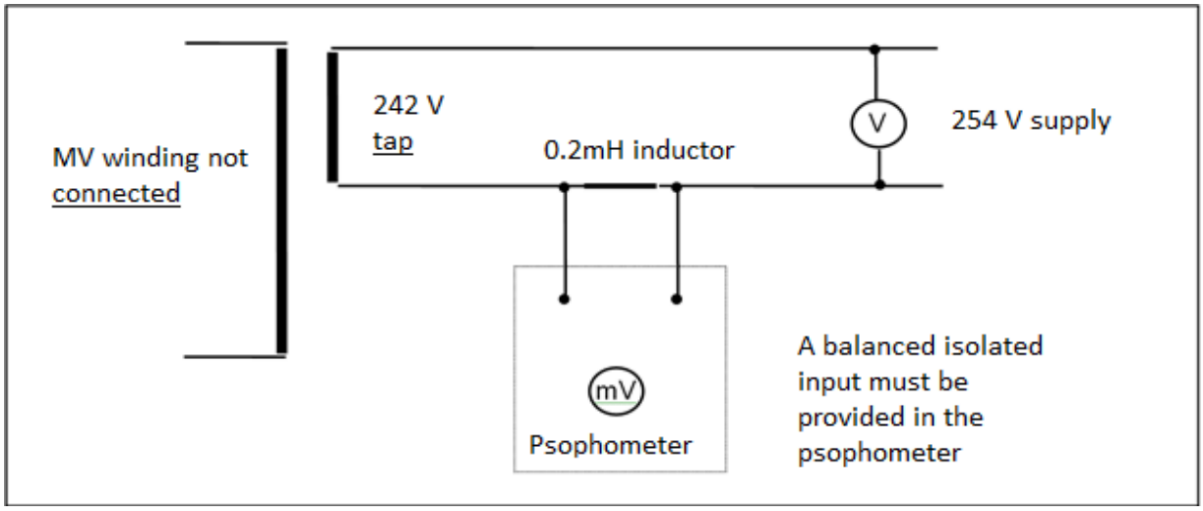


Figure 19: Connection diagram for measurement of equivalent disturbing current on single-phase

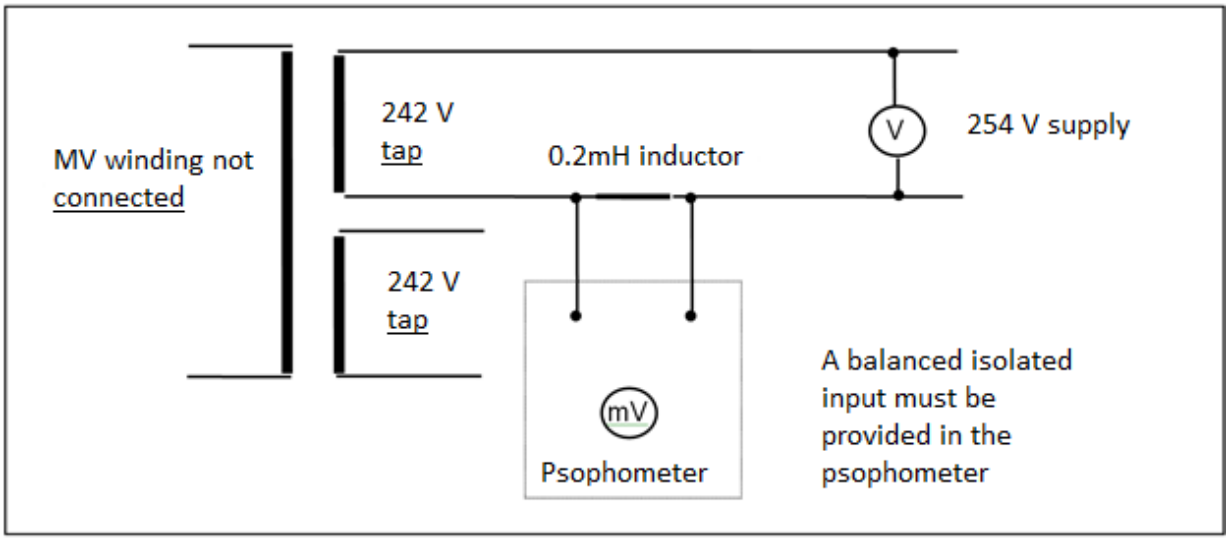


Figure 20: Connection diagram for measurement of equivalent disturbing current on dual-phase transformers

4.3 Routine Tests

The following routine tests shall be performed in accordance with the latest revisions of IEC/SANS 60076-1 and SANS 780 on each transformer.

a) Measurement of winding resistance – as per SANS 60076-1 Clause 11.2.

b) Measurement of voltage ratio and phase displacement – as per SANS 60076-1 Clause 11.3.

c) Measurement of short-circuit impedance and load loss – as per SANS 60076-1 Clause 11.4.

d) Measurement of no-load loss and current – as per SANS 60076-1 Clause 11.5.

e) Applied voltage test (Separate source voltage test) – as per SANS 60076-3 Clause 10.

f) Induced voltage withstand test (Induced overvoltage test) – as per SANS 60076-3 Clause 11.2 and SANS 780 Annex D.

g) Measurement of paint thickness – as per SANS 780 10.2.2.

h) Test for effectiveness of sealing - as per SANS 60076-1 Clause 11.8 or agreed method.

i) Measurement of secondary voltage across outer two terminals to be 484 V. (Only applicable to dual-phase transformers.)

j) Measurement of insulation resistance test – as per SANS 60076-1 and SANS 780 Annex D.

k) Reactance (%) - as per SANS 780 Annex D.

l) Dielectric routine tests - as per SANS 780 and SANS 60076-3 or agreed requirements as per Eskom standards.

m) Vector group test - as per SANS 780 Annex D.

5. Design Reviews

A design review shall be done on the first transformer of each type. A design review in a planned exercise is envisaged to ensure that there is a common understanding of the applicable standards and standard requirements, and to provide an opportunity to scrutinize the design to ensure the requirements meet the Employer's requirements.

- The objective is to review specific aspects of the electrical, mechanical, magnetic and thermal design to:
  - Ensure there is a clear and mutual understanding of the technical requirements.
  - Verify the system and project requirements and to indicate areas where special attention may be required.
  - Verify that the design complies with the technical requirements.
  - Identify any prototype features and evaluate their reliability and risks.

A design review meeting is required before the procurement of any materials or manufacturing proceeds. The purpose of the design review is to allow Eskom to understand the basic design, construction and installation of the transformer and to make sure that interchangeability requirements are met. Eskom shall not be obliged to accept components and/or materials procured prior to the design review and without a written agreement from Engineering. The design review shall follow an internationally and/or nationally benchmarked process.

The manufacturer shall design the transformer in order that it performs satisfactorily under all service conditions specified in this document.

The manufacturer must demonstrate that all the decisive design parameters are well within the manufacturer's design limits based on proven research, or relevant limits specified in standards or internationally benchmarked criteria.

Eskom reserves the right to reject the design when the manufacturer fails to demonstrate the capability for design and manufacturing of the transformer under review. This can happen when the presented design does not meet internationally and/or nationally and Eskom's accepted criteria and the manufacturer cannot prove his design by previously tested transformers of the same concept and voltage class.

The manufacturer shall supply design review details to Eskom prior to the design review meeting. All the discussions and final decisions taken during the design review must be recorded, signed by all the parties, and submitted to Eskom.

Eskom's participation in the design review will in no way relieve the manufacturer of any of their duties in terms of any contract.

6. Markings

6.1 Certification Mark

a) Transformers shall carry a SANS 780 certification mark.

6.2 Off Circuit Tap Switch Markings

a) The off circuit tap switch will be located on the LV side of the transformer.

b) A permanent label shall clearly indicate the direction for changing the tap position (i.e. the operation of the off circuit tapping switch shall be such that turning the handle clockwise the tap position number is increased.)

c) A warning label that indicates "DO NOT OPERATE WHEN ENERGISED" must be affixed adjacent to the switch handle.

6.3 Rating Plate

In addition to the requirements of the relevant clauses of SANS 780, the rating plates shall have the following information:

a) A warranty period of 36 months (from the date of manufacture listed on the name plate), must clearly be stipulated on the rating plate;

b) Eskom order number and Eskom contract number;

c) Eskom material number (SAP);

d) The following statement: “Eskom standard 240-45395762 Rev. 4”;

e) The following statement: “Oil contains no trace of PCB’s”;

f) Primary and secondary winding material. E.g. Winding material: Cu/Al;

g) Type of core material e.g. Steel, Amorphous;

The rating plate must be manufactured from material (anodized aluminium or Teflon material) suitable for outdoor applications and must have a lifespan equivalent to the 25 year lifespan of the transformer. The standard of the labels physical properties must comply with accepted International standards for the labelling of outdoor equipment.

The rating shall not be directly fastened to the transformer tank in any manner that may compromise the integrity of the tank or the corrosion protection of the transformer. The method of attachment will be subject to Eskom’s acceptance and will be evaluated at the contracting stage.

Lettering must be a minimum of 5mm high, printed in black on a light background.

6.4 Centre of Gravity

The centre of gravity must be marked on the tank. (The calculation of the centre of gravity should take into account the dimensions of radiators.)

6.5 Bushing Lock-Nut Label

All units supplied must have a stick-on label indicating if the bushing nuts need to be tightened, and the number of “flat” turns that need to be applied. This label must be placed in a visible position.

6.6 Other Markings

a) “ESKOM”, SAP number, the primary voltage, secondary voltage, and rating of the transformer shall be marked on the tank, e.g. ESKOM, 0175086, 22 kV/420 V 50 kVA. The markings shall be white and in characters larger than 50 mm. The markings shall be positioned in such a way as to be clearly visible from the ground.

b) Winding terminals shall be marked in accordance with SANS 780.

c) The LV terminals of dual-phase transformers shall be marked a1, n and a2 respectively.

7. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Azwi Mamanyuha	General Manager – Technology & Engineering
Mfundi Songo	Senior Manager – Technology & Engineering
Queeneth Khumalo	CS&MES Study Committee Chairperson
Andreas Beutel	MV&LV Study Committee Chairperson
Sidwell Mtetwa	Corporate Specialist for Transformers and Reactors

8. Revisions

Date	Rev	Compiler	Remarks
March 2022	4	MM Moabelo	Additional improvements due to business needs. Definitions and Abbreviations tables updated with new entries. Added content related to voltage requirements. LV Flag requirements added for all sizes to accommodate Data Concentrator (Smart Metering Solution) connections. Additional clarity on LV Flag hardware added. Additional clarity wrt losses and penalties. Coastal corrosion specification reinstated. Removed natural aging requirement for testing and aligned compliance requirements to existing Engineering Instruction. Added Eskom and SAP No markings to tank markings. 3.3 kV IV transformers requirements added, Annex C added.
Oct 2021	Draft 3.1	MM Moabelo	Dual Voltage Ratio Transformers definition removed. Eskom contract number added to the rating plate. Inland vs Coastal bushing requirements removed. The inter-turn winding insulation stress requirement added Al cable termination and gland plate hole requirements added Earthing terminals requirements updated and clarified. Inland transformer requirements removed from the corrosion protection section. Type Test section refined to mainly reference SANS780, duplicated to the SANS 780 removed. Natural ageing and pollution performance test section, KIPTS removed as stated by [23] Routine tests section updated to include SANS clauses. Design Review section added. Barcode requirement removed from the rating plate.
Nov 2016	3	A Singh	Amended the specification to accommodate for Natural Ester Oil according to the IEC Standard 62770; 2013. Stipulated the life time a transformer is expected to operate on the Eskom network. Added a clause on the expectation from Eskom with respect to electrical clearances and design reviews. Added a clause on the compatibility of the materials used in the manufacture of transformers. Added a clause regarding oil levels in transformers. Added a clause for oil storage, handling and filling.

Date	Rev	Compiler	Remarks
July 2015	2	A Singh	Combined the Pole Mounted transformer specification with the Ground Mounted transformer specification into one document. Updated all references to DSP34-1658 to 240-75655504 Updates 3.1.11 and 3.2.10 to include Inland Creepage 3.2.13 Added reference to table 9 in SANS 780 Added clause 5.5 Unique Identifier change to 240-45395762 and new SCOT template applied Referenced documents given new 240 unique identifiers. Title name changed to specific requirements for distribution pole and ground-mounted transformers up to 33 kv and 1 MVA as the document now includes requirements for ground mounted transformers and dual voltage-ratio transformers Figure and Table numbers updated 6.6kV has been included as a voltage option 2.1 Scope updated to reflect inclusion of ground-mounted transformers, dual-voltage ratio transformers and low loss technologies 3.1 General updated to include general requirement added technologies. 3.2 Electrical requirements updated to include general requirement added technologies 3.2.4 Insulation Level Table 1 includes requirements for voltages <1kV and note added 3.2.6 Enamel wire insulation shall be Grade 3, as defined by SANS 60317-0-1.Paper tape covered wire shall have a minimum covering of 0.125 mm. Clauses added stipulating minimum impulse withstand and minimum power frequency withstand between turns. 3.2.8.6 Tapping for Dual Voltage-Ratio Transformer added 3.2.9 Bushings for Pole Mounted Transformers clamp details added 3.2.10 Ground-Mounted Transformers: MV, LV Cable termination enclosures and Bushings added and figures included 3.2.12 Losses content added 3.3.5 Transformer under base details added for ground-mounted transformers 3.3.8 Surge arrester brackets double surge arrestor requirements added Notes added to Figure 11, 12, 13, 16 Figure 17 added 3.5.7 MV tap arrangement and ESVSS for Dual voltage-ratio transformers added 5.3 Rating plate new requirements added 5.4 Centre of Gravity new clause added

Date	Rev	Compiler	Remarks
March 2012	1	DR Theron	The requirements for pole-mounted distribution transformers were previously contained in 5 separate specifications. In this revision the 5 specifications are combined in a single specification and a number of new requirements are introduced, as detailed below. Document number changed to 240-45395762 by TDAC 4.2.3 The no-load secondary voltage levels has been aligned with SANS 780 4.2.4 Eskom's latest oil specification ESP 32-406 is referenced 3.2.7 New requirement for inter-turn winding insulation. 3.2.9 New requirement for interlayer winding insulation 3.2.10 The tapping ranges and steps aligned with SANS780 4.2.9 LV bushing flags are also required on 100 kVA transformers. Dimensional requirements are specified for LV bushing flags 3.2.14 The capitalization formula as specified in 10TB-018 has been adopted 3.3.4 The dimensions of the pole mounting brackets were increased. 4.3.9 Eskom's latest corrosion specification DSP 34-1658 is referenced.

9. Development team

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

- Ezé van Tonder
- Henry Jordaan
- Mashilo Moabelo
- Shabnum Behari
- Vusi Phiri
- Queeneth Khumalo
- Khutso Mokuwe
- Mohamed Mukuddem

10. Acknowledgements

The development team would like to acknowledge previous specification authors for the development of the superseded specification.

Annex A – Test report summary sheet

(Normative)

The tenderer shall submit a separate test report summary sheet per item offered.

Item description: ……					
Test		**Report no.**	**Test facility**	**Comments**	**Report submitted (Y/N)**
4.2.1	Temperature rise test				
4.2.2	Dielectric type test				
4.2.3	Tank stiffness test				
4.2.4	Corrugated tank fatigue test				
4.2.5	Short-circuit and short-time current withstand tests				
4.2.6	Pollution performance test (1000 hour and Pollution Test)				
4.2.7	Equivalent disturbing current test This test is only applicable to SWER transformers)				
4.3	Routine tests (all tests as per 4.3 of 240-45395762 are required)				

Annex B – Technical Schedules A and B

Technical Schedules A and B for Pole Mounted and Ground Mounted transformers to be issued in conjunction with this standard as separate documents.

Annex C – Unique requirements for IV transformers rated at 3.3kV

The 3.3kV intermediate voltage transformer has specific requirements which will be covered in this Annex. This Annex supersedes requirements that differ from the requirements stated in the main body of this standard, for 3.3kV transformers only.

Power ratings:

- 16kVA (single phase), 50kVA (three phase), 100kVA (three phase)

Primary voltage:

- 3.3kV or 1.9kV (phase to ground)

Secondary Voltage:

- As per clause 3.1 a

Mounting Requirements:

- Single pole mounting is applied.
- Unique Requirement: Ground Mounted options with single pole mounting brackets included.*

* This is required to maintain existing installations that have been designed in this manner.

C.1 3.3kV Ground Mount Units requirements:

C.1.1 1.9/3.3kV cable box

a) The cable box shall be air filled and shall be positioned on the side of the transformer tank adjacent to the pole mounting brackets as per Figure C.1.

b) The two/four 1.9/3.3 kV bushings shall be positioned horizontally in a straight line.

c) The minimum distance from the bushing centre line to the gland plate shall be 300 mm.

d) An earthing terminal in accordance with clause 3.3.7 shall be welded to the centre of the side wall of the cable box adjacent to the neutral bushing and at a height of 100 mm from the gland plate.

e) The cable box shall be fitted with two No. 3 mechanical compression glands that complies with SABS 1213.

f) The cable box shall have one or three holes drilled in the gland plate intended for single core connections between the phase bushing/s and the surge arrestor/s installed on the transformer tank below the cable box. The holes shall be fitted with rubber grommets and shall be suitable for single core cables with a diameter of 9 mm.

g) A warning sign in accordance with Figure C.2 shall be fitted to the cover/lid of the 3.3 kV cable box. If pop-rivets are used to attach the sign to the cover, only aircraft pop-rivets will be acceptable. Normal pop-rivets are not acceptable.

C.1.2 LV cable box

a) The LV cable box shall be air filled and shall be positioned on the side of the transformer tank adjacent to the pole mounting brackets as per Figure C.1.

b) The LV cable box shall have one bushing per phase. The minimum clearance (i.e. 60mm between live metal phase-to-phase and phase-to-earth), indicated in Figure 8, shall be maintained taking into account the flags, lugs and fasteners required to connect the cable to the bushing.

c) An earthing terminal in accordance with clause 3.3.7 shall be welded to the centre of the sidewall of the LV cable box adjacent to the LV neutral bushing.

d) A surge arrester in accordance with Eskom drawing D-DT-3088 shall be mounted on the earthing terminal in the LV cable box and shall be connected to the neutral bushing terminal. The position of the surge arrester shall not interfere with the connection of the LV cables.

e) The gland plate shall be fitted with mechanical compression glands that comply with SABS 1213 and are suitable for the termination of the cables stated in Schedule A of the enquiry document.

f) A warning sign in accordance with Figure C.3 shall be fitted to the cover/lid of the LV cable box. If pop-rivets are used to attach the sign to the cover, only aircraft pop-rivets will be acceptable. Normal pop-rivets are not acceptable.

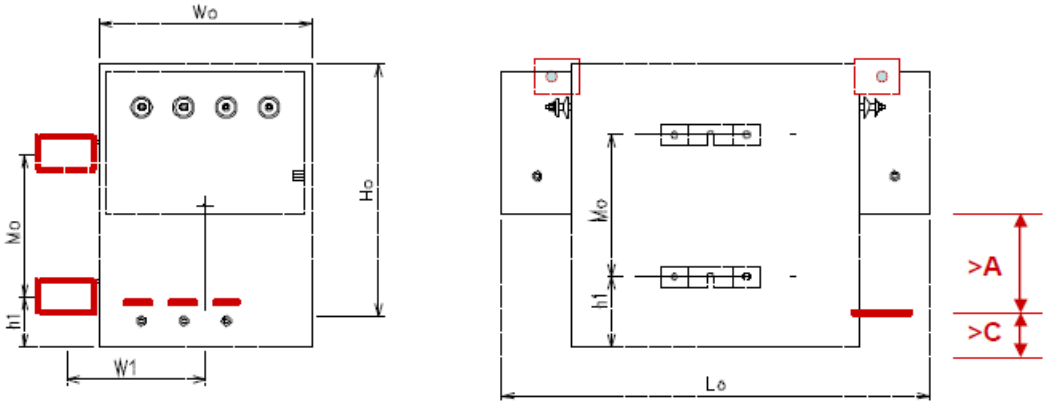


Figure C.1: Ground Mounted 3.3kV IV transformer with pole mounting features

Figure C.2: Ground Mounted 3.3kV IV transformer Label – 1.9/3.3kV Cable Box

Figure C.3: Ground Mounted 3.3kV IV transformer Label – LV Cable Box