Eskom	Standard	Asset Management

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1. INTRODUCTION

This document contains information regarding the requirements for power and control cables as well as control & instrumentation (C&I) cables for power stations in Generation. These cables requirements shall be applicable in peaking power stations and renewable plants.

2. SUPPORTING CLAUSES

2.1 SCOPE

This document has been prepared to assist those involved in the designing and installation of cables at the generation plants. All cabling and associated work shall be designed and executed in accordance with approved standards, codes of practice and the manufacturer's recommendations.

Cables used for wiring of Panels, Distribution boards, Motor Control Centres are not covered in this standard, however, will be covered in respective switchgear standards.

2.1.1 Purpose

The purpose of this document is to define the requirements with regards to the selection, design and execution of cabling and racking at power stations.

2.1.2 Applicability

This document shall apply in Eskom Generation.

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] 240-114967625 Operating regulations for high voltage systems in Eskom.

[3] 240-150642762 Generation Plant Safety Regulations.

[4] 240-75655504 Corrosion protection standard for new indoor and outdoor Eskom equipment, components, materials, and structures manufactured from steel Standard.

[5] 240-71432150 Plant Labelling Standard.

[6] 240-86973501 Engineering Drawing Standard - common requirements.

[7] 240-56356396 Earthing and Lightning Protection Standard.

[8] 240-54937450 Fire Protection and Life Safety Design Standard.

[9] 240-143485806 Generation Auxiliary Plant Medium Voltage Protection Standard.

[10] 240-56357424 MV and LV Switchgear Protection Standard.

[11] 240-56176097 Electrical cables schedule Template.

[12] 240-77302094 Electrical termination schedule Template

[13] SANS 97 Impregnated-paper-insulated metal-sheathed cables for rated voltages from 3.3/3.3 kV up to 19/33 kV.

[14] SANS 1339 Electric Cables–Cross-linked polyethylene (XLPE) insulated cables for voltages from 3.8/6.6kV to 19/33kV.

[15] SANS 1411 Materials of insulated electrical cables and flexible cords, Parts 1 to 6.

[16] SANS 1507-3 Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V). Part 2: PVC Distribution cables.

[17] SANS 1520-2 Flexible electric trailing cable for use in mines. Part 2: High voltage (3.8/6.6 kV to 19/33 kV) cables.

[18] SANS 1574-5 Electric flexible cables with solid extruded dielectric insulation Part 5: Rubber-insulated cables for industrial use.

[19] SANS 1574-1 Electric flexible cables with solid extruded dielectric insulation Part 1: General.

[20] SANS 10142-1 The wiring for premises Part 1: Low-voltage installations.

[21] SANS 10177-2 Fire testing of materials, components and elements used in buildings Part 2: Fire resistance test for building elements.

[22] SANS 876 Cable terminations and live conductors within air filled enclosures (insulation coordination) for rated AC voltage from 7.2 kV and up to 36 kV.

[23] SANS 1803-1 Lugs and ferrules for insulated electric cables Part 1: Copper conductors.

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

[25] 0.00/1310 Standard Power and Control Cable Code.

[26] 0.00/2713 Instrument cable code.

[27] 0.54/393 Earthing standards drawings.

[28] 0.00/10341-01 MV and LV Switchgear Lugs and Terminals.

[29] 0.00/10341-02 MV and LV Switchgear Pre-insulated Lugs and Sleeves.

[30] 0.00/10341-03 MV and LV Switchgear Wiring and Termination.

[31] 0.00/10341-04 MV and LV Switchgear Circuit Function Letters.

[32] SANS 1213 Mechanical cable glands.

[33] SANS 808 Cable glands for use on flameproof enclosures (Ex d).

[34] SANS 61238-1 Compression and mechanical connectors for power cables for rated voltages up to 30 kV (Um=36 kV) Part 1: Test methods and requirements.

[35] SANS 10198-1 The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 1 Definitions and statutory requirements.

[36] SANS 10198-2 The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 2 Choice of cable type and methods of installation.

[37] SANS 10198-3 The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 3 Earthing systems – general provisions.

[38] SANS 10198-4 The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 4 Current ratings.

[39] SANS 10198-5 The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 5 Determination of thermal and electrical resistivity of soil.

[40] SANS 10198-6 The selection, handling and installation of electric power cables of rating not exceeding 33 kV - Part 6 Transportation and storage.

[41] SANS 10198-7 The selection, handling and installation of electric power cables of rating not exceeding 33 kV - Part 7 Safety precautions.

[42] SANS 10198-8 The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 8 Cable laying and installation.

[43] SANS 10198-10 The selection, handling and installation of electric power cables of rating not exceeding 33 kV - Part 10 Jointing and terminating of paper-insulated cables.

[44] SANS 10198-11 The selection, handling and installation of electric power cables of rating not exceeding 33 kV - Part 11 Jointing and terminating of polymeric-insulated cables.

[45] SANS 10198-13 The selection, handling and installation of electric power cables of rating not exceeding 33 kV - Part 13 Testing, commissioning and fault location.

[46] SANS 61914 Cable cleats for electrical installations.

2.2.2 Informative

[47] Insert informative document references here.

2.3 DEFINITIONS

The definitions given in SANS 1507, SANS 1574, SANS 1339 and the following shall apply:

Definition	Description
Approved by	The accountability of the Approver of the document is equivalent to the specified role of Functional Responsible/Owner as identified in 240-53114186 and 32-6 for Documents and Records Management.
Cable cleat	Device designed to provide securing of cables when installed at intervals along the length of cables. **Note 1** to entry: A cable cleat is provided with a means of attachment to a mounting surface but does not rely on an unspecified mounting surface for the retention of the cables. Examples of mounting surfaces that may be specified are ladder, tray, strut or rail. Where declared, cable cleats provide resistance to electromechanical forces.
Highest system voltage	The highest value of operating voltage which occurs under normal operating conditions at any time and at any point on the system
Intermediate restraint	Cable retaining device designed to be used with cable cleats, without being attached to the mounting surface, to hold the cables together in order to provide resistance to electromechanical forces.
Routine test	Test conducted at the manufacturer's works on all cable lengths during manufacture or in the finished state, as appropriate.
Sample test	Test conducted on a regular basis at the manufacturer's works or on representative samples taken by the manufacturer, or as requested by the purchaser at the time of enquiry or order.
Type test	Test conducted before a type of cable covered by this standard is supplied on a general commercial basis, in order to demonstrate that the cable has the necessary performance characteristics for the intended application.
U	rated power frequency voltage between conductors for which the cable is designed
U_0	rated power frequency voltage between conductor and earth or metal screen for which the cable is designed

Definition	Description
U_{max}	maximum value of the “highest system voltage” for which the equipment may be used

2.3.1 Disclosure Classification

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

2.4 ABBREVIATIONS

Abbreviation	Description
CCA	Copper-clad Aluminium
CSA	Cross sectional area
CT	Current Transformer
LV	Low Voltage
MCR	Maximum Continuous Rating
MV	Medium Voltage
PVC	Polyvinyl chloride
rms	Root mean square
SANS	South African National Standards
UV	Ultra-violet
VT	Voltage Transformer
XLPE	Cross Linked Polyethylene

2.5 ROLES AND RESPONSIBILITIES

- Generation Asset Management is the custodian of the standard.
- Generation power stations should ensure that acquisition of all new power and control cabling is done in accordance with the provisions of this document.
- This document shall be used in conjunction with the technical specification.

2.6 PROCESS FOR MONITORING

Not applicable.

2.7 RELATED/SUPPORTING DOCUMENTS

Not applicable.

3. REQUIREMENTS FOR CONTROL AND POWER CABLES FOR POWER STATIONS STANDARD

3.1 STATUTORY REQUIREMENTS

a) The requirements of the Occupational Health and Safety Act, Act 85 of 1993, (OHS Act) and all subsequent amendments and regulations shall be observed and adhered to.

b) The requirements of SANS 10142-1, SANS 1507, SANS 1339 and SANS 10198-1 shall be observed and adhered to.

c) All cable offered shall carry valid product type tests in accordance with the relevant SANS standard, and where applicable for local type tested cables the SANAS accredited product certification body mark scheme.

3.2 CABLE IDENTIFICATION

3.2.1 Eskom standard cable codes

The cable types are designated in accordance with Eskom standard cable codes detailed on the following drawings;

- 0.00/1310 Standard power and control cable code
- 0.00/2713 Instrument cable code

The cable identifies the cable construction in terms of voltage grade, insulation type, construction around the cores, individual core area, conductor material and outer sheathing or protection.

3.3 CABLE TYPES AND SPECIFICATION

3.3.1 General

a) Each power station will standardise on the cables sizes to be use in order to optimise number of different types of cables. This will also optimise the number of cable drums to be kept for spares.

b) The Contractor shall indicate basic information with regards to the compounds used in the cable construction of each type of cable as per Schedule B.

3.3.2 Medium voltage XLPE cables

3.3.2.1 General requirements for MV cables

a) Medium voltage cables shall comply with SANS 1339 and the requirements of this standard.

b) All cable offered shall carry valid product type tests in accordance with the relevant SANS standard. A copy of all relevant type test reports and the required tender returnable documentation shall be submitted at the time of tender enquiry submissions.

3.3.2.2 Voltage rating

For XLPE insulated cables the rating shall be as follows:

a) For 3.3 kV system the rated cable voltage is $U_0/U(U_{max})$1.9/3.3(3.6) kV.

b) For 6.6 kV system the rated cable voltage is $U_0/U(U_{max})$ 3.8/6.6(7.2) kV.

c) For 11 kV system the rated cable voltage is $U_0/U(U_{max})$ 6.35/11(12) kV.

d) For 15 kV system the rated cable voltage is $U_0/U(U_{max})$ 12.7/22(24) kV.

3.3.2.3 Conductors

a) Conductors shall be copper or aluminium in accordance with SANS 1411-1. The conductors shall be Class 2 in accordance with SANS 1411-1.

b) Single and three core cables shall be with the cores individually screened with copper tape.

3.3.2.4 Armour

a) Single-core cables shall be unarmoured.

3.3.2.5 XLPE insulation

XLPE-insulated cables shall comply with SANS 1339 and shall meet the following specific requirements:

3.3.2.5.1 Type

The cable construction shall be type B.

3.3.2.5.2 Semi conducting core screen

The core screen shall be strippable.

3.3.2.5.3 Bedding under armouring

The bedding under the armouring shall comprise an extruded layer of XPLE type A in accordance with SANS 1411-4.

3.3.2.5.4 Outer sheath

The cables shall be XLPE insulated with flame-retardant reduced halogen emission PVC outer sheath and bedding (emit a mass of not more than 15% halogen). Acceptance criteria for insulation shall be in accordance with SANS 1411-2.

3.3.2.5.5 Water blocking

Where water blocking is specified in the technical schedules, the cable shall be longitudinally water-blocked in the following parts of the cable:

a) In the region of the armouring and metal layers;

b) In the interstices between the cores of a three-core cable;

c) In the region of the metal screen; and

d) Along the conductor length.

3.3.2.5.6 Screening and armouring

a) Single and 3-core cables shall be with the cores individually screened with copper tape. These cables shall be manufactured to SANS 1339 and SANS 1411 parts 1, 2, 4, 6 and 7.

3.3.3 Low voltage power cables

3.3.3.1 General requirements for Low Voltage cables

a) Low voltage cables shall comply with SANS 1507-3 and the requirements of this standard.

b) All cable offered shall carry valid product type tests in accordance with the relevant SANS standard. A copy of all relevant type test reports and the required tender returnable documentation shall be submitted at the time of tender enquiry submissions.

3.3.3.2 Voltage rating

For 230 Vac, 400V, 525V and 690V systems the rated cables voltage is (U_0/U) 600/1000 V.

3.3.3.3 Conductors

a) The conductors shall be copper stranded for low voltage power cables. The conductor size required will be specified in schedule A.
b) Options for CCA or aluminium alloy conductors will be allowed for low voltage cables for pilot or trial projects of new conductor types. The conductor size required will be specified in schedule A.

3.3.3.4 Insulation

PVC cable shall comply with SANS 1507-3 and SANS 1411-2.

3.3.3.5 Colour coding, identification of LV cable cores and terminations

a) Colour coding of cable cores shall be in accordance with Table 2 of SANS 1507-3(2020 edition).

b) For multicore cables (more than 4 cores), cores shall be identified by numbering.

c) For terminations purpose it may become necessary to code by coloured sleeves:

- AC phases colours: red-yellow-blue
- Neutral: black
- DC positive: red
- DC negative: blue
- DC battery midpoint: black
- Earth: green/yellow (plain green is not permissible).

3.3.3.6 Bedding under armouring

The cables shall have PVC bedding.

3.3.3.7 Armouring

a) Single-core cables shall have aluminium wire armour, unless otherwise specified in schedule A.

b) Multi-core cables shall have galvanized steel wire armour, unless otherwise specified in schedule A.

3.3.3.8 Outer sheath

a) The cables shall have PVC outer sheathing.

b) The outer sheath shall be ultraviolet (UV) radiation stabilised.

3.3.4 Mineral Insulated cables (Rubber-insulated cables)

a) Mineral insulated cables shall be in accordance with SANS 1574-5.

b) Mineral insulated cables shall only be used in exceptional circumstances where route temperatures are high.

c) Voltage rating of the mineral insulated cable shall be 600V/1000V for system voltages.

d) The insulation type shall be RD7 rubber insulation in accordance with SANS 1574-5.

e) Protective covering material shall be RS8 in accordance with SANS 1411-3.

3.3.5 Control, protection and instrumentation cables

3.3.5.1 Cable type: BVXnnCM multicore

a) Multicore cables shall be in accordance with SANS 1507-3 and the requirements of this standard.

b) All cable offered shall carry valid product type tests in accordance with the relevant SANS standard. A copy of all relevant type test reports and the required tender returnable documentation shall be submitted at the time of tender enquiry submissions.

3.3.5.1.1 Voltage rating

For 24V (ac or dc) to 220Vdc systems the rated cable voltage is 600/1000 V.

3.3.5.1.2 Conductors

a) The conductors shall be copper stranded for multi core control cables. The conductor size required will be specified in schedule A.

b) Options for CCA or aluminium alloy conductors will be allowed for multi core control cables for pilot or trial projects of new conductor types. The conductor size required will be specified in schedule A.

3.3.5.1.3 Insulation

PVC cable shall comply with SANS 1507-3 and SANS 1411-2.

3.3.5.1.4 Colour coding, identification of multi core cable cores and terminations

Colour coding, identification of multi core cables and terminations shall be same as clause **3.3.3.5**.

3.3.5.1.5 Bedding under armouring

The cables shall have PVC bedding if the cable is required with the armouring it will be specified in schedule A.

3.3.5.1.6 Armouring

If the armouring is required, it will be specified in schedule A and in line with clause **3.3.3.7**.

3.3.5.1.7 Outer sheath

The requirements shall be in line with clause **3.3.3.8**.

3.3.5.2 Cable type: BVSnnCM multicore

Multi-core thermoplastic insulated with untwisted pairs, overall tin foil screened and glass fibre cover in line with Instrument cable code 0.00/2713. These cables shall be used for non-conventional control circuits where low impedance electronic circuitry is employed. This cable type shall only be used when requested specifically by the Employer.

3.3.5.3 Cable type: UVGnnACM multicore

3.3.5.3.1 General

a) These multi core cables are used for all cables required for instrumentation involving transducers, computers, or other electronic devices where noise and cross-talk must be kept to a minimum.

b) The cable is multi core twisted pair, overall metallic tape screen in line with Instrument cable code 0.00/2713.

3.3.5.3.2 Voltage rating

The voltage rating of these cable shall be 300/500V.

3.3.5.3.3 Conductors

a) The conductors shall be in accordance with SANS 1411-1.

b) The conductor’s material shall be specified in schedule A.

c) Where stranded conductors are used, a minimum of seven strands shall be used in accordance with SANS 1411-1.

3.3.5.3.4 Insulation

a) The conductor insulation shall be flexible grade PVC as detailed in SANS 1411-2.

b) Insulation shall be flame retardant and reduced halogen emission PVC. Reduced halogen emission properties shall, when tested in accordance with section 5.10 of SANS 1411-2(2014), emit a mass of not more than 15 % of halogen expressed as hydrogen chloride (HCl).

3.3.5.3.5 Core identification

a) Conductor twisted pairs in this series shall be identified by a colour code system of orange, violet and turquoise rings.

b) The cores of cables shall be identified by the dielectric colour core as below:

Table 1: Core colour identification

Single Conductors		Paired Conductors		Triple Conductors	
Conductor No	**Colour**	**Pair No**	**Colours**	**Triple No**	**Colours**
1	Blue	1	Blue/red	1	Blue/Red/Grey
2	Red				
3	Grey	2	Grey/Yellow		
4	Yellow			2	Yellow/Green/Brown
5	Green	3	Green/Brown		
6	Brown				
7	White	4	White/Black	3	White/Black/Pink
8	Black				

c) Single colour wires shall have the specified colour incorporated in the thermoplastic insulation.

d) Where a number of cores are grouped together in a cable, each core in the group shall be identified by the colour in the **Table 1** above, and by marking as detailed below:

Table 2: Group numbers and corresponding number of colour ring/s

Group Number	Number of rings and their colour
Group 1	One ring of orange
Group 2	Two rings of orange
Group 3	Three rings orange
Group 4	Four rings orange
Group 5	Five rings orange
Group 6	One ring of violet
Group 7	Two rings of violet

Group 8	Three rings of violet
Group 9	Four rings of violet
Group 10	Five rings of violet
Group 11	One ring of turquoise
Group 12	Two rings of turquoise

e) Rings shall be 2 mm wide, and groups of rings shall be spaced at not more than 60mm.

f) The base and applied surface colours shall comply with the colour stability tests in accordance with SANS 1411-2.

3.3.5.3.6 Cable sheath and bedding

a) The cables shall have PVC on outer sheathing and bedding.

b) The outer sheath shall be ultraviolet (UV) radiation stabilised.

3.3.5.3.7 Armouring

Multi-core cables shall have galvanized steel wire armour, unless otherwise specified in schedule A.

3.3.5.3.8 Electrical requirements for finished cables

a) **Conductor resistance**: The dc resistance of each conductor shall not exceed the appropriate maximum value given in SANS 1411-1.

b) **Voltage withstand**: when testing, as appropriate, test voltage should be increased to the full value and maintained at this value for 15 min. Test voltages shall be as follows:

Table 3: Test Voltage (SANS 1507-1)

Cables	**Test voltage (V)**			
Rated Voltage V	**ac (rms)**		**dc**	
	Between conductors	**Between any conductor and earth**	**Between conductors**	**Between any conductor and earth**
300/500	1 000	1 000	1500	1500

c) **Insulation resistance**: The insulation resistance of each conductor shall not be less than the guaranteed figure stated in schedule B.

3.3.6 Flexible connections

a) Where electrical equipment is mounted on the boiler face which is subject to vertical movement due to heat expansion the connection between the equipment and the static steelwork shall be made by means of high temperature flexible cables in a flexible conduit.

b) These cables shall comply with same clause as in clause **3.3.4**.

3.4 MARKING

3.4.1 Marking of cable sheaths

a) All cable sheaths shall be black with colour coding traces or printing as follows:

Table 4: Marking and information cables sheaths.

CABLE TRACE COLOUR	IDENTIFYING CABLE AS HAVING
Red	Flame retardant PVC sheath only (LOI >27%)
Orange	Flame retardant PVC bedding and sheath
Blue	Low halogen emission PVC bedding and sheath (See note 1)
White	Halogen free cable

Notes: The emission of HCL gases in a fire situation is reduced from approximately 30% of the weight for standard PVC to below 15%.

b) Cables outer sheath shall be legibly marked in accordance with respective cable standards (SANS 97, SANS 1339, SANS 1507 and SANS 1574).

c) Additional information to appear on the outer sheath:
- voltage level,
- Cross-sectional area in mm^2,
- name or trade-mark of cable manufacturer and
- SABS specification to which the cable is manufactured, even if some portions of the cable make-up deviate from the specification such as SANS 1507.

3.4.2 Marking of cable drums

Cables drums shall be legibly marked in accordance with respective cable standards (SANS 97, SANS 1339, SANS 1507 and SANS 1574).

3.4.3 Special cables

Special cable types which may be required for thermocouple leads, high temperature/high flexibility applications, or heavy current high frequency applications such as turbo generator excitation circuits are not covered by this standard. The supply and installation of such cables shall be the responsibility of the supplier of the associated Plant.

3.5 DOCUMENTATION

3.5.1 Cable dimensional data

- Diameter over conductor;
- Diameter over insulation;
- Diameter over bedding;
- Diameter over armour wires (if applicable); and
- Diameter over the outer sheath,
- Insulation thickness around conductor.

3.5.2 Cable rating information

a) Maximum sustained current rating in:
- Ground,

- Air, and
- Ducts.

Note: The standard installation conditions assumed shall be stated.

b) Short-circuit ratings.

c) Cable mass (kg/m).

d) Gross mass per standard drum length (kg).

e) The 50 Hz a.c. resistance at maximum sustained conductor operating temperature (ohm/km).

f) Reactance per phase (ohm/km).

g) Capacitance per phase (nF/km).

h) Zero sequence impedance and capacitance per phase at maximum sustained conductor operating temperature (ohm/km).

3.6 FIRE PERFORMANCE REQUIREMENTS OF CABLES

The fire performance requirements shall be specified in line with the type of installation:

a) For cables that are buried under ground; the armour bedding and outer sheath of the cables shall be flame retardant (red stripe).

b) For cables installed in cables tunnels, trenches and buildings; the outer sheath of the cable shall have low halogen emission (blue stripe).

c) If the other part of the cable is buried underground and the other part goes into the cable tunnel, trench and or building; an assessment shall be undertaken in order to select the correct cable.

3.7 CABLE LAYOUT, RACKING AND LAYING

3.7.1 Drawings

a) The Employer shall provide drawings showing cable servitudes and the cable layout along the servitudes.

b) The cabling contractor shall provide a cable racking system vertically, horizontally and horizontally in a vertical plane as called for in the specification and in the drawings issued by the Employer. Details of the racking system and/or supplementary steelwork shall be submitted to the Engineer for acceptance before installation. Where necessary the Employer shall obtain approval from Others responsible for major structures to which racking should be fitted.

3.7.2 Cable racks

a) Cable racks shall be provided such that every cable is adequately supported throughout its run. Racking for power cables and control cables shall be designed to support the cables at least every 375 mm. Control cables may have to run on cable trays or in ducting so that they are supported over their entire length.

b) The minimum spacing between open telephone, control and instrumentation cable racks and power cable racks shall be 1000 mm. This may be reduced at crossings, which is at right angles. Where limited space makes it necessary to bring power and control cable racking closer than 1000 mm, control cable trays shall be installed and closed by means of a suitable cover to create a Faraday cage around the control cables.

c) Separate racks or trays shall be installed for cables of the following voltage levels:

P Process control

Open- (racks) and covered (trays). All control, instrumentation and telephone cables below 60 V AC or DC.

L Low Voltage

Power supply cables 24 V and 220 V DC, control cables 220 V DC and 230 V AC, power cables, 230 V, 400 V and 660 V AC.

S Low voltage trefoil

Power cables 400 and 660 V in trefoil (and neutral for 400 V) configuration.

M Medium Voltage

Power Cables 6.6 and 11 kV three core

T Medium Voltage trefoil

Power cables 6.6 kV and 11 kV in trefoil configuration

d) Cables in trefoil configuration shall be clamped with non-magnetic cable cleats and intermediate restraints capable of withstanding forces generated by short circuit currents in accordance with **Table 11**. The normal centre line distance between cable cleats and intermediate restraints shall be calculated based on the electromechanical forces withstand of the cable cleats in line with SANS 61914.

e) For field mounted runs, in particular for small power and control cabling, cable trays manufactured from high tension wire mesh shall be acceptable. These trays are less prone to collection of dust.

3.7.3 Reduction of fire hazards along racking routes

a) Where practical, cable racks shall be routed away from fire exposure or hazards or shall be protected from such exposures. Where cable racks are subject to oil spills, they shall be designed to prevent the spread of oil spill fires (see paragraph **3.7.9**, Sun and dust shields).

b) Under-floor and concealed cable spreading areas which have a height of more than 800 mm and total floor area exceeding 300 m^2 shall allow for the provision with a fire detection system (by Others). Refer also to the standard 240-54937450 Fire Protection and Life Safety Design Standard.

3.7.4 Loading of cable trays and ladder racks

a) The laying of cable onto racks shall conform to the following requirements:

- Two MV or LV trefoil groups per 450 mm wide rack.
- Three MV or LV trefoil groups per 600 mm wide rack•Three LV trefoil groups plus two neutral cables per 600 or 800 mm wide rack depending on cable and clamps sizes.
- All three core MV and multi-core LV cables above 16 mm^2 rated area are laid in a single layer per rack only.
- LV cables up to 6 mm^2 rated area are laid in a double layer on crowded rack routes, otherwise also only in single layers.
- Stacking of control and telephone cables up to the top edge of the side member is permissible.

b) The following worst case loads for horizontal cable racks in kg per linear metre of racking shall apply:

Table 5: Loading of Cable Trays and Ladder Racks (A)

LOADING OF HORIZONTAL RACKS						
Parameter	**Rack width [mm]**					
	150	300	450	600	800	1000
Dead weight cable load	30 kg	60 kg	90 kg	120 kg	150 kg	190 kg
Safety factor 1.6 for dead weight	50 kg	100 kg	150 kg	200 kg	240 kg	305 kg
Live weight (2)	115 kg	145 kg	175 kg	205 kg	235 kg	275 kg
Safety factor 1.2 for live weight	140 kg	175 kg	210 kg	245 kg	280 kg	330 kg
Resultant design load	150 kg	180 kg	220 kg	250 kg	300 kg	350 kg

Notes:

1. 1000 mm wide rack is used generally for cable risers only. In individually approved and exceptional cases only, it may be used for horizontal runs.
2. Live weight assumes that personnel climb temporarily onto fully loaded racking for installation and access purposes, adding an additional 85 kg/m above the calculated weight.

c) The distance of support columns shall be selected in such a way that a horizontally installed rack shall be deflected not more than 1:150 at the midpoint between two supports when subjected to the design load shown above i.e. 5 mm at the midpoint between supports 1500 mm apart.

d) Where support columns carry more than one rack or tray the centre line distance shall be selected according to the design load of the rack carrying the greatest design load.

e) A cantilever arm may not deflect more that 1:150 at the front when supporting a rack with a load equal to the design load shown above evenly distributed over its width i.e. 5 mm approximately for a cantilever arm carrying a 800 mm wide rack.

f) The following worst case loads for perforated cable trays in kg per linear metre of tray shall apply:

Table 6: Loading of Cable Trays and Ladder Racks (B)

LOADING OF PERFORATED CABLE TRAYS					
Parameter	**Rack width [mm]**				
	150	300	450	600	800
Dead weight cable load	60 kg	80 kg	100 kg	120 kg	150 kg
Safety factor 2,5 for dead weight	150 kg	200 kg	250 kg	300 kg	375 kg
Design load (1) and (2)	60 kg	80 kg	100 kg	120 kg	150 kg

Note that for (1) both cable trays and weldmesh racks shall not normally be expected to carry live weight of persons climbing on to the trays for installation or maintenance purposes (must be positioned so as to avoid ready “step functions”) and (2) the weights indicated above are based on a centreline distances of supports of 1500 mm.

3.7.5 Separation of power and control cables at outside plant buildings and substations

In order to minimise problems inside and outside buildings with routing and laying of cables and also noise interference in control cables, separate power and control cable entry into buildings shall be used. Where possible two or more separate cable entry openings shall be provided or made use of. This will also facilitate early separate closing of openings when cable laying is completed (in stages).

3.7.6 Use of racking by Others

The Employer shall advise the Contractor on racking requirements of Others. The Contractor shall install racking for such purposes at the rate prices of the contract. The Engineer shall advise the Contractor with regard to exact requirements as well as the required completion dates for the racking.

3.7.7 Supporting of cables on racks

a) Armoured and unarmoured multi-core cables shall be supported every 375 mm in the horizontal position where racks are provided. Where cables leave the racks or descend or ascend vertically, they shall be clamped every 750 mm at clipping points to be provided by the Contractor.

b) Single core cables shall be clamped by clipping points at intervals not exceeding 750 mm in the horizontal position but, although fixing holes are provided in the supporting steelwork at each clipping point, they shall be fixed to the supports every 3000 mm only. Alternative fixing points shall be offset against each other by about 100 mm along the racking route in order to create a basic snake formation along which the cable can expand and contract on heat cycling. Single core cables shall be clamped by clipping points at intervals not exceeding 750 mm in the vertical position.

3.7.8 Clipping points

Clipping points are defined as all points at which cables are secured to racking, trays, walls or ceilings by means of cable cleats, straps or saddles, made of nylon, stainless steel or another approved material. These cable cleats, straps or saddles shall comply with SANS 61914 in terms of testing to provide resistance to electromechanical forces, UV, corrosion and flame tests.

3.7.8.1 General

a) On cable risers cables shall be fixed to cable ladders or inside trays at intervals based on the tested axial loading of the cable cleats and retention to electromechanical forces in accordance with SANS 61914.

b) On vertical cable runs in (galvanised) conduit adequate space between separate conduit lengths shall be left to allow strapping of the cable to a support structure to take up the weight of the cable for each conduit length.

c) On horizontal racks installed in a vertical plane cables shall be fixed at interval based on the tested lateral loading of the cable cleat in accordance with SANS 61914.

3.7.8.2 Single core cables

a) Clipping points for trefoil groups of/or single core cables comprise a non magnetic portion or is of non magnetic material to prevent the creation of eddy currents in the clamp. Only clamps tested in accordance with SANS 61914 will be accepted. Clamps shall be the correct size for the cables.

b) Clamps shall be capable of withstanding the forces generated by the through fault current specified in **Table 11** when installed in accordance with this specification.

3.7.8.3 Multi-core cables

a) Clipping points for multi-core cables shall be applied at positions based on electromechanical forces withstand capability of the cable cleats.

b) For indoor and outdoor installations protected from direct sun radiation nylon strapping shall be used for all cables up to 30 mm diameter. These nylon strapping shall comply with the requirements of SANS 61914.

c) Stainless steel strapping shall be used for cables above 30 mm diameter for indoor installation. For all cables installed outdoors only stainless steel strapping shall be acceptable. Stainless steel strapping shall be strapped over a plastic bedding strip to prevent damage to the cable sheath. Alternatively coated stainless steel strapping shall be used. These stainless steel strapping shall comply with the requirements of SANS 61914.

d) Approved galvanised “K-clamps” with rubber or plastic inserts to protect the cable shall be used for terminating unarmoured cables in floor mounted indoor switchgear. The switchboard manufacturer shall provide suitable C-profile rails.

3.7.8.4 Control cables

Where a large number of control cables are accommodated in a limited space, they may be bunched and fixed to racking or trays by means of an approved strap. Not more than 12 cables shall be accommodated under one strap.

3.7.9 Sun and dust shields

a) Where cabling is subject to direct sun radiation, oil spills or severe dust accumulation, shields shall be provided. The shields shall be designed to protect the cables against sunlight or against oil, dust and other foreign matter, as required for the particular case and does not obstruct air flow past the cables or diminish the thermal rating of the cables in any way.

b) Sun shields shall be designed to protect cable racks against direct sun radiation at angles not less than 35º from the vertical plane and if slotted for ventilation, gives not less than 75% coverage.

3.7.10 Sleeve pipes for cables

Sleeve pipes shall be provided to carry cables under roadways, foundations, aprons and certain floors. Details of all permissible types of cable pipes are provided in Table 7.

Table 7: Sleeve pipes for drawing-in of cables

Arrangement of sleeving	Type of cabling	Pipe arrangement	Type of pipe	Overall Diameter of cable (mm)	Nominal bore of pipe (mm)	Length of pipe
Pipes under road and railway crossings	Armoured multi-core, in exceptions also	PVC	Straight	Up to 60	100	1.2m beyond road kerbstones but not to exceed 15m 3m Beyond railway sleepers
	Single core in trefoil	PVC in trefoil		Above 60	150	

Pipes in ground, in concrete under floors	Armoured multi-core in exceptions	PVC	Straight	Up to 60	100	15m maximum end to end or between manholes
	Single core in trefoil	PVC in trefoil		Above 60	150	
	Armoured multi-core, in exceptions also unarmoured	PVC	Bends 600mm radius	Up to 45	100	
			Bends 900mm radius	Above 45	150	
	Single core in trefoil	PVC in trefoil	Bends 750mm radius	Up to 40 Above 40	100 150	

3.7.11 Cable chases

Cables shall only be buried in chases in concrete floors or walls where no alternative arrangements are possible. Floor chases shall be filled with sand and screeded over. This arrangement is avoided in areas where oil spillage is possible.

3.7.12 Cable laying in ground

a) The details of the depth of laying and spacing of all types of cable used is as shown in Table 9. The dimensions stated are the minimum permissible and shall not be reduced without investigating current loadings in detail. Where cables are laid in ground, such runs shall be shown in detail on appropriate drawings for reference purposes and protected by concrete slabs or yellow plastic cover plates and marker tapes.

Table 8: Minimum permissible bending radii for LV and MV cables

Voltage	Type of Cable	Minimum radius during installation	Fixed in position	
			Minimum	Preferred
LV	Unarmoured Single core thermoplastic	15 x D	10 x D	12 x D
LV	Unarmoured Multi core thermoplastic	12 x D	10 x D	12 x D
LV	Armoured Multi core thermoplastic	15 x D	12 x D	15 x D
MV	Armoured Multi core cross linked polyethylene	18 x D	15 x D	15 x D
MV	Unarmoured single core cross linked polyethylene	15 x D	12 x D	12 x D
D = Overall diameter of cable				

b) Every effort shall be made to run cables either in tunnels, trenches or sleeve pipes, should they have to be laid below ground level.

3.7.13 Cable route markers

Concrete cable route markers as per drawing **0.66/3355** in **Appendix C** shall be provided to mark all cable servitudes and the general location of buried cables. The route markers shall be located at 50 m intervals and wherever a route changes direction, to mark buried joints and where cables cross roads, railways or any other servitudes.

3.7.14 Cable laying in air from great heights

a) In the boiler house area it is usual practice to lay cables from drums transported to the highest floor level required. Extreme care shall be taken when lowering cable for laying from a drum to ensure that the cable weight is countered by a suitable braking means (e.g. weight of 100 m, 4 x 70 mm^2 armoured cable is 510 kg). Assuming the total unarmoured cable weight is taken up by the conductors only, the weight of 100 m is about 10% of the ultimate tensile strength only. This method shall be acceptable, provided that clipping is performed promptly.

b) Attempts shall be made to limit the pulling force required to a minimum to avoid stretching the outer layers of the cable. The cable manufacturer's maximum allowable mechanical forces on cables during installation shall not be exceeded.

3.8 TERMINATION OF CABLES AND CORES

3.8.1 Insulation co-ordination

3.8.1.1 Impulse insulation levels

a) Cables and accessories shall comply with List 3 in Table 2 of SANS 1019.

b) Impulse insulations levels of equipment such as Primary and secondary switchgear etc shall be in accordance with their respective standards.

3.8.1.2 Insulation requirements for air filled termination enclosures

The clearance and creepage within air filled termination enclosures shall comply with the requirements of SANS 876.

3.8.2 Termination through gland plates

a) Where cables enter enclosures through gland plates, mechanical cable glands of the armour or cable gripping type to SANS 1213 shall be used. Glands shall be of the correct size for the cable. Weatherproof shrouds shall be required only for exposed positions indoors and for all field mounted terminations.

b) Cables glands used in hazardous locations, shall comply with all relevant parts of SANS 60079.

c) Cables glands used for flameproof enclosures shall comply with SANS 808.

d) The quality of cable gland terminations shall be in line with and may not be lower than the degree of protection (IP rating) of the enclosure against ingress of dust and water.

e) For MV cables where cable glands are required, split gland plates shall be provided to enable removal of the cable without removal of the gland plate.

f) For single core cable terminations the gland plate and both gland and lock nut shall be of non-magnetic material.

g) Cables shall be installed from the back to the front on the gland plate to enable cables to be added without difficulty at a later stage, if required. Low voltage and control cables shall be grouped separately on the gland plate.

h) Outdoor cables shall not enter at the top of a distribution board and where cables enter on the side, care shall be taken to prevent water ingress.

3.8.3 Termination of cables in switchgear

a) If the switchgear has been type-tested with the gland plate in place, cables shall be terminated with gland plates in that switchgear. The switchgear supplier, in writing, shall authorise the deviation from using gland plates.

b) Where additional CTs are required and do not fit inside the cable compartment, the switchgear supplier shall provide a solution. The solution provided is supported by a type test report, which can be an extension of the original type test report validity in writing.

c) Where cables enter switchgear or other cubicles through floor openings, of which an adequately fire-rated material will later seal to make the switchgear vermin proof, gland plates can be considered. In this case, the switchgear manufacturer shall provide termination designs and support structure for the cables onto which they can be securely clamped. Non-magnetic clamps shall be used for single-core cables.

3.8.4 Cable entry into enclosures with non-standard threads

Certain imported equipment is supplied by Others with enclosures having cable entries with other than metric threads. To permit fitting of cable glands to SANS 1213 the Contractor shall supply and fit the correct reducers from one type and size of thread to the other.

3.8.5 MV Terminations and earthing of single core cables

a) Approved termination kits for terminating MV cables shall be supplied. Care shall be taken to ensure that the dimensions and procedures issued with the kit are adhered to.

b) Single core cables connecting between boards shall be single-point-earthed on the feeder side. Cables connecting transformers to boards are single-point-earthed at the switchgear. Trefoil earth tails shall be bonded together with the shortest possible earth strap to the earth bar.

c) Cable earth tails shall be long enough to connect directly to the earth bar without jointing.

3.8.5.2 Correct connecting of MV cables

a) Terminations should be made off ensuring that the phase cores do not cross and that clearances between the cores are maximised as shown in Figure 1.

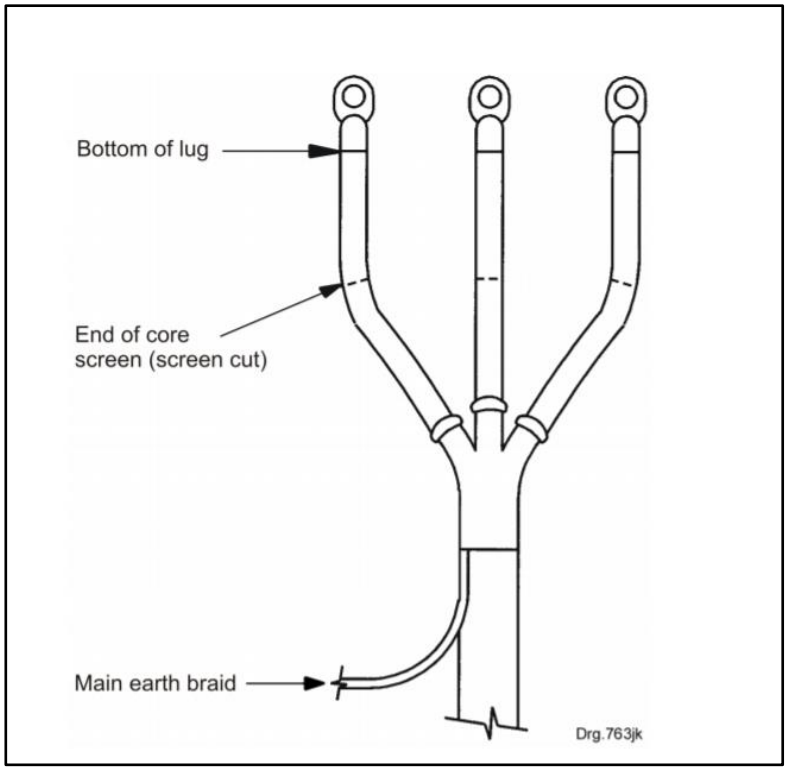

Figure 1: Example of cable termination without core crossings.

b) Where possible, crossing of cores to achieve the correct phasing is to be done at cables joints as opposed to the terminations.

c) Should it be not possible to achieve correct phasing at the joint, phase cores shall cross below the end of screen cut as shown in Figure 2. As shown in Figure 2, from the screen cut (c) to the lug, minimum clearances must be maintained as per SANS 876.

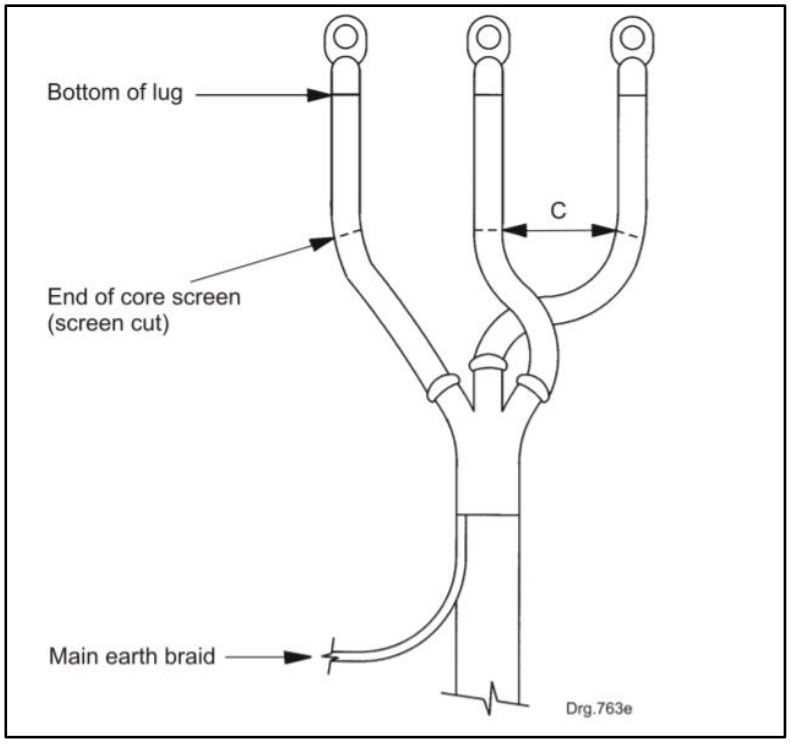

Figure 2: Example of a cable termination where the core crossing is made below the end of the core screen.

3.8.6 LV Power cable terminations

Cables of larger rated cross sectional areas terminated straight onto the terminals of the lowest drive compartment in a MCC may give problems due to heat expansion. An S-bend or a complete loop shall be provided near the termination so that expansion due to temperature changes does not stress the cable or terminal.

3.8.7 Battery terminations

Cables from the battery charge or UPS shall not be terminated directly onto terminals of batteries. These cables shall be terminated on the wall mounted or stand mounted termination devices offered by battery supplier. The connection details shall be in accordance with 240-56360034.

3.8.8 Multi-core thermoplastic insulated cable terminations

Terminations shall as a minimum requirement comply with the drawing 0.00/10341 (relevant sheets). Spare cores (those not connected to any terminal) shall be left long enough to reach the furthest terminal and is neatly fastened, ferruled with the cable numbers and earthed on one side only, usually the outgoing side of the cable. Lug/terminal combinations different from those shown on the standard drawing shall not be not used without approval.

3.8.9 Mineral-insulated cable terminations

Cable terminations for mineral-insulated cables shall be made with a cold-seal compound and all cores shall be insulated throughout their length with continuous neoprene or nylon sleeving. Terminations having jointed or PVC sleeving shall not be acceptable. The termination shall be suitable for operation up to 80ºC.

3.8.10 Process control cable terminations

a) Control and instrument cable terminations shall comply with the drawing 0.00/10341 (relevant sheets).

b) The termination of control cables onto delicate control equipment shall be performed in accordance with the special instructions from the respective process control equipment supplier.

c) Process control cable shall generally be terminated by using screw clamp type connections at the field equipment end. Pre-insulated lugs shall be crimped onto stranded cores for screw clamp type terminations, e.g. on line-up terminals.

d) Termination of cables onto line-up terminal strips

e) Wire trunking for internal wiring and for the safe routing of incoming cable cores to the terminal strips shall be used in switchgear and large distribution boards. When trunking is not available or economical, control (and smaller power) cabling shall be harnessed and secured in a neat manner.

f) Identification of cores by means of approved ferrules sized to suit the core diameter shall be provided.

3.8.11 Earthing of equipment and cables

For detailed instructions on the earthing methods when terminating cables, screens etc, refer to 240-56356396 Earthing and Lightning Protection Standard as well as the earthing standards, 0.54/393.

3.8.12 Panel jumper wires

With certain items of equipment it may be necessary to interconnect terminals in the same, adjacent or nearby panels using jumper wires of rated area up to 4 mm^2. The necessary jumper wires complete with ferrules and suitable lugs or terminating pins where necessary shall be supplied and installed. Lugs and terminating pins and the crimping tool used to fix them to the wire shall be reviewed and approved by the Engineer.

3.8.13 Cable lugs, ferrules and crimping tools

a) The size of cable lugs shall be selected to fit the bare copper conductors on which they are used. For conductors 0.5 to 6 mm^2 pre-insulated crimping lugs as per drawing 0.00/10341-02 shall be used. All small lugs shall be crimped by means of the correct crimping tools. Crimping tools shall either be of the manual or hydraulic type. Only standard pre-fabricated crimp lugs shall be used. Cutting, re-drilling and other site modifications shall not be allowed. Pre-insulated crimp lugs with unbrazed barrels shall not be crimped sideways.

b) Mechanical torque shear lugs and ferrules that comply with the requirements of SANS 61238-1 shall be used for connecting conductors and are supplied and included with each cable accessory.

c) Mechanical torque shear lugs and ferrules shall be installed using the correct socket/allen wrench and appropriate holding tool.

d) Compression lugs and ferrules shall comply with the requirements of SANS 61238-1.

e) Compression lugs and ferrules shall be compressed using a hexagonal die crimping system. The crimping dies shall be in accordance with SANS 1803-1.

f) For high fault current applications above 40kA heavy duty lugs with double crimps shall be used.

g) Cable cutters shall be used to strip flexible stranded cable, not a hack saw as this creates distortion in the cable.

3.8.14 Supply of bolts and nuts

a) In many cases the equipment supplier shall provide only termination points without any other hardware. In that case, the cable installer shall supply correctly dimensioned bolts, washers (contact, flat and spring washers as required) and nuts.

b) Material for outdoor installations shall be hot-dip or electro galvanised. Material for indoor terminations shall be cadmium plated and passivated.

3.8.15 Connection torque

a) Torque wrenches shall be used to tighten screw-joints of copper bars as well as bolting cable lugs onto copper bars, battery terminating plates and motor terminals to consistent and repeatable values.

b) High tensile bolts of tensile strength 8.8 (class 8G) and nuts of strength 5.5 (class 5D) shall be used. Bolts with tensile strength 5.5 (class 5D) shall not be accepted. The Contractor supplies all bolts, nuts, flat and spring or contact washers for terminating power cables onto boards and other equipment, e.g. transformers.

c) The specified material shall be used for the types of connections as shown in the following table:

Table 9: Connection torque (A)

MATERIALS AND BOLT SIZES FOR DIFFERENT TYPES OF JOINTS		
JOINT	**MATERIAL**	**BOLT SIZES**
Copper bar joints	hex bolt, 2 contact washers, nut	M5, 6, 8, 10, 12, 16
Cable lugs onto copper bar	bolt, washer, contact washers, nut	Cheese head: M4, 5, 6 Hex bolts: M5, 6, 8, 10, 12
Copper bar, large transformer bushings	bolt, washer, contact washer	M16, 20, 24, 30, 36
Two cable lugs front and back onto copper bar	bolt, spring washer, washer-washer, spring washer, nut	Cheese head: M4, 5, 6 Hex bolt: 6, 8, 10

d) The torque values for the different bolt sizes are given in the following table:

Table 10: Connection torque (B)

TORQUE VALUES				
Thread Size	**8.8 High tensile bolt Original tightening [Nm]**	**Testing [Nm]**	**4.6 Brass/copper/copper alloy bolts Original tightening [Nm]**	**Testing [Nm]**
M4	1.8	1.5	-	-
M5	5.0	4.3	2.5	2.12
M6	8.0	6.8	4.0	3.4
M8	20	17	8.0	6.8
M10	40	35	13.0	11

M12	70	60	20	17
M16	155	130	40	34
M20	480	410	-	-
M24	835	710	-	-
M30	1660	1410	-	-
M36	2900	2460	-	-

e) The above values shall be reached to within ± 10% tolerance and be witnessed during erection in accordance with the quality check sheet.

f) For motor terminations with bolts and nuts of a lower tensile strength (4.6 and 4 respectively) of brass and or copper/copper alloys lower torque values shall be used.

3.8.16 Cable lengths and through joints

3.8.16.1 Lengths and through joints

a) Full drum lengths of cable shall be used wherever possible. One through joint shall be accepted as routine per standard drum length of cable or part thereof, measured along the approved route between terminations. All other cases are treated as exceptions and approval is required before through joints may be installed.

b) Through joints in protection cables and secondary CT or VT leads shall not be acceptable. No through joints are permissible under any circumstances with screened instrumentation cables.

c) Where an LV cable run exceeds the maximum drum length, soldered resin encapsulated joints shall be required.

3.8.16.2 Junction and reduction boxes

a) On long low voltage cable runs the volt drop consideration may require the use of cables with rated areas one or more sizes above that which would normally suffice for given motor currents. It may then become necessary to install cable junction boxes near the consumer and to install a short length of cable with the smaller rated area to suit the termination box size of the motor. Such junction (reduction) boxes shall be supplied for sizes of the larger cable 50 to 185 mm^2.

b) Construction:

- Boxes and cover plates shall be constructed of folded steel minimum 2mm thick;
- Degree of protection of the boxes shall be the same rating as of the electrical equipment to which the cable is connected;
- The colour of the boxes shall be G29 (light grey) or B26 (orange) in accordance with SANS 1091;
- The boxes shall be rated for the applicable fault current;
- Phase flash barrier shall be installed between the phases.

c) Labels shall be in accordance with 240-71432150.

3.9 CABLE RATINGS

3.9.1 General

a) The current ratings shall be based on the requirements of SANS 10198-4 and the recommendations from the cable manufacturers for unarmoured cable with halogen-free, low smoke and fume, fire retardant insulating compounds.

b) For armoured cables with PVC insulation and bedding, steel wire armour and fire retardant PVC sheath separate tables contain the information for the respective current ratings.

c) De-rating for bunching of cables etc. shall be based on factors given by SANS 10198-4 and the industry.

3.9.2 Protection of cables

The requirements of cable protection are contained in 240-143485806 and 240-56357424.

3.9.3 Fault current ratings

a) The fault current ratings for the different voltage levels used in the auxiliary power system are as follows:

Table 11: Fault current ratings

SYSTEM FAULT CURRENT RATINGS	
Voltage level	**Fault current**
11 kV (specific boards)	40 kA
11 kV (general)	31.5 kA
6.6 kV	25 kA
400 V	50 kA
660 V	50 kA
220 V dc	10 kA
24 V dc	25 kA

b) The rated cross-sectional areas for cables under the direct control of circuit breakers shall be chosen to withstand a three-phase or DC through fault without damage for the total operating time of the protection and circuit breaker. Where the circuit breaker is fitted with instantaneous over current protection, the cable is suitable for carrying full load (continuously) or short circuit current for 0.2 seconds, whichever requires the larger cable.

3.9.4 Voltage regulation

3.9.4.1 Regulation for different applications

a) The different voltage drops that are tolerated depend on the type of consumer that is supplied and are as follows:

- 1.5% - For critical drives like standby jacking oil pumps or turbine barring gear, though operating during start up and shut down only.
- 3% - For all drives, and other consumers operating continuously under normal operating conditions of the station or a unit. This is applicable also for redundancy applications i.e. one out of two situation as for belt drives and for the coal mills which is a four out of five mills requirement at unit MCR.

- 5% - For all drives and other consumers operating intermittently only under normal operating conditions of the station or a unit. This can include drives like actuators, valve drives, shuttle heads, soot blowers and precipitator rapper motors.
- 5% - For all drives operating continuously for a number of hours but during start up and shut down of a unit only and for motor heaters used only at standstill.
- 5% - For all DC operated solenoid circuits with the full continuous solenoid operating current flowing.

b) With regard to the above limits, discretion is used in marginal cases when selecting cables because of voltage drops, in particular with larger rated cross-sectional areas.

3.9.4.2 Voltage drop curves

a) The Contractor shall compile the voltage drop curves and the associated design criteria that shall be used for the sizing of cables. This shall be submitted to the Engineer for acceptance after the Contract has been awarded.

b) The following cable design criteria shall be provided by the Contractor and agreed with the Engineer:

- The horizontal portion of the curves is determined by current carrying limitations only, assuming cables are in a single layer.
- The current de-rating must be considered besides the volt drop for all bunched cables, otherwise the maximum permissible operating temperature of cables may be exceeded as a result of restricted heat-loss dissipation. This shall be indicated on the curves.
- The curve portions that mean that the current is limited by volt drop considerations only shall be indicated on the curves.
- For a cable or trefoil group laid in sleeve pipes up to 15 m length current carrying capacity of that cable laid in air or ground, i.e. immediately before or after the sleeved section shall be used in determining current limits.
- For a cable or trefoil group laid in sleeve pipes longer than 15 m the current limit as per de-rating must be updated with the specific cable specification and applied.
- For cables laid in trenches in the HV Yard continuous current limits for cables laid in air (at 30°C) must be reduced by 15% as air temperatures in these shallow trenches can reach approximately 40°C.

3.10 CABLE TRANSPORTATION AND STORAGE

a) Cable shall be transported and stored in accordance with SANS 10198-6.

b) To prevent ingress of moisture and therefore corrosion, cable ends on returned drums may not be left open. The sealing of the cable end caps shall be by means of heat shrink caps.

Notes:

1. SANS 97 states that cable shall be sealed “by means of a metal cap plumbed onto the metal sheath or by other acceptable means to prevent the ingress of air or moisture”.
2. SANS 1339 states that cable shall be sealed “by means of a heat shrink cap or by other acceptable means, to prevent the ingress of moisture”.

c) Cable end caps shall be regularly inspected for damage or cracks that may have occurred after any handling, transport, storage. Damaged end caps shall be removed and replaced.

d) Cable on damaged drums shall be re-drummed on a drum having a barrel diameter no smaller than the original to avoid over bending.

e) Drums shall be stored on a hard-surface that has an efficient draining system.

f) Cable drums shall be so arranged that they are easily identifiable, accessible and that they may be released on a “first in – first out” basis.

g) Drums shall be rolled only in the direction indicated on the drum.

h) Drum bolts shall be tight at all times.

i) Before off-loading, drums shall be checked for damage.

j) Drums shall be lifted by a crane or forklift of suitable size and carrying capacity.

k) Cable drums shall not be dropped or laid flat.

l) If rolled off the truck, the maximum ramp slope shall be 1 in 4.

m) MV cable drums shall be transported using a cable trailer. If this is not possible, drums may be transported by truck.

n) When transporting by truck, all cable drums shall be secured (e.g. chained) to the truck bed to prevent them from rolling or sliding.

o) New and opened drums shall be protected against climatic influences. Drums shall not be stored directly on the ground but rather on wooden or other beams to permit drainage of rainwater and prevent rotting of the drums. Drums shall be rotated through 180^{o} on a yearly basis.

p) As protection of the outer cable layer against UV-radiation, slats shall not be removed from unused drums. Drums returned to the store after usage shall be protected again on return against deterioration of the outer cable layer through UV-radiation by means of temporary protection like tarpaulins, partial covering with slats or by moving it indoors.

3.11 SEALING OF HOLES IN FLOORS AND WALLS AND FIRE BARRIERS

3.11.1 Coating of cables in vicinity of fire barriers

To increase the fire survivability of the installation fire retardant coatings shall be applied onto certain critical cable runs as well as at all cable entries though fire barriers or building walls. The coating shall be applied over a distance of five metres from both sides of the barrier or wall.

3.11.2 Fire barriers

a) Fire barriers shall be installed wherever electrical cables pass through wall, floors and ceilings, inside low and medium voltage switchboards, generator protection panels, battery chargers, UPSs’ which are boundary elements of a specified fire zone in line with 240-54937450.

b) Fire barriers have a fire rating of two hours minimum in compliance with the fire resistance criteria for insulation, stability and integrity as specified by recognised testing institutions and their standards.

c) Test certificates are provided with fire barriers in accordance with:

- SANS 10177-2, Fire testing of materials, components and elements used in buildings Part 2: Fire resistance test for building element or,
- IEEE 634: 1978, Testing for Fire Rated Penetration Seals or,
- ASTM E814: Fire Test of through Penetration Fire Stops.

3.11.3 Sealing of opening in floors and walls

a) Wherever cables pass through holes or slots in floors and walls or enter or leave sleeve pipes in floors or walls; the openings shall be sealed with vermiculite plaster or other material approved by the Engineer. This material shall be domed or slightly raised towards the centre to prevent the accumulation of water or oil in the seal. The sealing material shall be water resistant and provides a barrier for smoke and toxic fumes.

b) In the case where cable sheaths are incompatible with barrier material, the cable shall be protected through the floor or wall by instamatic paint so that the sealing material is not in direct contact with the cable at any point.

3.11.4 Closing of cable entries to buildings and transformer bays

a) Once cabling work is completed, all cable entries shall be close up leading from inside buildings directly into ground outside, as well as those from transformer bays. These are made watertight by applying bituminous paint over the outside plaster.

b) This prevents ingress of vermin into the cable trenches or cable basement as well as entry of rainwater carrying silt and debris with it. Flooded cable basements can lead to premature failure of electrical equipment.

3.12 TESTING AND COMMISSIONING OF CABLES

3.12.1 Type tests and sample tests

a) Type tests and sample tests shall be in accordance with SANS 97, 1507, 1574, 1339.

b) All required type test reports (complete type test reports, including reference to all type tested materials used in the cable construction) shall be submitted to Eskom together with the Appendix B for approval at the time of tendering.

3.12.2 Routine tests

The Contractor indicates in Appendix B the specific tests performed on the different type of cables and shall provide test certificates at the delivery of the cables.

3.12.3 Site tests

All tests shall be in accordance with SANS 97, 1507, 1574, 1339, 10198-13 and other relevant standards.

3.12.4 Insulation resistance

a) The insulation resistance of each core to sheath or conduit and between cores of all cables shall be measured and recorded after the cable has been installed and made off.

b) For each cable termination the person carrying out the job shall print and sign his name, enter the date on which the work is carried out and records the insulation readings in the appropriate place on the cable pull card.

c) Cables having 110 V grade insulation or higher shall be tested by applying a voltage of 500Vdc for 1 min, as set out in SANS 5526. When performing insulation resistance testing, cable length and temperature (inclusive of temperature correction factor from OEM) shall be taken into consideration. Insulation resistance values shall be in line with Table 9 of SANS 1507-3 (2020).

3.12.5 High voltage tests (Voltage withstand)

a) Voltage withstand testing cables shall be as follows:

Table 12: Test voltages for Voltage withstand tests.

Cable type	Reference to SANS
UVG cables (300/500V)	Table C.2 of SANS 1507-1(2020)
LV PVC	Table 7 of SANS 1507-3(2020)
LV Rubber-insulated	Table 6 of SANS 1574-5 (2013)
MV PILC	Table 3 of SANS 97(2020)
MV XLPE	Table 4 of SANS 1339(2020)

b) Through- or tee-joints which are installed in an existing cable shall be subjected to a high voltage test before being put into service.

3.12.6 Conductor resistance

If required, any completed cable run shall be tested for conductor resistance.

3.12.7 Commissioning procedure

a) The provisions of the power station project commissioning procedure shall be strictly adhered to, as well as the requirements described here below.

b) The Contractor shall certify that the plant is wired in accordance with the schematic wiring and termination diagrams issued to him, updated where necessary, to represent a true record of cabling and terminations as installed.

Electrical cable schedule template (240-56176097) and electrical termination schedule template (240-77302094) shall be used to capture cable installation information.

c) For control interface cables the process control supplier shall certify that the cable terminations are in accordance with standard or special termination information as the case may be.

d) Prior to commissioning, the Employer shall appoint a representative, normally the relevant plant contractor, who co-ordinates the commissioning of all equipment forming an integral part of the units being commissioned. For such commissioning the Contractor shall supply suitably qualified personnel available to carry out changes in cables and terminations to reverse the direction of rotation of drives or complete or change control and protection cable functions in order to assist other main contractors in the commissioning of their plant.

e) The Contractor shall co-operate with Others and the Engineer during the commissioning of the plant for which he supplies the cabling.

4. AUTHORISATION

This document has been seen and accepted by:

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5. REVISIONS

Date	Rev.	Compiler	Remarks
November 2012	0	MJ Magano	Draft Document for review created from GGS 0386
May 2013	1	MJ Magano	Final Document for Publication
May 2021	1.1	D Monyane	Document due for revision: Major Changes • Technical requirements for UVGnnACM multicore cables • Dielectric resistance of the cable in accordance with SANS 1507-3. • Introduction of SANS 61914 – Cable cleats for electrical installation. • Removed requirements for battery terminations and made reference to the Battery standard. • Transferred cable ratings Table 10, 10a, 11, 11a, 12, 12a, 13, 13a, 14 and 14a. to Appendix B
February 2022	1.2	D Monyane	First draft document review for WG members' review
February 2022	1.3	D Monyane	Final Draft after Comments Review Process
March 2022	2	D Monyane	Final Document for Authorisation and Publication

6. DEVELOPMENT TEAM

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

- Vonani Mathebula
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7. ACKNOWLEDGEMENTS

- WG members.

APPENDIX A: TECHNICAL SCHEDULE A AND B

a) SCHEDULE A: PARTICULARS OF EMPLOYER'S REQUIREMENTS

b) SCHEDULE B: GUARANTEES AND TECHNICAL PARTICULARS OF PLANT AND MATERIAL OFFERED

c) Notes with regards to the completion of the schedule:

- Values and parameters entered in Schedule A are considered to be the minimum requirements. Where the Contractor does not fully comply with the Employer's requirement, any deviations must be clearly indicated in Schedule B and listed in the Deviation Schedule.
- Where there is a need to substantiate or further describe an item in Schedule B, especially in instances of non-compliance with Schedule A, particulars are furnished on a separate sheet clearly marked with the notation of the Schedule A item referred to.
- If a blank space is left in Schedule B next to certain requirement specified in Schedule A, this constitutes a confirmation that the tenderer does not comply with that specific requirement.
- Where 'xxx' is indicated for an item in Schedule A, the Contractor is required to fill in the appropriate information in Schedule B, for the equipment offered.
- Where '***' is indicated in the Schedule A column, Eskom engineering practitioner shall provide information before enquiry is issued to the market.
- Technical schedule A and B shall completed for every type of cable.

Item no.	Clause of 240-56227443	Item Description	Units	Schedule A	Schedule B
	3.2	**Cable Identification in line with Eskom cable codes (0.00/1310 rev13)**			
	3.3.2	MV XLPE cable (SANS 1339)		xxx	
		Cable code (e.g. EXE**QCM)		***	
	3.3.2.2	Rated Voltage (U_r)	kV	***	
		Insulation type		XLPE	
		Cable finish construction: a) For 3 core cable – individual copper screen tape + single steel wire armouring b) For single core cable – individual copper screen tape		***	
		Number of cores		***	
		Conductor size	mm^2	***	
		Conductor material		***	

Item no.	Clause of 240-56227443	Item Description	Units	Schedule A	Schedule B
		Serving or protection: a) For buried cable cables – Flame retardant PVC sheathed b) For cables in tunnels and trenches – Low halogen PVC sheathed		***	
	3.3.2.5.5	Water blocking		xxx	
	3.3.3	Low voltage power cables (SANS 1507-3)		xxx	
		Cable code (BVX**QCM)		***	
		Rated Voltage (U_r)	kV	***	
		Insulation type		PVC	
		Cable finish construction: a) For cables that require protection against mechanical damage – Single wire armouring b) For cables not requiring protection – General PVC covered.		***	
		Number of cores		***	
		Conductor size	mm^2	***	
		Conductor material		***	
		Serving or protection: a) For buried cable cables – Flame retardant PVC sheathed b) For cables in tunnels and trenches – Low halogen PVC sheathed		***	
		Cable Identification in line with Eskom cable codes (0.00/2713)			
	3.3.5.2	Multi-core thermoplastic insulated with untwisted pairs			
		Cable code (e.g. UVG**ACM)			

Item no.	Clause of 240-56227443	Item Description	Units	Schedule A	Schedule B
		Rated Voltage (U_r)	kV	300/500V	
		Insulation type		PVC	
		Cable construction		Twisted pairs, overall metallic tape screen	
		Number of pairs		***	
		Conductor size	mm^2	***	
		Conductor material		***	
		Serving or protection		***	
	3.3.5.3.5	Core identification in line with Table 1 and 2.		xxx	
	3.3.5.3.8 c)	Insulation resistance	MΩ.km	xxx	
		Core details			
		Conductor DC resistance at 20°C	Ω/km	xxx	
		Inductive reactance at 50Hz	Ω/km	xxx	
		Capacitance all cores to sheath	Ω/km	xxx	
		Capacitance between cores	Ω/km	xxx	
		Maximum continuous conductor temperature	°C	xxx	
		Insulation material			
		Core insulation compound used		xxx	
		Screen insulation compound used		xxx	
		Cable sheath compound used		xxx	
		Screen and armouring			
		Screen material		xxx	
		Screen coverage		100%	
		Screen thickness		0.15mm minimum	
		Water barrier		Yes	
		Overall screen resistance	Ω/km	xxx	
		Individual screen resistance		xxx	
		Individual screen coverage		100%	

Item no.	Clause of 240-56227443	Item Description	Units	Schedule A	Schedule B
		Armouring wire material		xxx	
		Armouring wire diameter	mm	xxx	
		Armouring tensile strength	N/mm^2	xxx	
		Marking			
	3.4.1	Marking of cables sheaths		Red/Orange/Blue/White	
		Manufactures of cables			
		MV power cables		xxx	
		LV power cables		xxx	
		Process control and instrumentation cables		xxx	
		Manufacturers of cable accessories			
		Termination and jointing kits for XLPE cables		xxx	
		Heat shrink sleeving jointing kits for LV power and control cables		xxx	
		Cable glands - Armour gripping type		xxx	
		Cable glands - Cable gripping type		xxx	
		Normal and heat shrink sleeving		xxx	
		Tinned copper cable lugs up to 630 mm^2		xxx	
		Pre-insulated cable lugs up to 6 mm^2		xxx	
		Crimping tools for 13.6		xxx	
		Crimping tools for 13.7		xxx	
		Cable junction boxes for cables 50 - 185 mm^2		xxx	
		Cable junction boxes for cables up to 35 mm^2		xxx	
		Cable racking			

Item no.	Clause of 240-56227443	Item Description	Units	Schedule A	Schedule B
		Standard ladder racks, open and closed trays with all accessories		xxx	
		- Manufacturer		xxx	
		- Galvanising method		xxx	
		- Minimum thickness		xxx	
		Support structure details		xxx	
		Fixing material details		xxx	
		Trefoil cable clamps manufacturer		xxx	
		Weldmesh trays and accessories manufacturer		xxx	
		Galvanised conduit manufacturer		xxx	
		Flexible conduit manufacturer		xxx	

APPENDIX B: TYPE TEST AND SAMPLE TEST CERTIFICATES/REPORTS

B1) Provide test certificate/report reference number and accredited testing authority name. The requirements are in accordance with Table 7 of SANS 1339 (2020).

Type Test Reports and certificates as required in SANS 1339					
Component	**Test property**	**Test method**	**Requirement**	**Test certificate/report reference number**	**Accredited Testing Authority**
Fillers and binders	Acid gas emission	SANS 60754-2	4.5.3		
Bedding	Acid gas emission	SANS 60754-2	4.5.3		
Outer sheath	Acid gas emission	SANS 60754-2	4.5.3		
Finished cable	Fire propagation	SANS 60332-3-24	4.5.1		
Type approval test	Smoke emission	SANS 61034-2	4.5.2		
	Bending test	SANS 6284-3	4.6.2.1		
	Partial discharge test	SANS 6291	4.6.2.3		
	Load cycling test	SANS 6284-3	4.6.2.2		
	Impulse voltage withstand	SANS 6284-3	4.6.2.4		
	Four hour high voltage withstand	SANS 6284-3	4.6.2.5		
Ageing test	50 Hz, 2 year test or	SANS 6284-5	4.7.2		
(One of the two tests 50Hz or 500Hz will be sufficient)	500 Hz, 3 000 h test	SANS 6284-5	4.7.3		
Water penetration test	Longitudinal water penetration test	SANS 1339	4.3.14		
Routine Test reports and certificates generic copies as required in SANS 1339					
Component	**Test property**	**Test method**	**Requirement**	**Test certificate/report reference number**	**Accredited Testing Authority**
Metallic core screen	Assembly	SANS 1339: 2020 (Visual examination)	4.3.7.1		
Core(s)	Identification	SANS 1339: 2020 (Visual examination)	4.3.6		
	Laying up	SANS 1339: 2020 (Visual examination)	4.3.8.1		
Finished cable	Marking	SANS 1339: 2020 (Visual examination)	7.2.1		
	Conductor resistance	SANS 6282-1	4.4.1		
	Voltage withstand	SANS 6284-3	4.4.2		

	Partial discharge test	SANS 6291	4.4.3		
	DC voltage test on outer sheath	SANS 6286	4.4.4		

Sample Test reports and certificates generic copies as required in SANS 1339

Component	Test property	Test method	Requirement	Test certificate/report reference number	Accredited Testing Authority
Conductor	Construction	SANS 1411-1	4.3.1		
Conductor screen	Thickness	SANS 6284-2	4.3.2.3		
	Measurement of insulation interface protrusions and voids	SANS 6284-1	4.3.2.2		
XLPE insulation	Composition	SANS 1411-4	4.3.3.1		
	Thickness	SANS 6284-1	4.3.3.2		
	Measurement of voids and contaminants	SANS 6284-1	4.3.3.1		
Core screen	Adhesion	SANS 6284-2	4.3.4.2		
	Thickness	SANS 6284-2	4.3.4.3		
	Measurement of insulation interface protrusions and voids	SANS 6284-1	4.3.4.2		
Metallic core screen	Wire size (Where applicable)	By Measurement	4.3.7.3		
Core(s)	Identification	Visual examination	4.3.6		
Lead or lead alloy sheath (where applicable)	Composition	SANS 6281 -2	4.3.10.2		
	Malleability	SANS 6281 -2	4.3.10.2		
	Thickness	SANS 6281 -2	4.3.10.4		
Bedding	Physical properties	SANS 1411-2 or 1411- 5	4.3.11.1		
	Thickness	SANS 60811-1-1	4.3.11.2		
Armour	Properties	SANS 1411-6	4.3.12.1		
	Wire diameter	SANS 6283	4.3.12.2		
Outer sheath	Physical properties	SANS 1411-2, SANS1411-5 or SANS1411-7	4.3.13.1		
	Thickness	SANS 60811-1-1	4.3.13.2		
Finished cable	Resistivity of semiconducting screens	SANS 6284-2	4.3.2.4		

B2) Provide test certificate/report reference number and accredited testing authority name. The requirements are in accordance with Table 7 of SANS 1507-3 (2020).

Type Test Reports and certificates as required in SANS 1507-3					
Component	**Test property**	**Test method**	**Requirement**	**Test certificate/report reference number**	**Accredited Testing Authority**
PVC Bedding	Halogen	SANS 5956	4.4.3		
PVC outer	Halogen	SANS 5956	4.4.3		
Finished cable	Fire propagation	SANS 60332-3	4.4.1		
	Smoke emission	SANS 61034-2	4.4.2		
Routine Test reports and certificates generic copies as required in SANS 1507-3					
Component	**Test property**	**Test method**	**Requirement**	**Test certificate/report reference number**	**Accredited Testing Authority**
PVC Insulation	Spark test	SANS 62230	4.2.2.3		
	Core identification	Visual examination	4.2.3		
	Assembly of cores	Visual examination	4.2.4		
Finished cable	Marking	Visual examination	SABS 1507-1: 4.2.1		
	Voltage withstand	SANS 6284-3	4.3.2		
	Conductor resistance	SANS 1411-1	4.3.1		
Sample Test reports and certificates generic copies as required in SANS 1507-3					
Component	**Test property**	**Test method**	**Requirement**	**Test certificate/report reference number**	**Accredited Testing Authority**
Conductor	Construction	SANS 1411-1	4.2.1		
PVC Insulation	Physical properties	SANS 1411-2	4.2.2.1		
	Thickness	SANS 60811-1-1	4.2.2.2		
	Core identification	Visual examination	4.2.3		
PVC Bedding	Physical properties	SANS 1411-2	4.2.5.3		
	Thickness	SANS 60811-1-1	4.2.5.3		
Lead sheath	Composition	SANS 6281-2	4.2.5.2		
	Belling	SANS 6281-2	4.2.5.2		
	Thickness	SANS 60811-1-1	4.2.5.2 (c)		
Armour	Armour Wire diameter	SANS 1411-6	4.2.5.4		

	Mass of zinc coating	SANS 1411-6	4.2.5.4		
	Adhesion of zinc coating	SANS 1411-6	4.2.5.4		
	Tensile strength	SANS 1411-6	4.2.5.4		
	Elongation at break	SANS 1411-6	4.2.5.4		
PVC outer sheath	Physical properties	SANS 1411-2	4.2.5.5		
	Thickness	SANS 60811-1-1	4.2.5.5		
Finished cable	Dielectric resistance	SANS 5526	4.3.3		

B3) Provide test certificate/report reference number and accredited testing authority name. The requirements are in accordance with Table 11 of SANS 1574-5 (2013).

Type Test Reports and certificates as required in SANS 1574-5 (2013)					
Component	**Test property**	**Test method**	**Requirement**	**Test certificate/report reference number**	**Accredited Testing Authority**
Finished flexible cable	Flexing test up to 4 mm^2	SANS 5515	4.5.1		
Routine Test reports and certificates generic copies as required in SANS 1574-5 (2013)					
Component	**Test property**	**Test method**	**Requirement**	**Test certificate/report reference number**	**Accredited Testing Authority**
Insulation	Spark test	SANS 62230	4.2.2.4		
	Core identification	Visual examination	4.2.3		
	Assembly of cores	Visual examination	4.2.4		
	Thickness	SANS 60811-201	4.2.2.3		
Sheath	Thickness	SANS60811-201	4.2.5.2		
Finished flexible cables	Marking	Visual examination	6.1		
	Solderability test	SANS 5515	4.5.2		
Sample Test reports and certificates generic copies as required in SANS 1574-5 (2013)					
Component	**Test property**	**Test method**	**Requirement**	**Test certificate/report reference number**	**Accredited Testing Authority**
Conductor	Construction	SANS 1411-1	4.2.1		
Insulation	Physical properties	SANS 1411-2	4.2.2.1		

	Core identification	Visual examination	4.2.3		
	Assembly of cores	Visual examination	4.2.4		
Sheath	Physical properties	SANS 1411-3	4.2.5		
Finished flexible cable	Conductor resistance	SANS 1411-1	4.4.1		
	Voltage withstand	SANS 6284-3	4.4.2		
	Insulation resistance	SANS 5526	4.4.3		
	Overall dimensions	SANS 60811-203	4.2.5.3		
	Ovality	SANS 60811-203	4.2.5.4		
	Heat resistance	SANS 6204	4.3		

B4) Provide test certificate/report reference number and accredited testing authority name. The requirements are in accordance with Table 8 of SANS 1574-3 (2018).

Type Test Reports and certificates as required in SANS 1574-3 (2018)					
Component	**Test property**	**Test method**	**Requirement**	**Test certificate/report reference number**	**Accredited Testing Authority**
Finished flexible cable	Flexing test up to 4 mm^2	SANS 5515	4.4.1		
Routine Test reports and certificates generic copies as required in SANS 1574-3 (2018)					
Component	**Test property**	**Test method**	**Requirement**	**Test certificate/report reference number**	**Accredited Testing Authority**
Insulation	Spark test	SANS 62230	4.2.2.4		
	Core identification	Visual examination	4.2.3		
	Assembly of cores	Visual examination	4.2.4		
	Thickness	SANS 60811-201	4.2.2.3		
Sheath	Thickness	SANS60811-201	4.2.5.2		
Finished flexible cables	Marking	Visual examination	6.1		
Sample Test reports and certificates generic copies as required in SANS 1574-3(2018)					
Component	**Test property**	**Test method**	**Requirement**	**Test certificate/report reference number**	**Accredited Testing Authority**
Conductor	Construction	SANS 1411-1	4.2.1		

Insulation	Physical properties	SANS 1411-2	4.2.2.1		
	Core identification	Visual examination	4.2.3		
	Assembly of cores	Visual examination	4.2.4		
Sheath	Physical properties	SANS 1411-3	4.2.5		
Finished flexible cable	Conductor resistance	SANS 1411-1	4.3.1		
	Voltage withstand	SANS 6284-3	4.3.2		
	Insulation resistance	SANS 5526	4.3.3		
	Overall dimensions	SANS 60811-203	4.2.5.3		
	Ovality	SANS 60811-203	4.2.5.4		

APPENDIX C: CABLE ROUTE MARKER DRAWING 0.66/3355 REV 1