

	Standard	Technology
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Title: **Oil Filled Power Cables and Accessories for Systems with Nominal Voltages of 44kV to 132kV Standard**

Unique Identifier: **240-56030399**

Alternative Reference Number: **N/A**

Area of Applicability: **Engineering**

Documentation Type: **Standard**

Revision: **1**

Total Pages: **13**

APPROVED FOR AUTHORISATION

☒ TECHNOLOGY ENGINEERING
DOCUMENT CENTRE ☎ x4962

Next Review Date: **November 2015**

Disclosure Classification: **CONTROLLED DISCLOSURE**

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1. INTRODUCTION

Eskom Distribution maintains a significant installed base of high-voltage, low-pressure, oil-filled, single-core and three-core cable systems. This standard is therefore based on [1] IEC 60141-1.

Note: New high-voltage cable systems in Eskom Distribution are comprised of single-core Cross-linked Polyethylene (XLPE) insulated cable and accessories.

The failure of any component of a high-voltage cable installation generally results in significant repair cost and disruption to the power system. In order to minimize the risk of this occurring, the Distribution Division has undertaken to purchase only high-voltage oil-filled cable and accessories that have been type tested in accordance with [1] IEC 60141-1

2. SUPPORTING CLAUSES

2.1 SCOPE

This standard covers Distribution Division's requirements for single-core and three-core oil-filled cables and accessories for systems with nominal voltages of 44 kV, 66 kV, 88 kV and 132 kV. The test methods and requirements specified are in accordance with [1] IEC 60141-1.

2.1.1 Purpose

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the following documents:

2.2.1 Normative

2.2.1.1 International Document(s)

- [1] IEC 60141-1 Tests on oil-filled and gas pressure cables and their accessories - Oil-filled, paper-insulated, metal-sheathed cables and accessories for alternating voltages up to and including 400kV
- [2] IEC 60228 Conductors of insulated cables

2.2.1.2 South African National Document(s)

- [3] NRS 077 XLPE-insulated cables and accessories for systems with nominal voltages of 44 kV, 66 kV, 88 kV and 132 kV
- [4] DST 34-1625 Distribution Standard – Part 22: Specification for XLPE-insulated power cables and accessories for systems with nominal voltages of 44 kV to 132 kV

2.2.1.2.1 Eskom Documents:

- [5] 240-56062751 New (Unused) Insulating Oil for Cables Specification
- [6] DST 34-1625 Distribution Standard – Part 22: Specification for XLPE-insulated power cables and accessories for systems with nominal voltages of 44 kV to 132 kV

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2.2.1.2 Eskom Assembly Drawings:

- | | | |
|------|-----------|--|
| [7] | D-DT-5030 | [Sheet 1 of 3] HV cable termination - support structure foundation
[Sheet 2 of 3] HV cable termination - support structure details
[Sheet 3 of 3] HV cable termination - support cap details |
| [8] | D-DT-5031 | [Sheet 1 of 3] HV cable end support (non self- supporting) steelwork assembly details
[Sheet 2 of 3] HV cable end support (non self-supporting) steelwork surge arrestor mounting plate
[Sheet 3 of 3] HV cable end support (non self-supporting) foundation details |
| [9] | D-DT-0881 | HV cable used in Eskom Distribution |
| [10] | D-DT-0890 | [Sheet 1 of 4] HV XLPE cable termination with surge arrester conductor assembly (also applicable on oil-filled HV cable)
[Sheet 2 of 4] HV XLPE cable termination with surge arrester overhead line assembly (also applicable on oil-filled HV cable) |
| [11] | D-DT-0891 | [Sheet 2 of 4] HV oil-filled single circuit direct buried joint bay layout
[Sheet 4 of 4] HV single circuit direct buried joint bay protective weather cover |
| [12] | D-DT-0892 | [Sheet 2 of 3] HV power cable trench details (tre-foil formation) |
| [13] | D-DT-0893 | [Sheet 1 of 5] HV cable bonding and earthing arrangement end-point bonded system
[Sheet 2 of 5] HV cable bonding and earthing arrangement double end-point bonded system
[Sheet 3 of 5] HV cable bonding and earthing arrangement multiple end-point bonded system
[Sheet 4 of 5] HV cable bonding and earthing arrangement cross-bonded system
[Sheet 5 of 5] HV cable outdoor termination bonding and earthing arrangement |
| [14] | D-DT-0894 | HV cable link disconnecting box manhole details |

2.2.1.3 Eskom Buyer's Guide Drawings:

- | | | |
|------|-----------|---|
| [15] | D-DT-2882 | HV cable oil and absorbent oil and chemical |
| [16] | D-DT-2879 | CAP, HV oil-filled cable end seal |
| [17] | D-DT-2877 | HV oil-filled cable repair sleeve |
| [18] | D-DT-2874 | Box, Link disconnecting box 1L Earth Kiosk |
| [19] | D-DT-2872 | Termination Kit/Sealing end HV single core paper insulated/oil-filled |
| [20] | D-DT-2871 | Joint Kit HV single core and 3 core oil-filled and transition |
| [21] | D-DT-2870 | Cable HV single core and 3 core oil-filled |
| [22] | D-DT-8073 | HV cable termination supports |
| [23] | D-DT-8074 | HV cable link disconnecting boxes |
| [24] | D-DT-8075 | Bonding leads for HV cables |

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2.2.2 Informative

[25] 32-9 Definition of Eskom Documents

[26] 32-644 Eskom Documentation Management Standard

[27] 474-65 Operating Manual of the Steering Committee of Wires Technologies (SCOWT)

2.3 DEFINITIONS

Definition	Description
Low pressure oil-filled cable	A self-contained (static), fluid-filled, paper-insulated, metal-sheathed cable which operates with a minimum static pressure of between 20 kPa (0,2 bar) and 300 kPa (3,0 bar) inclusive, a maximum static pressure of not more than 800 kPa (8,0 bar) and a minimum transient pressure of not less than 20 kPa (0,2 bar). (The quoted pressures are above atmospheric pressure.)
Self-supporting termination	A cable termination having an outer housing that is rigid and requiring no additional mechanical support.

2.3.1 Disclosure Classification

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

2.4 ABBREVIATIONS

Abbreviation	Description
CAP	Committee for Accepted Products
GM	General Manager
HV	High Voltage
IARC	Industry Association Resource Centre (formerly 'Distribution Technology')
LAP	List of Accepted Products
MDPE	Medium-density Polyethylene
MIG	Metal Inert Gas
n/a	not applicable
SCOWT	Operating Manual of the Steering Committee of Wires Technologies
T&Q	Technology and Quality
T&Q	Technology and Quality
XLPE	Cross-linked Polyethylene

2.5 ROLES AND RESPONSIBILITIES

None

2.6 PROCESS FOR MONITORING

None

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2.7 RELATED/SUPPORTING DOCUMENTS

None

3. STANDARD FOR OIL FILLED POWER CABLES AND ACCESSORIES FOR SYSTEMS WITH NOMINAL VOLTAGES OF 44KV TO 132KV

3.1 REQUIREMENTS

Oil-filled high voltage cable and accessories shall comply with the requirements of [1] IEC 60141-1, this standard and, where indicated, the requirements of [3] NRS 077. Where conflicting requirements arise, the requirements of this standard shall take precedence.

Note: Cable, accessories and ancillary equipment for use on high-voltage oil-filled systems in Eskom Distribution are given in the Buyer's Guide drawings listed in paragraph **Error! Reference source not found.**

3.1.1 Standard Installation Conditions

- a. The standard installation conditions given in [3] NRS 077 shall apply. In addition, the cable depth of burial and configuration installation conditions shall be in accordance with [10] D-DT-0890, [11] D-DT-0891 and [12] D-DT-0892.
 - Notes: Although [10] D-DT-0890 and D-DT-0892 are intended for single-core XLPE-insulated cables, their requirements are also be applicable to all oil-filled cables.
 - In general, for single-core high-voltage cables, the bonding and earthing arrangement (special bonding) is in accordance with [13] D-DT-0893.
- b. Cables and accessories shall be designed to operate in a 'Category A' system in accordance with [1] IEC 60141-1.

3.1.2 Cable and Accessory Operating Voltages

The standard operating voltages given in [3] NRS 077 shall apply.

3.1.3 Cable Materials and Construction

The cable construction shall be in accordance with the relevant sheet of [9] D-DT-0881 (refer to [21] D-DT-2870).

3.1.3.1 Conductor

- a. The cable conductor material shall be stranded and compacted aluminium or copper in accordance with [2] IEC 60228.

Note: Single-core cables require a hollow-core to accommodate an oil duct.

- b. The conductor cross-sectional area shall be 400 mm², 500 mm², 630 mm² or 1 000 mm² and shall be specified in the enquiry document.

Note: The most common sizes of high-voltage oil-filled cable installed in Eskom Distribution networks are 400 mm², 500 mm² and 10 00 mm².

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3.1.3.2 Conductor Screen

The conductor screen shall comprise carbon black paper or a combination of carbon black paper and non-magnetic conducting foil, tape or metallized paper tape.

3.1.3.3 Insulation

The insulation shall consist of helically applied paper tape layers.

3.1.3.4 Core Screen

The core screen shall comprise carbon black paper or a combination of carbon black paper and non-magnetic conducting foil, tape or metallized paper tape.

3.1.3.5 Laying up of Three Core Cables

The cores of three-core cables shall be laid up together with an appropriate right-hand lay.

3.1.3.6 Metallic Woven Fabric Tape

- a. The laid-up cores of three-core cables shall be bound together with a helically applied, copper-woven or aluminium-woven fabric tape that effectively bonds together the individual conducting core screens and bonds each screen to the metallic sheath.
- b. The core of a single core cable shall have a helically applied, copper-woven or aluminium-woven fabric tape.

3.1.3.7 Cable Oil, Ducts and Filler Materials

- a. Cable oil shall comply with the requirements of [5] 240-56062751.
- b. Where applicable, stainless steel helical oil ducts shall be provided in accordance with [9] D-DT-0881.
- c. For three-core cables, appropriate filler materials shall be provided.

3.1.3.8 Metal Sheath

The metal sheath shall be a helically corrugated aluminium sheath. All other requirements for the corrugated aluminium sheath shall comply with the requirements of [3] NRS 077.

Note: A helically corrugated metal sheath allows for the longitudinal flow of oil within the cable.

3.1.3.9 Outer Sheath

The outer sheath shall comply with the requirements of [3] NRS 077.

3.1.4 Cable Accessories

3.1.4.1 Cable Joints

- a. Straight-through joints (refer to [20] D-DT-2871) shall allow for the flow of oil through the joint.
- b. Stop joints (refer to [20] D-DT-2871) shall provide an oil barrier suitable for creating hydraulic sections in the cable system.

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- c. Trifurcating joints (refer to [20] D-DT-2871) shall be designed to join a three-core cable to three single-core cables.

Note: Trifurcating joints that consist of a three-core cable splitter box (refer to paragraph 3.1.4.2) and three single-core joints will be considered.

- d. Cable joints shall be sheath interrupting (i.e. shall be supplied with an insulating flange) and shall comply with the requirements of [3] NRS 077.

Note: Sheath interrupting joints are required in order to accommodate the particular special bonding applicable to the cable system being maintained. Sheath interrupting joints may also be used as non-sheath interrupting joints. This decision has been made in order to limit strategic stockholding requirements.

- e. Unless otherwise specified by Eskom in the enquiry document, each cable joint shall be supplied with a suitable means to join the relevant conductor(s). Acceptable conductor joining methods include:

- conductor welding (Metal Inert Gas (MIG)), in which case the joint shall be supplied with the appropriate welding jig(s); or
- sweating, in which case the joint shall be supplied with appropriate ferrule(s) to allow for soldered contact of the conductor in the ferrule(s); or
- torque shear mechanical compression, in which case the joint shall be supplied with appropriate torque-shear mechanical connector(s); or
- suitable alternative methods approved by Eskom.

- f. Cable joints shall be supplied with sets of paper rolls and crêpe paper tapes. Where applicable, preference shall be given to pre-chamfered paper rolls.

- g. Where pre-chamfered paper rolls are supplied, each roll shall be marked correctly and be stored in a sealed oil tin.

3.1.4.2 Splitter Boxes

- a. Splitter boxes (refer to [20] D-DT-2871) shall be designed to trifurcate and seal the individual cores of a three-core cable and shall be provided with 3 × 15 m lengths of single-core outer protection sheaths for the three individual cores of the three-core cable.
- b. The single-core outer protection sheaths shall comprise a Medium-density Polyethylene (MDPE) outer sheath bonded to a corrugated aluminium sheath.

3.1.4.3 Transition Joints

- a. Transition joints (refer to [20] D-DT-2871) shall be designed to join oil-filled cable to XLPE-insulated cable in accordance with [6] 240-56030625.

Notes: Transition joints are required either to join a single-core oil-filled cable to a single-core XLPE-insulated cable or to join a three-core oil-filled cable to three single-core XLPE-insulated cables. The latter constitutes a trifurcating transition joint.

- Trifurcating transition joints that consist of a three-core cable splitter box (refer to paragraph 3.1.4.2) with three single-core transition joints will be considered.
- Transition cable joints shall be sheath interrupting (i.e. shall be supplied with an insulating flange) and shall comply with the requirements of [3] NRS 077.

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3.1.4.4 Outdoor Cable Sealing Ends

- a. Outdoor cable sealing ends (refer to [19] D-DT-2872) shall be self-supporting and shall comply with the requirements of [3] NRS 077.
- b. Outdoor sealing ends shall be suitable for mounting on the medium equipment support and cap shown in [7] D-DT-5030 (sheets 2 and 3) and [10] D-DT-0890 (sheets 1 and 2).
- c. Outdoor sealing ends shall have a specific creepage of 31 mm/kV.

In the case of self-supporting type terminations, unless otherwise specified in Appendix A (refer to Annex B), the diameter of the tinned copper vertical stem shall be 38 mm.

3.2 TESTS

Cable and accessories shall be tested in accordance with [1] IEC 60141-1. Minimum test voltages shall comply with the requirements of [3] NRS 077.

3.3 MARKING, LABELLING AND PACKAGING

3.3.1 General Requirements

Marking, labelling and packaging shall comply with the requirements of [3] NRS 077 and oil-filled cable shall be packaged on steel drums with the associated oil pressure tank fitted on the inside.

3.3.2 Marking of Outer Sheath

Cables shall be legibly marked in accordance with the requirements of [3] NRS 077, but the marking shall include the specification number to which the cable has been manufactured and the word 'ESKOM'. A typical legend would be:

XXXXXXXXX CABLES 2011 76/132 kV IEC 60840 500 mm² Cu ESKOM

3.4 DOCUMENTATION

Documentation shall comply with the requirements of [3] NRS 077.

The cable parameters shall be stated for the rated conductor operating temperature for both normal and emergency operation.

Note: Where applicable, circuit parameters shall be given for the standard installation conditions given in paragraph 3.1.1.

3.5 SPARES

The length of cable and number and type of accessories to be supplied shall be stated in the enquiry document.

Note: Oil-filled high-voltage cables and accessories are classified as strategic spares in the Eskom Distribution Division.

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3.6 INSPECTION

Prior to the delivery of cable and/or accessories to Eskom, the relevant Eskom personnel from the regional TSG Cables Section, Technology and Quality Department and Industry Association Resource Centre (IARC) shall be contacted to carry out an inspection of the cable and/or accessories.

3.7 KEYWORDS

Underground cable; underground distribution system; accessories; joints; terminations; HV; high voltage; specifications; oil-filled; fluid-filled; self-contained; static; low pressure; paper-insulated; CSA; aluminium sheath; metallic sheath, metal-sheathed.

4. AUTHORISATION

This document has been seen and accepted by:

Name & Surname	Designation
	This Document has been approved by TDAC ROD 13 February 2013

5. REVISIONS

Date	Rev.	Compiler	Remarks
November 2012	0	B. Mwarehwa	Draft document for Review created from DSP 34-1903
May 2013	1	B. Mwarehwa	Final Document for Publication

6. DEVELOPMENT TEAM

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

- None

7. ACKNOWLEDGEMENTS

- None

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APPENDIX A: TECHNICAL SCHEDULES

B.1 TECHNICAL SCHEDULES A AND B: 44 KV, 66 KV, 88 KV OR 132 KV OIL-FILLED CABLE

Schedule A: Purchaser's specific requirements

Schedule B: Guarantees and technical particulars of equipment offered

Item	Subclause	Description	Units of Measure	Schedule A	Schedule B
1.	7	Cable mass	kg/m	xxxxxxx	
2.	7	Oil volume per metre	l/m	xxxxxxx	
3.	7	DC resistance of conductor at 20 oC	n/km	xxxxxxx	
4	7	AC resistance of conductor at operating temperature	n/km	xxxxxxx	
5	7	AC resistance of sheath with conductor at operating temperature	n/km	xxxxxxx	
6	7	Reactance per phase	n/km	xxxxxxx	
7	7	Capacitance per phase	nF/km	xxxxxxx	
8	7	Zero sequence resistance	n/km	xxxxxxx	
9	7	Zero sequence reactance	n/km	xxxxxxx	
10	7	Zero sequence capacitance	nF/km	xxxxxxx	
11	7	Rated continuous current	A	xxxxxxx	
12	7	Rated symmetrical fault withstand	kA – s	xxxxxxx	
13	7	Rated earth fault withstand	kA – s	xxxxxxx	
14	7	Conductor temperature at rated load	°C	xxxxxxx	
15	7	Conductor temperature after symmetrical fault (1 s) assuming operation at specified load prior to fault	°C	xxxxxxx	
16	7	Sheath temperature after earth fault (1 s) assuming operation at specified load prior to fault	°C	xxxxxxx	
17	7	Conductor losses at maximum conductor operating temperature	kW/km	xxxxxxx	
18	7	Type test report number for the cable offered or similar cable previously tested (report to be provided)		xxxxxxx	
19	7	Dimensioned drawing number for the cable cross-section (drawing to be		xxxxxxx	
20	7	Minimum installation bending radius	m	xxxxxxx	
21	7	Emergency current rating	A	xxxxxxx	
22	7	Emergency current conductor operating temperature	oC		

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B.2 TECHNICAL SCHEDULES A AND B: 44 KV, 66 KV, 88 KV OR 132 KV OIL-FILLED CABLE JOINTS

Schedule A: Purchaser's specific requirements.

Schedule B: Guarantees and technical particulars of equipment offered.

Item	Subclause	Description	Schedule A	Schedule B
23.	4.4.1 (e)	Conductor joining method	XXXXXXXX	
24.	7	Type test report number for the cable joint offered or similar cable joint previously tested (report to be provided)	XXXXXXXX	
25.	7	Dimensioned drawing number for the cable joint (drawing to be supplied)	XXXXXXXX	
26.	7	Installation instruction drawing number for the cable joint (instruction to be supplied)	XXXXXXXX	
27.	7	Details of training offered on cable joint	XXXXXXXX	

B.3 TECHNICAL SCHEDULES A AND B: 44 KV, 66 KV, 88 KV OR 132 KV OIL-FILLED CABLE SEALING ENDS

Schedule A: Purchaser's specific requirements

Schedule B: Guarantees and technical particulars of equipment offered

Item	Subclause	Description	Units of Measure	Schedule A	Schedule B
28.		Insulator material (porcelain/silicone)		XXXXXXXX	
29.		Measured creepage	mm	XXXXXXXX	
30.	7	Type test report number for the cable sealing end offered or similar sealing end previously tested (report to be provided)		XXXXXXXX	
31.	7	Dimensioned drawing number for the cable sealing end (drawing to be supplied)		XXXXXXXX	
32.	7	Installation instruction drawing number for the cable sealing end (instruction to be supplied)		XXXXXXXX	
33.	7	Details of training offered on cable sealing end		XXXXXXXX	

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