



Standard

Technology

Title: **SUB-TRANSMISSION LINES
SECTION 2:
CONDUCTORS**

Unique Identifier: **240-75884084**

Alternative Reference Number: **34-1207**

Area of Applicability: **Engineering**

Documentation Type: **Standard**

Revision: **1**

Total Pages: **23**

Next Review Date: **March 2022**

Disclosure Classification: **Controlled
Disclosure**

Compiled by

Approved by

Authorized by

Prashant Mathuradas
Senior Engineer

Kris Rozmiarek
Chief Engineer

Riaz Vajeth
Senior Manager - LES

Date: 29/03/2017

Date: 29/03/2017

Date: 29/3/2017

Supported by SCOT/SC

Riaz Vajeth
SCOT/SC Chairperson

Date: 29/3/2017

Content

	Page
1. Introduction	4
2. Supporting clauses	4
2.1 Scope	4
2.1.1 Purpose	4
2.1.2 Applicability	4
2.2 Normative/informative references	4
2.2.1 Normative	4
2.2.2 Informative	5
2.3 Definitions	5
2.3.1 General	5
2.3.2 Disclosure classification	5
2.4 Abbreviations	5
2.5 Roles and responsibilities	5
2.6 Process for monitoring	5
2.7 Related/supporting documents	5
3. Requirements	6
3.1 Standards conductors	6
3.2 Selection procedure	7
3.3 Conductor mechanics	7
3.3.1 Determination of sag	8
3.3.2 Change of state of conductor	10
3.3.3 Equivalent span	11
3.4 Creep	11
3.5 Templating	11
3.6 Handling guidelines	12
3.7 Joints	14
3.8 Damaged conductors	15
3.9 Jumpers	15
4. Authorization	15
5. Revisions	16
6. Development team	16
7. Acknowledgements	16
Annex A – Conductor and shield wire characteristics	17
Annex B – Conductor creep equations	19
Annex C – Impact Assessment	21
Figures	
Figure 1: Conductor suspended between supports at the same height	8
Figure 2: Forces acting on conductor	9
Figure 3: Minimum vertical clearance	12

Tables

Table 1: Standard dimensions of conductors and terminal stems14

Table A.1: Standard conductor and shield data17

Table A.2: MVA Ratings for conductors17

Table A.3: Probabilistic ratings17

Table A.4: Shield burn-off18

1. Introduction

Part 6 of the Distribution Standard has been prepared to establish specifications for, and promote the use of, standard designs, structures and materials for sub-transmission overhead lines. Section 2 of the sub-transmission lines standard deals with standard bare conductors and shield wires.

2. Supporting clauses

2.1 Scope

This section covers standard conductors and shield wires used in construction of the overhead sub-transmission lines with voltages ranging from 44 kV to 132 kV. Basic information required for planning, design, survey and construction is provided in this section. This section covers conductor mechanics, loading criteria, selection procedure and the handling of conductors. The information in this section is applicable to standard large conductors used on 22 kV and 33 kV lines.

2.1.1 Purpose

None

2.1.2 Applicability

None

2.2 Normative/informative references

2.2.1 Normative

The following documents contain provisions that, through reference in the text, constitute requirements of this standard. At the time of publication, the edition indicated was valid. All controlled documents are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the documents listed below. Information on currently valid national and international standards and specifications can be obtained from the Information Centre and Eskom Documentation Centre at Megawatt Park.

- [1] ESKASABK1: Draft 1, Determination of conductor current ratings in Eskom.
- [2] IEC 60050-466:1990, International electrotechnical vocabulary — Chapter 466: Overhead lines.
- [3] IEC 60888:1987, Zinc-coated steel for stranded conductors.
- [4] IEC 61089:1997, Round wire concentric lay overhead electrical stranded conductors.
- [5] IEC 61394:1997, Overhead lines- Characteristics of greases for aluminium, aluminium alloy and steel bare conductors.
- [6] SABS 182-3:1975, Conductors for overhead electrical transmission lines – Part 3: Aluminium conductors, steel reinforced.
- [7] SABS 182-5:1979, Conductors for overhead electrical transmission lines – Part 5: Zinc-coated steel wires for conductors and stays.
- [8] SABS 0280:1998, Overhead power lines for conditions prevailing in South Africa.
- [9] Mechanical Design of High Voltage Transmission Lines- Conductor creep, Course notes – Division of Continuing Engineering Education, University of the Witwatersrand, 1991 presented by H. Brian White and Dr David G. Havard.
- [10] SCSSCAAU5: Rev.0, Current-carrying compression fittings for overhead Sub-transmission systems.
- [11] SCSSCAAY5: Rev 0, Phase conductor for distribution lines.

ESKOM COPYRIGHT PROTECTED

-
- [12] TRMSCAAC1: Rev 2, Transmission line towers and line construction.
- [13] ESKASABK1: Rev 0, Determination of conductor current ratings in Eskom.
- [14] ESKSCAAB4: Rev 1, Zinc-coated earth conductor, guy and stay wire for transmission lines.
- [15] Work Group 12 Cigre: Electra Number 144 October 1992 pages 107-125 The thermal behaviour of overhead conductors Section 1 and 2 mathematical model for evaluation of conductor temperature in the steady state and the application thereof.
- [16] Work Group 12 Cigre: Electra Number 164 February 1996 pages 103-119 *Probabilistic determination of conductor current rating.*

2.2.2 Informative

None

2.3 Definitions

Note: The terms used in this document are generally consistent with the definitions given in the International Electrotechnical Vocabulary (IEV).

2.3.1 General

The definitions applicable to this section document are covered in SCSASAAV1.

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
ACSR	Aluminium conductor steel reinforced
EDT	Every day tension
GSW	Galvanized steel wire
OPGW	Optical Cable Ground Wire
OSHA	The Occupation Health and Safety Act, No 85 of 1993
UTS	Ultimate tensile strength

2.5 Roles and responsibilities

Not applicable.

2.6 Process for monitoring

Not applicable.

2.7 Related/supporting documents

Not applicable.

3. Requirements

3.1 Standards conductors

ACSR conductors shall be used in construction of sub-transmission lines. The following (low steel content) ACSR conductors shall be used in design and construction of new sub-transmission lines. (For specific conductor data refer to table 1 annex A):

for 66 kV lines:

- Mink
- Hare, and
- Chickadee

for 132 kV lines:

- Chickadee.
- Kingbird, and
- Tern

Note: The voltage levels given for conductors have been chosen with corona effects in mind. If corona problems are expected with a conductor, then a larger diameter conductor shall be selected.

These conductors shall be greased if they are used in a high pollution area where corrosion of the conductor is expected. The standard greases shall be approved by Eskom and shall be manufactured in accordance with IEC61394. The approved greases are updated periodically on a distribution bulletin. The conductor shall be greased completely except for the outer surface in accordance with case 4 of annex C of IEC 61089 specification.

The ratings of these standard sub-transmission conductors are given in annex A. Annex A includes an Ampacity table. The ampacity of a conductor can be determined using the deterministic or probabilistic approach. The absolute probability method is the preferred method and is used to generate the tables in annex A.

Note: Previously it was acceptable to template at 50 °C and determine the current rating for 75 °C and 90 °C. The ratings given, in this standard and ESKASABK1, are the same as those used previously. However the current rating previously given as 75 °C is now given at 50 °C temperature. For further information, refer to ESKASABK1: "Determination of conductor current ratings in Eskom".

Conductors for new lines shall be chosen based on the least life-cycle cost of transferring power and weighted KPIs (see 4.2). Lines that require conductors other than the standard conductors given above, shall be motivated with a full design, cost analysis and load flow study. Manufacturing and testing of the conductor shall be done in accordance with IEC 61089.

If a shield wire is required then 3/4,00 or 7/3,35 galvanized steel wire shall be used. 19/2,65 shield wire shall only be used when the shielding/earthing design requires a higher burn-off rating (table 4 of annex A).

Manufacturing and testing of the galvanized steel, for shield wire and inner cores of ACSR, shall be done in accordance with IEC 60888.

All conductors and galvanized steel wire shall comply with the following specifications: SCSSCAAY5, SABS 182-3 and SABS 182-5.

Optical Cable Ground Wire (OPGW) shall be strung using the stringing sag and tension tables and recommendations given by the manufacturer of the OPGW. The phase conductor and OPGW sag and tension tables shall correspond to the standard methods for sagging phase and earth wires. The OPGW shall have a maximum sag less than or equal to 90 % of the phase conductor sag it is being strung with. Design permitting the tension in the OPGW shall be higher than the tension which gives the 90 % sag value.

3.2 Selection procedure

The selection of a conductor is an important task in the line design as it represents approximately 20 % of the total cost of a line. The following network planning information shall be considered when selecting a conductor:

- Intended start and end points of the line,
- Power transfer required in MVA (peak),
- Load growth over 20 years,
- Load profile yearly and daily,
- Required minimum and maximum impedance values,
- Cost/km used in the IRR evaluation as well as the upper limit to the cost/km,
- The line voltage and whether it is fixed or can be altered,
- Life cycle and maintenance costs and
- Environmental constraints.

The following design process shall be followed for sub-transmission lines:

- a) The possible routes can be determined by the EIA analysis. If justified, profiles for a number of routes shall be generated and loaded into a Tower spotting program.
- b) The aluminium area required is calculated based on the mean power transfer over twenty years
- c) The possible conductors shall be considered. These shall include standard and non-standard conductors.
- d) With each conductor the tower family shall be considered for the specific terrain. This tower family's loading requirements shall be determined on TLCADD. The optimum tower family may not necessarily be one of the existing basic tower families. If the profiles are not available, the basic design spans shall be used.
- e) The design options shall be evaluated using the technical indicator utilizing the initial cost, cost of losses, MVA thermal rating (annex A) and MVA SIL (Surge Impedance Loading) as well as voltage drop.
- f) For lines over 10km at least 10 different design options shall be considered. These shall include lines with different templating temperatures, conductors, towers and foundation configurations.

Annex A shows how the designer can select Tern or twin Hare conductors for lines expected to carry loads greater than 70 MVA. The option of twin Hare conductors has been introduced to combat voltage drop problems experienced on long distance lines. The twin configuration decreases the inductance of the line and hence the voltage drop. For lines where voltage drop does not pose a problem, Tern conductor shall be used.

3.3 Conductor mechanics

The general theory of sag & tension is based on the fact that, if a flexible wire of uniform weight is suspended between two rigid supports, it sags and assumes a curved shape defined as catenary.

The general equation of the catenary can be expressed in the following forms:

Exponential form

$$y = \frac{c}{2} \left(e^{\frac{x}{c}} + e^{-\frac{x}{c}} \right)$$

Hyperbolic form

$$y = c \cdot \cosh\left(\frac{x}{c}\right)$$

or expanded into a series form

$$y = c \left(1 + \frac{x^2}{1 \cdot 2 \cdot c^2} + \frac{x^4}{1 \cdot 2 \cdot 3 \cdot 4 \cdot c^4} + \frac{x^6}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5 \cdot 6 \cdot c^6} + \dots \right)$$

Consecutive terms of this series are decreasing rapidly. For spans up to 500 m and provided the ratio of sag to span does not exceed 4%, all terms but the first two are negligible. The equation then adopts a parabolic form:

$$y = c \left(1 + \frac{x^2}{2 \cdot c^2} \right)$$

3.3.1 Determination of sag

The amount of sag for conductor between supports at the same height is expressed in terms of the distance “x” from the centre of the span (point of maximum sag) and of “y” conductor height above this point (see figure 1).

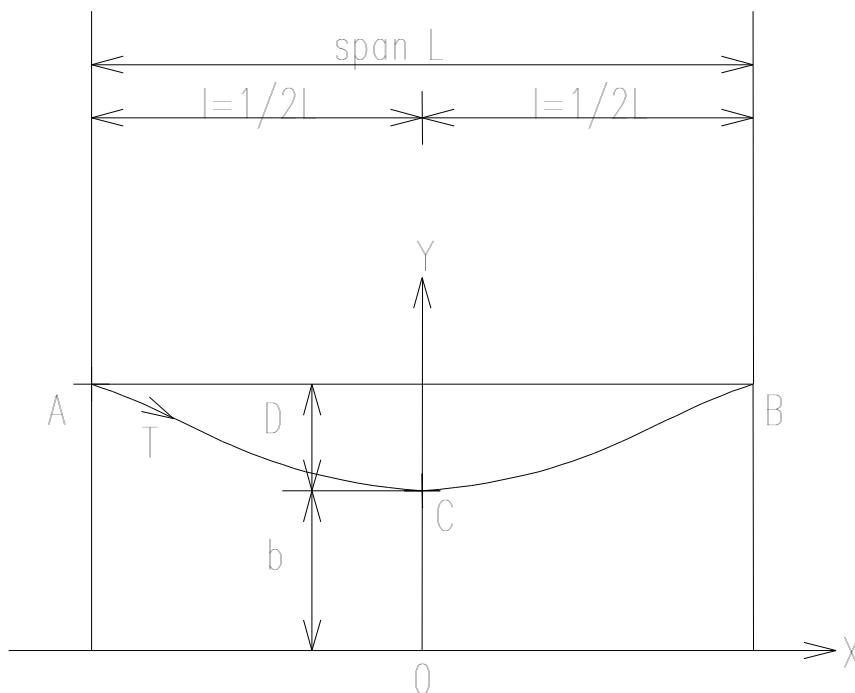


Figure 1: Conductor suspended between supports at the same height

Sag $D = Y_{AB} - Y_C$

Using the equations above the values for Y_{AB} and Y_C are as follows:

For $X_{AB} = l = \frac{L}{2}$ $Y_A = c \left(1 + \frac{L^2}{8c^2} \right)$

ESKOM COPYRIGHT PROTECTED

And for $X_{AB} = 0$ $Y_C = c$

$$D = Y_A - Y_C = c \left(1 + \frac{L^2}{8b^2} \right) - c$$

Sag

$$D = \frac{L^2}{8c}$$

The parabolic curve assumes:

A constant mass along the straight line between the points of support (this is true only at the centre), and

A uniform tension throughout the conductor.

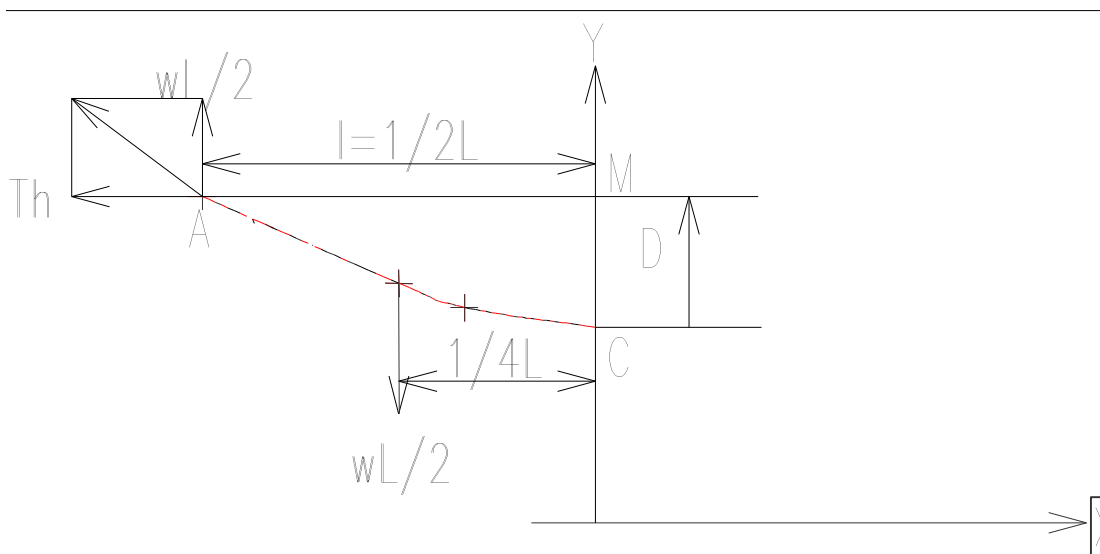


Figure 2: Forces acting on conductor

Taking moments about point "A" (see figure 2).

$$T_h D = \frac{WL}{2} \cdot \frac{L}{4}$$

$$D = \frac{WL^2}{8T_h}$$

Sag

Note: This equation applies to single spans with a strain structure either side where the conductor is made off.

From sag equations $c = \frac{L^2}{8D} = \frac{T_h}{W}$

The total loading: $W = \sqrt{(W_c^2 + W_w^2)}$

Where: $W_w = p \cdot d$ $p =$ wind pressure and $d =$ conductor diameter

The term W may include ice loading in addition to conductor weight.

In still air conditions the wind loading is zero, therefore total loading is equal to the weight of the conductor, thus the equation is:

ESKOM COPYRIGHT PROTECTED

Sag in still air
$$D = \frac{W_c L^2}{8T_h}$$

The length of the conductor in the parabolic span is expressed by the following equation:

$$S_c = L + \frac{W_c^2 L^3}{24T_h^2}$$

Since tension conditions can vary substantially with wind loading or a sudden decrease in temperature a set of limits are required for tensioning of conductors. The conditions are as follows:

- a) **Wind load.** The wind pressure acting on the conductor increases the conductor tension. In line with the OSH Act, the maximum wind pressure is based on a wind velocity producing a force of 700 Pa on 60% of the projected area of the conductor.
- b) **Maximum permissible tension.** The maximum tension in the conductor or earth wire is limited to 40% of UTS on maximum final tension (tension including creep) at temperature of -5°C with 700 Pa wind pressure on 0,6 of the projected conductor area.
- c) **Other limiting conditions.** The EDT (i.e. the final tension including creep @ 15°C) in the conductor is limited to such tension as is required to achieve the catenary constant (C value) equal to 1800. The tension for shield wire is limited to a tension that the structure can hold but a minimum tension such that the sag in not greater than 90% of the conductor sag should be designed. The maximum c value the shield wire may have is equal to 2100.

Note: The impact of aeolian vibration on conductor fatigue is minimized by use of the vibration dampers.

Note: C value = T/W

3.3.2 Change of state of conductor

If, after erection, the conductor temperature rises (because of I^2R loss or of a rise in ambient temperature), the conductor expands, increasing the sag, but at the same time reduction of tension allows the conductor to contract elastically. Further, if the loading increases (owing for example to wind pressure), the tension rises and the conductor stretches. Analysis of these opposing tendencies leads to a cubic equation relating tension, temperature, loading and elasticity.

$$T_2^3 + T_2^2 \left[AE \left(\frac{W_1^2 L^2}{24T_1^2} + \alpha (\theta_2 - \theta_1) - T_1 \right) \right] - \frac{AEW_2^2 L^2}{24} = 0$$

For two sets of conditions (subscripts 1 and 2) equation of states is as follows:

- The subscript 1 denotes a set of known tension and temperature values i.e. initial conditions.
- Subscript 2 denotes the values for a second set of conditions for which tension is trying to be found.

Tensions for different temperatures can be read from a sag and tension chart. The sag and tension charts apply to equivalent (ruling) spans and single strain spans. The charts, used in the design of the line, are based on the final stress-strain characteristics of the conductor and represent the final values after the conductor has been subjected to the mechanical design load and creep.

Stringing charts to be used in the construction of lines shall be produced for strain sections under the expected initial conductor loading conditions.

3.3.3 Equivalent span

The equations for sag derived in 4.3.2 apply to single spans with two strain structures at each end. In practice the conductor is installed and sagged in one operation for a section of line. Sections usually consist of several suspension or intermediate spans supported by number of intermediate structures positioned in between two strain structures.

The equivalent span theory works on the following principle:

Uneven spans in the strain section can be replaced by a series of equal spans of such length that the total length of the conductor and the horizontal tension of the section would be unchanged.

Three assumptions are necessary for the equivalent span to be true.

3.3.3.1 Assumptions:

- The span lengths within a section are large compared to the difference in the elevation of supports. Therefore they can be considered to be at equal elevations.
- The horizontal tension of the conductor is constant throughout the strain section, even if the conductor length of the individual spans vary.
- The sag and tension characteristics of the single strain span, of the same length, could be applied.

The equivalent span shall be calculated using the following equation:

$$l_c = \sqrt{\frac{\sum l_i^3}{\sum l_i}}$$

Where

l_i is the length of the span in the section.

3.4 Creep

Creep is defined as the time-dependent increase in conductor length of a conductor under stress. Conductors, due to their twisted construction, can often be loosely packed after manufacture. The constant load when tensioning a conductor gradually pulls the twisted construction until it is tight. Long term creep can be attributed to the materials that are used to manufacture conductors. These metallic materials elongate over time under the constant force. Over time the conductor elongation can cause the conductor to sag below the vertical clearance measured when originally strung.

For this reason conductors shall not be tensioned initially to the critical clearance. An initial tension shall be found that, when creep is added, (final tension) does not give a sag value that drops the conductor below the critical clearance. Then the initial tension can be calculated. The creep equations and graph are given in annex B.

3.5 Templating

Templating (tower spotting) is a graphical line design operation where the curves representing conductor shape are used to check clearances and to find an optimal tower position. When templating the line, the limits to be noted shall be the vertical clearance between conductor at maximum sag and any obstacles below the line, and the conductor / earth wire at minimum sag and obstacles above the line. The clearance values between phases, phase-to-ground and minimum vertical clearances are limited by the OHS Act (see section 1). The maximum sag of conductors will be at maximum operating temperature after conductor has elongated totally due to creep. The templating temperature of a line is an integral part of the line design and shall be engineered at design stage.

A templating temperature of 60°C has been recommended in SABS 0280. A templating temperature of 50 °C has traditionally been used in Eskom Distribution. Based on the current rating standard ESKASABK1, the templating temperature must be the same as the corresponding ampacity level. That is, if the thermal rating required is equivalent to a templating temperature of 70°C, the templating temperature should be 70°C. The maximum templating temperature that shall be used for a design is 80 °C.

Before deciding on a tension of the line templating the line shall be checked for the uplift case at minimum sag. The minimum sag can be found at -5°C and shall be checked on all spans to check for an uplift case. Uplift of a pole is characteristic of lines built over a valley and of the pole in the valley.

The shape of the conductor curve suspended between two strain towers, at a fixed temperature for the particular equivalent span can be defined by the Conductor Constant (CC) or by the catenary constant (C value). These two unique constants can worked out with the following expressions:

$$CC = \frac{D}{L^2} \quad CC = \frac{W_c}{8T_h} \quad C = \frac{T_h}{W_c}$$

The Conductor constant equation produces a very shallow curve. To represent the conductor on paper, a much deeper curve is required. Therefore, the line profiles are plotted to a vertical scale that is 10 times as large as the horizontal scale. The shape of the deeper curve is embodied in the Template Constant, which is related to the conductor constant by the scale factor.

The maximum allowable sag of the conductor that will not violate ground clearance in the specific span can be calculated using the following equation:

Max. Sag (@required templating temperature e.g. 70°C) = Attachment height – statutory ground clearance.

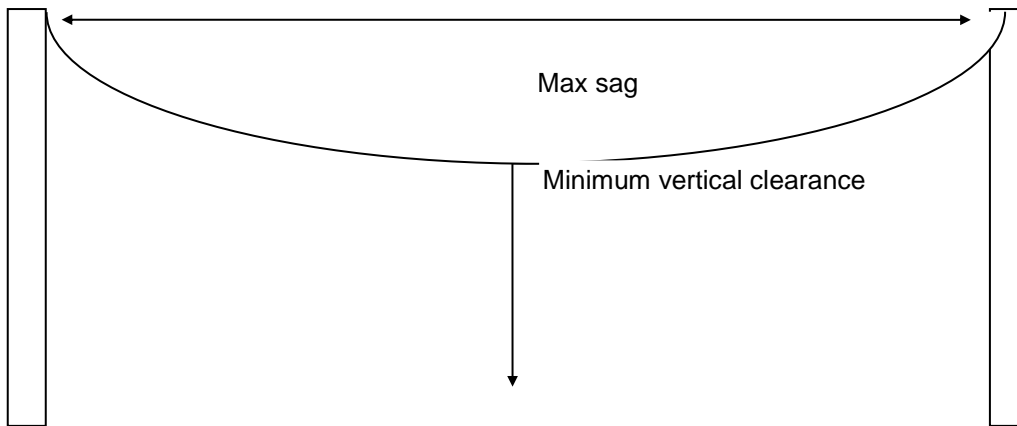


Figure 3: Minimum vertical clearance

3.6 Handling guidelines

Substantial temporary conductor supports shall be used, or equally effective measures shall be taken, to prevent encroachment on statutory clearances, or other clearance requirements stated in the permits, between the conductor being strung and other power or communication lines, roads or railways that are being crossed. Suitable structures shall be erected under each phase to protect all fences from conductors during stringing.

ACSR phase and GSW shield conductors shall be tension strung. The equipment and methods used for stringing the conductors shall be such that the conductors will not be damaged. Particular care shall be taken at all times to ensure that the conductors do not become kinked, twisted or abraded in any manner.

When necessary, suitable arrangements shall be made for temporary staying of towers, and anchoring of conductors. Conductors shall not be anchored to any portion of any tower, except strain towers, and then only at the points designed for conductor attachment.

Matched conductor drums, marked with the same number followed by the suffix A, B, C etc., shall be used for each pull of multiple conductors per phase to ensure even sag characteristics and a minimum number of joints. The most suitable sets of matched conductor drums shall be selected for each stringing position to minimize wastage of conductor.

Where multiple conductors per phase are used, these shall be attached to a single running board and strung simultaneously to ensure matched sags. The individual conductors shall be attached to the running board using auxiliary clamps that will not allow relative movement of strands or layers of wire, and will not over-tension or deform individual wires. Running boards shall pass through blocks smoothly without hanging, catching or causing wide variations in pulling tensions, damage to the blocks or over stressing of towers. The pulling line shall be a non-rotating line that will not impart twist or torque to the running board or conductors. Swivels shall be used to attach the pulling line and conductors to the running board. Swivels shall be small enough to pass through the blocks without damage to either, and shall have ball bearings that are free turning under load.

All conductors shall be strung by the controlled-tension method using rubber faced, double-bullwheel-type tension stringing equipment. This equipment shall be so designed that there shall be no conduction of the heat generated by the braking action, to the bullwheels. There shall be appropriate mechanical braking on the reels to prevent loose conductor between the reels and the bullwheels, but sufficient tension to pull the conductor in between layers remaining on the reel. The tension shall be controlled individually on each conductor, and when the desired tension is obtained, the same constant tension shall be held so long as the brakes are left at this setting. Tensions, while pulling, shall be sufficient to clear all obstacles safely without damage to the conductor. At no time shall the pulling tension exceed the tension shown on the sag charts. Pulling of more than one drum length of conductor shall be subject to Eskom's approval.

Adequate protection shall be provided where there may be danger of a conductor being crossed over by vehicles or damaged by other equipment and objects. Conductors shall not be left in contact with the ground, vegetable matter or any conducting or semi-conducting material. Wood lagging or similar material shall be used to protect the conductor when working at ground level.

The placement of tensioning and pulling equipment shall be such that the vertical angle of pull on a cross-arm during stringing operations shall not be more than 20°. Conductors shall not be pulled around angles that exceed 20°. With tandem-mounted blocks, the pulling angle shall not exceed 40°.

The sheaves shall conform to the conductor manufacturer's recommendation for diameter, the size and shape of the groove for the size of conductor used. Block surfaces that will be in contact with the conductor shall be coated with neoprene or rubber. This covering shall be kept clean and free of materials that might damage the conductor surface. The conductor sheaves shall have a separate groove for the pulling line. The pulling line shall not run on the rubber covered conductor grooves. The sheaves shall be inspected for damage or contamination before each usage.

During stringing operations and before regulating, if it becomes necessary to leave the conductor in the blocks for longer than eighteen hours, the conductor shall be left at reduced tension, and Eskom's site representative shall be immediately notified. In no case shall conductors be left with less than the following clearances:

- a) cultivated or open country 6 m;
- b) roads and trails 8 m; and
- c) over railroad tracks 9 m.

Stringing shall be completed using a dynamometer. Dynamometer scales shall be graduated in newtons and shall be tested and recalibrated at regular intervals. When pulling up the conductor, caution shall be used to avoid pulling the conductor above the design sag.

3.7 Joints

Only Eskom coded jointers shall be authorized to make joints on phase and earth conductors. As far as possible, complete drum lengths of conductor and earth conductor shall be used, to reduce the number of joints. Joints shall not be closer than 15 m to the nearest suspension tower, or 30 m from the nearest strain tower. Joints shall not be installed in spans crossing railways, proclaimed roads, power or important communication lines. In no case shall more than one joint be installed in a given span, nor shall a joint be installed in a span dead-ended at both ends. The minimum distance between joints shall be 300 m unless otherwise instructed.

The conductor shall be cut with a ratchet or guillotine cutter to produce a clean cut, retaining the normal strand lay and producing minimum burrs. The aluminium strands shall then be stripped from the steel core using an acceptable stripper. Under no circumstances shall high tensile hacksaw blades be used to cut conductor. Conductors shall be marked with paint, crayon or wax pencil – not by metal objects.

The conductor strands shall be cleaned by application of non-oxidizing paste and wire brushing. The correct Alcan dies, given in table 1, shall be used to compress joints.

Table 1: Standard dimensions of conductors and terminal stems

1	2	3	4	5	8
Type	Diameter d (max.)	Stranding and wire diameter	Aluminium area	Breaking force	Conductor code name
	mm	mm	Mm ²	kN	
HV line conductors, earth and stay wires					
Stranded ACSR Conductors (IEC 61089)	10,98	6/1/3,66	63,13	21,90	MINK DA6 (22,2) DS6 (7,6)
	14,16	6/1/4,72	105,00	36,54	HARE DA7 (25,4) DS7 (10,1)
	18,87	18/1/3,77	200,93	44,90	CHICKADEE DA8 (28,2) DS8 (12,7)
	23,90	18/1/4,78	323,01	72,32	KINGBIRD DA9 (32,3) DS8 (12,7)
	27,00	45\3,38 7\2,25	403,77	98,70	TERN DA 11 (40,2) DS8 (12,7)
Galvanized steel wire Shield and stay wire (1100 MPa) SABS 152-2	8,62	3/4,00		41,47	3/4,00 DS8 (12,7)
	10,23	7/3,35		67,45	7/3,35 DS10 (16,1)
	13,55	19/2,65		114,38	19/2,65 DS12 (20,22)

ESKOM COPYRIGHT PROTECTED

After compression has been completed, all corners, sharp projections and indentations resulting from compression shall be carefully rounded. Tape and tape residue shall be removed from fittings and conductors.

Under no circumstances shall a compression joint be allowed to pass the travellers unless accepted by Eskom.

3.8 Damaged conductors

Damage shall be any deformity, on the surface of the conductor that can be detected by eye or by feel. Damage shall include, but not be limited to nicks, scratches, abrasions, kinks, birdcaging, popped out, and broken strands. Depending upon the severity of the damage and the length of damaged section, the repair shall be made by careful smoothing with extra fine sandpaper, covering with preformed repair rods, installing a compression-type repair sleeve, or by cutting and splicing. Kinked, birdcaged or severely damaged sections of conductor shall be cut out. When there is repeated damage in the same span, or in consecutive spans, the entire conductor in such spans shall be replaced. All damage caused by auxiliary erection clamps or other gripping devices shall be repaired or cut out, as specified by Eskom's site representative, before the conductor is sagged.

Preformed repair rods shall be installed if no more than one strand is broken, or nicked deeper than one third of the strand diameter, or when a number of strands are reduced in area not exceeding the area of one strand. Not more than two sets of preformed repair rods shall be installed on any one conductor in any given span.

A compression-type repair sleeve shall be installed, if not more than one third of the outer strands of the conductor are damaged over a length of not more than 100 mm, or not more than two strands are broken in the outer layer of conductor and the area of any other damaged strands is not reduced by more than 25 %. Compression-type repair sleeves shall not be installed on one conductor in a given span if it already contains a conductor splice, conductor dead-end or another compression-type repair sleeve.

Damage to the steel strands or aluminium strands, that exceeds the stated limits for repair sleeves, shall be cut out and spliced using a compression type mid-span joint.

3.9 Jumpers

The jumpers shall be formed to provide the maximum amount of clearance from earthed hardware, and tower steelwork. Their positioning shall comply with the clearances stated under the specified displacements.

4. Authorization

This document has been seen and accepted by:

Name and surname	Designation
P Moyo	Power Delivery Engineering GM (Acting)
V Singh	Power Plant Technologies Manager
B Branfield	OHLSC

This standard shall apply throughout Eskom Holdings Limited, its divisions, subsidiaries and entities wherein Eskom has a controlling interest.

5. Revisions

This revision cancels and replaces revision no 1 of document no. **SCSASABH1**.

Date	Rev	Compiler	Remarks
March 2017	1	K Rozmiarek	Document reformatted on to new template, with new document number. No content change. This document supersedes document DSP_34-1207
Jan 2012	0	V Singh	3 year review Document number changed to DST 34-1207
July 2004	1A	None	Probabilistic conductor ratings reduced from 100C to 80C as revised in ESKASABK1 and this document assigned a new reference number from SCSASABH1 to DISSASABH1
Dec 2000	1	None	General revision to specification & greasing conductor information added
Sept 1999	0	None	Original issue – SCSASABH1

6. Development team

- Monyane Rapapa
- Bob Branfield

7. Acknowledgements

Not applicable.

Annex A – Conductor and shield wire characteristics
(Normative)

Table A.1: Standard conductor and shield data

1	2	3	4	5	6	7	8	9
Conductor	Stranding and wire diameter	Overall diameter	Total area	Mass	Rated tensile strength	Coefficient of linear expansion	Initial modulus of elasticity	Final modulus of elasticity
	mm							
Mink	6/1/3,66	10,98	73,65	257	21900	19,31	49100	80400
Hare	6/1/4,72	14,16	122,48	427	36000	19,31	48500	80400
Chickadee	18/1/3,77	18,87	212,09	643	44900	21,44	41000	66200
Kingbird	18/1/4,78	23,90	340,96	1028	71320	21,69	40400	66200
Tern	45/3,38+7/2,25	27,00	431,60	1340	98700	21,12	42900	66600
Shield wires								
3/4.00	3/4.00	8,62	37,7	307	42700	11,52	193000	193000
7/3,35	7/3,35	10,05	61,7	485	67450	11,52	193000	193000
19/2,65	19/2,65	13,25	104,8	826	113000	11,52	193000	193000

Table A.2: MVA Ratings for conductors

1	2	3	4
132 kV		66 kV	
Conductor Three-phase	MVA ratings Three-phase	Conductor	MVA ratings Three-phase
Chickadee	40 to 60	Mink	< 10 MVA
Kingbird	50 to 80	Hare	10 MVA to 25 MVA
Tern / Twin Hare	> 70	Chicadee	> 20 MVA

Table A.3: Probabilistic ratings

1	2		3		4		5	
Conductors								
Temperature	50 °C		60 °C		70 °C		80 °C	
	Normal	Emergency	Normal	Emergency	Normal	Emergency	Normal	Emergency
Mink	209	272	258	324	297	367	330	402
Hare	292	380	357	454	408	515	455	565
Wolf	378	501	473	602	548	683	610	751
Bear	529	715	663	860	770	976	859	1076
Chickadee	433	576	541	690	625	786	698	864
Kingbird	590	793	738	955	855	1088	956	1196
Tern	611	814	784	991	911	1138	1023	1257

Note: The values are taken from the Eskom document - ESKASABK1: Determination of conductor current ratings in Eskom.

ESKOM COPYRIGHT PROTECTED

Table A.4: Shield burn-off

1	2	3	4
Shield wire	3 s burn-off current (kA)	10 kA burn-off time (s)	20 kA burn-off time (s)
3/4,00	4,690	0.66	0.16
7/3,35	7,450	1,66	0,41
19/2,65	12,555	4,74	1,18

Annex B – Conductor creep equations

(Normative)

Creep directly affects the length of the conductor and therefore the equations used to calculate the creep of a conductor are the equations of length.

$$\Delta S_c = \frac{kL^{1,8}}{200} \left(\frac{T_2^2}{T_{20}} \right)^2 \quad (1)$$

where

S_c is the conductor length (metres).

K is the creep constant (millimetres per kilometre) – As per graph C.1.

L is the span length (metres).

T_2 is the final tension (newtons).

T_{20} is the tension at 20 °C (newtons).

Recall $S = L + \frac{W^2 L^3}{24T^2}$ (2) from 4.3.3

If

$$\Delta S_c = S_2 - S_1 \quad (3)$$

where

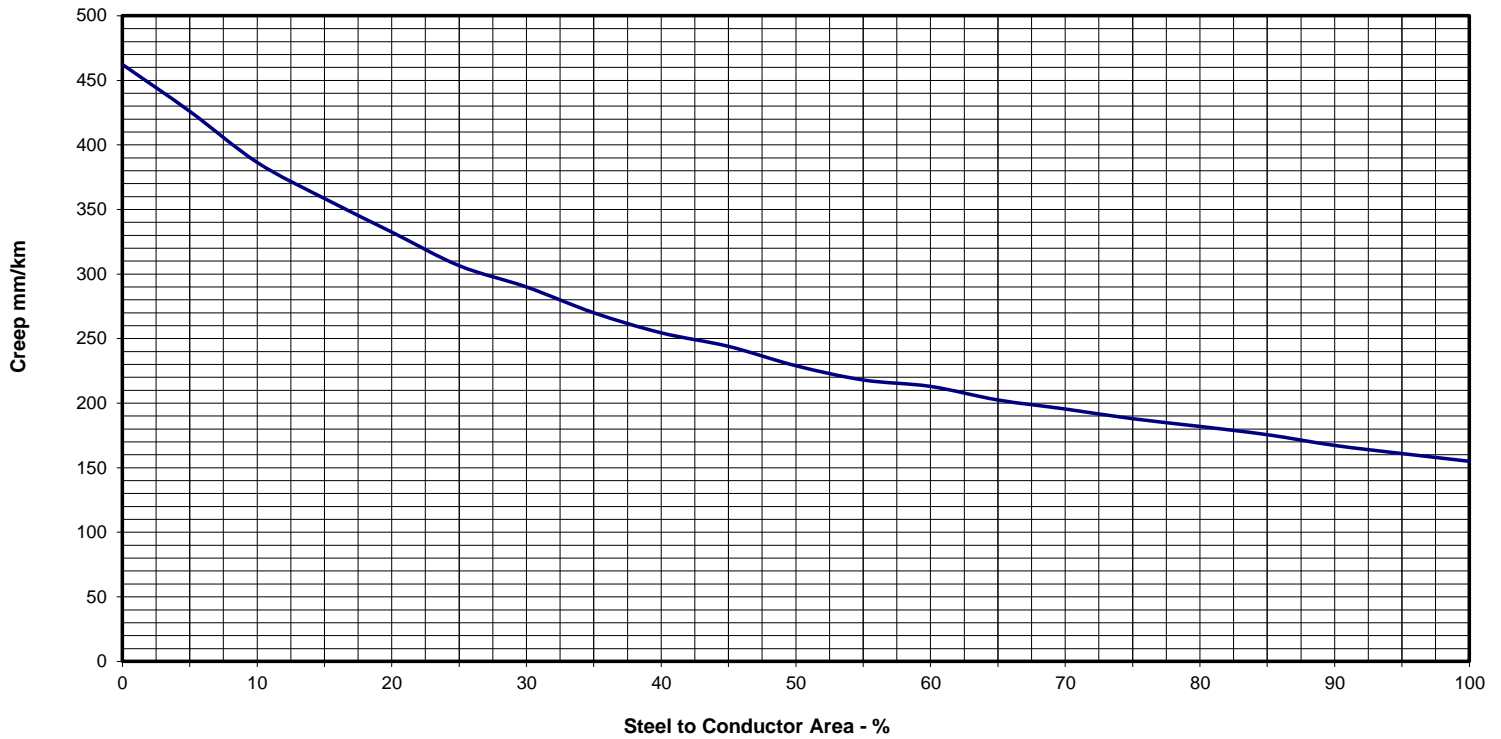
S_1 is the length of conductor at stringing tension (metres)

S_2 is the length of conductor after creep with reduced tension (metres)

Making substitutions gives:

$$\frac{kL^{1,8}}{200} \left(\frac{T_2}{T_{20}} \right)^2 = \frac{W^2 L^3}{24} \left[\frac{1}{T_2^2} - \frac{1}{T_1^2} \right] \quad (4)$$

By substituting a known string tension in T_1 , a unknown final (creeped) tension T_2 can be found.



Graph 1 – Conductor creep

ESKOM COPYRIGHT PROTECTED

When downloaded from the WEB, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorized version on the WEB.

Annex C – Impact Assessment

(Normative)

Impact assessment form to be completed for all documents.

1) Guidelines

- All comments must be completed.
- Motivate why items are N/A (not applicable)
- Indicate actions to be taken, persons or organisations responsible for actions and deadline for action.
- Change control committees to discuss the impact assessment, and if necessary give feedback to the compiler of any omissions or errors.

2) Critical points

2.1 Importance of this document. E.g. is implementation required due to safety deficiencies, statutory requirements, technology changes, document revisions, improved service quality, improved service performance, optimised costs.

Comment: Review

2.2 If the document to be released impacts on statutory or legal compliance - this need to be very clearly stated and so highlighted.

Comment: No

2.3 Impact on stock holding and depletion of existing stock prior to switch over.

Comment: N/A

2.4 When will new stock be available?

Comment: N/A

2.5 Has the interchangeability of the product or item been verified - i.e. when it fails is a straight swap possible with a competitor's product?

Comment: N/A

2.6 Identify and provide details of other critical (items required for the successful implementation of this document) points to be considered in the implementation of this document.

Comment: None

2.7 Provide details of any comments made by the Regions regarding the implementation of this document.

Comment: N/A

3) Implementation timeframe

3.1 Time period for implementation of requirements.

Comment: Immediate

3.2 Deadline for changeover to new item and personnel to be informed of DX wide change-over.

Comment: N/A

4) Buyers Guide and Power Office

4.1 Does the Buyers Guide or Buyers List need updating?

Comment: N/A

4.2 What Buyer's Guides or items have been created?

Comment: N/A

4.3 List all assembly drawing changes that have been revised in conjunction with this document.

Comment: N/A

4.4 If the implementation of this document requires assessment by CAP, provide details under 5

4.5 Which Power Office packages have been created, modified or removed?

Comment: N/A

5) CAP / LAP Pre-Qualification Process related impacts

5.1 Is an ad-hoc re-evaluation of all currently accepted suppliers required as a result of implementation of this document?

Comment: N/A

5.2 If NO, provide motivation for issuing this specification before Acceptance Cycle Expiry date.

Comment: N/A

5.3 Are ALL suppliers (currently accepted per LAP), aware of the nature of changes contained in this document?

Comment: N/A

5.4 Is implementation of the provisions of this document required during the current supplier qualification period?

Comment: N/A

5.5 If Yes to 5.4, what date has been set for all currently accepted suppliers to comply fully?

Comment: N/A

5.6 If Yes to 5.4, have all currently accepted suppliers been sent a prior formal notification informing them of Eskom's expectations, including the implementation date deadline?

Comment: N/A

5.7 Can the changes made, potentially impact upon the purchase price of the material/equipment?

Comment: N/A

5.8 Material group(s) affected by specification: (Refer to Pre-Qualification invitation schedule for list of material groups)

Comment: N/A

6) Training or communication

6.1 Is training required?

Comment: No

6.2 State the level of training required to implement this document. (E.g. awareness training, practical / on job, module, etc.)

Comment: N/A

6.3 State designations of personnel that will require training.

Comment: N/A

6.4 Is the training material available? Identify person responsible for the development of training material.

Comment: N/A

6.5 If applicable, provide details of training that will take place. (E.G. sponsor, costs, trainer, schedule of training, course material availability, training in erection / use of new equipment, maintenance training, etc).

Comment: N/A

6.6 Was Technical Training Section consulted w.r.t module development process?

Comment: N/A

6.7 State communications channels to be used to inform target audience.

Comment: N/A

7) Special tools, equipment, software

7.1 What special tools, equipment, software, etc will need to be purchased by the Region to effectively implement?

Comment: N/A

7.2 Are there stock numbers available for the new equipment?

Comment: N/A

7.3 What will be the costs of these special tools, equipment, software?

Comment: N/A

8) Finances

8.1 What total costs would the Regions be required to incur in implementing this document? Identify all cost activities associated with implementation, e.g. labour, training, tooling, stock, obsolescence

Comment: N/A

.....
.....
.....

Impact assessment completed by:

Name: Vinod Singh_____

Designation: Power Plant Technologies Manager_____