Eskom	Standard	Technology

Title: **SUB TRANSMISSION LINES SECTION 9: STEEL MONO POLE 132KV SUSPENSION STRUCTURES (SUSPENSION ARM)**

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SCOT Study Committee Number/Name: **Perform Line Engineering**

Content

Executive summary

The Distribution Standard is a multi-part document whose total structure is defined in Part 0. This part of the Distribution Standard consists of the following sections under the general title: Sub-transmission lines.

General

Section 0 – Introduction

Section 1 – General

Section 2 – Conductors

Section 3 – Insulators

Section 4 – Vibration

Section 5 – Foundations and soil compaction

Section 6 – Earthing

Section 7 – Lattice structures (132kV)

Section 8 – Concrete monopole structures (132kV)

Section 9 – Steel monopole structures (132kV)

Section 10 – Wood pole structures (132kV)

Section 11 – Guyed steel monopole structures (132kV)

Section 12 – Wood pole structures (66kV)

Section 13 – Steel monopole structures (66kV)

Section 14 – Assembly and informative drawings for 66kV and 132kV lines

This standard was prepared in consultation with the 2002 /2003 HV workgroup.

1. Introduction

The purpose of Part 6 of the Distribution Standard is to establish standardisation of designs, structure components and assemblies for 66kV and 132kV overhead lines. Various sections of this part are structure type specific while other sections refer to components / assemblies / practices that are common to all structure types. The user of Part 6 should be familiar with the contents of all sections and contract documentation will typically refer to multiple sections or parts thereof.

In the interest of standardisation of structures and rationalisation of components, 88kV lines are built to 132kV standards

2. Supporting Clauses

2.1 Scope

This section of the Distribution Standard addresses shielded free standing suspension monopole structure for single circuit 132 kV lines for use with Chicadee conductor. The design of the monopole is based on a conventional free standing compact structure but the line post insulators have been replaced by three x-arms and suspended insulators. It may be used in conjunction with various 132kV structures but is normally used in conjunction with structures from the Distribution Standard, Part 6: Sub transmission lines Section 9: Steel Monopole 132kV Compact Line Tower Series.

The following structures are contained in this section:

D-DT 7640 Intermediate Structure (0°)

2.1.1 Purpose

None

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.1.3 Development

The introduction of moderately priced 132kV line post insulators allowed for the development of much needed compact towers. As most counties are under pressure to make servitudes as narrow as possible these structures assist in meeting that need and have become very popular. South Africa has an additional problem of conductor theft and bracing members being stolen from lattice towers. The use of a smooth monopole eliminates the possibility of member theft from the structure and as the structure needs special equipment to climb. This makes conductor theft difficult.

ESKOM developed both a sectional steel and concrete compact monopole in conjunction with the structure manufacturers. The 132kV monopole structure with post insulators has been in use for some years and they have proven to be very reliable.

The 132kV steel mono-pole structure with post insulators has a distance of 1.45m between live conductor and steel pole. Based on wingspan dimensions of a vulture the environmentalists regard this distance as too small and a serious electrocution risk for the perching birds. They consider 2.2m as the minimum acceptable distance between live and earth. In spite of this there have been no reported bird fatalities to date. A compact post-insulator structure was erected near a vulture restaurant with equipment to monitor bird perching and possible bridging of the gap between the live conductor and steel pole. However, no birds perched on the structure.

ESKOM have, however, noted the concerns of the environmentalists and various options were considered to make the structure more “vulture friendly”. These were:

- Extending the x-arm by placing a 900mm extension bracket placed between the pole and insulator base
- Fitting an insulated bird guard on the live end of the insulator (trunnion clamp)

- Insulating the pole by placing an insulated shield on the pole surface
- Placing an obstruction on the pole to protrude above the insulator and prevent perching
- Replacing the post insulator with a x-arm and suspension insulator

The second last option is being further developed and the last option has already been tested and implemented in one area. The concept of a monopole with x-arms and suspended insulators is nothing new and is presently used in many countries.

2.1.4 Characteristics

The sectional steel monopole with x-arms and suspension insulators has the following characteristics:

- Small footprint
- Large electrical span due to the structure geometry
- Conductor swing (uplift) limitations
- Sectional steel components that are transportable to most areas
- Difficult to climb without special equipment

These characteristics make this structure a cost-effective alternate to lattice steel structures, especially where the presence of vultures, servitude width and tower footprints are important considerations.

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] IEC 60826:1991, Loading and strength of overhead transmission lines

[2] IEC 60652:1979, Loading tests on overhead lines tower (BS 7733) (IEC 60826)

[3] IEC 60050:1990, International Electro-technical Vocabulary

[4] SANS 10280-1: 2010: Code of practice for overhead power lines for conditions prevailing in South Africa

[5] TRMASAAJ7:Rev.1, Earthing of transmission line towers.

[6] TRMSCAAC1:Rev.3, Transmission line towers and line construction.

[7] 240-75883148 (DST 34-1657), Conventional stay planting, percussion stay and rock anchor installation and testing

[8] DST 34-1209, Soil compaction for stay and pole foundations

[9] 240-75880946 (DST 34-1205), *Earthing*

[10] DST-1229, Foundations and soils

[11] DST 34-1683: Distribution specification for steel mono-pole compact line towers for Sub transmission lines

[12] 240-61227444 (DST 34-550): Guide for the storage, transport and handling of composite insulators.

[13] 240-61268576 (DST 34-1439): Standard for the labelling of high voltage equipment.

[14] DISASADC3: Quality control and handing over documentation for sub-transmission lines.

[15] Drawings:

[16] D DT 7640 – Single circuit intermediate suspension structure (bird friendly)

2.2.2 Informative

[17] Appendix A

2.3 Definitions

2.3.1 General

Definition	Description
angle strain structure	A structure at the beginning or end of a section, which carries the resultant conductor tensile forces where the line changes direction.
cantilever load	A load applied to a supporting member which induces a bending moment at the support
conductor uplift (minimum weight span)	The upward vertical load imposed by the conductor at a support resulting from the gradient to the adjacent supports and conductor tensions.
dead man anchor	A stay anchor consisting of a single block of concrete into which the stay rod or anchor bolts are embedded.
earth conductor	A conductor of low impedance that provides an electrical connection between a given point in equipment (an installation or system) and an earth electrode.
earth electrode	One or more horizontal conductors and/or earth rods bonded together and embedded in the earth for the purpose of making effective electrical contact with the general mass of the earth and to act as a path for the discharge of either lightning or fault currents.
earth rod	An earth electrode consisting of a metal rod driven onto the ground.
electrical/clashing span	The maximum span considering the conductor configuration and spacing adopted to ensure midspan electrical clearance.
factor of safety (of any component)	The ratio of a component's failing load to the maximum safe working load for which it is designed.
Foundation	A structure set in or on the ground to which the base of a support is attached to provide the necessary anchorage to withstand all applied loads.
guyed structure	A structure whose stability is ensured by stays
horizontal line post insulator	A rigid insulator with metal base and end fittings, which is mounted horizontally onto a structure and is capable of withstanding cantilever loads.
intermediate structure	A structure that supports the overhead line in a section by means of either post or suspension insulators.
long-rod insulator	A single insulator designed for tensile loading to support an overhead line conductor under tension or suspension.
planting centres	The distance between the centres of the support members at ground level.
Pole	A vertical single member support made from wood, concrete, steel or other material
Section	The portion of line between two structures onto which the conductors are made off.
shield wire	A conductor connected to earth at some or all structures, which is normally (but not necessarily) suspended above the line conductors to provide a degree of protection against lightning strikes.

Definition	Description
soil nomination	The process by which a professional civil engineer categorises soils according to their bearing capacities.
soil type	The classification of soils according to their pressure bearing capabilities
Span	The part of the line between two consecutive points of support of a conductor
span length	The horizontal distance between two adjacent supports.
stay	A steel wire, rope or rod, working under tension, that connects a point of support to a separate anchor, or connects two points of a support.
stay anchor	A device, usually buried in the ground, so installed as to provide a firm point of attachment for resisting uplift.
stay rod assembly	A rod and plates that are buried to a specific depth and compacted so that they can carry the required stay loadings of the structure
strain structure	A structure at the beginning or end of a section, which carries balanced conductor tensile forces.
structure, support (of an overhead line)	A device designed to carry, through the insulators, a set of conductors of the line.
suspension structure	A structure that supports the overhead line in a section by means of suspension insulators.
temporary stay	A stay, of equivalent strength to a permanent stay, that is used to temporarily support a structure during construction or stringing activities.
tension imbalance	The condition that exists when the loads on each side of the tower differ due to conductors tensions.
terminal structure	A structure that carries the total conductor tensile forces on one side of the tower.
test hole	A hole excavated near a proposed tower to determine the soil type for foundation purposes.
ultimate design load/ultimate tensile strength	The load that all elements should just sustain without failure during any specified operation.
weight span	The horizontal distance between the lowest points of the conductor on either side of the support.
wind loading	The horizontal load imposed by wind pressure applied to any element of the overhead line, with or without ice loading.
wind span	Half the sum of the adjacent spans on each side of a support.
working load of the foundation	The load transferred from the tower to the foundation for given load conditions excluding factors of safety or overload factors.

2.3.2 Disclorure Classification

Controlled Disclosure: Controlled Disclosure to External Parties (either enforced by law, or discretionary)

2.4 Abbreviations

Abbreviation	Description
IARC	Industry Association Resource Centre (Previously Distribution Technology)
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. Sub Transmission Lines Section 9: Steel Mono Pole 132kv Suspension Structures (Suspension Arm)

3.1 Requirements

3.1.1 General requirements and practices

3.1.1.1 Design philosophy

All structures shall be designed in accordance with the OHS Act, relevant design codes and reference shall be made to DST 34-1202: Distribution Standard Part 6: Sub Transmission Lines Section 1: General. Any deviations from the aforementioned act, code or standard, and/or features peculiar only to the structures in this document will be expressly stated.

Whilst structures with specific span parameters and attachment heights are mentioned in the standard it is the duty and responsibility of the manufacturer to ensure that structure is designed and constructed to withstand the resultants loads. In most cases the acceptance criteria for a structure design is a successful type test performed at a certified tower test station. These test reports shall be requested at tender evaluation stage.

ESKOM carried out tests on both the structure and x-arm. The test reports for the arm and structure are available on the HV website.

3.1.1.2 Insulation co-ordination

The monopole with suspension insulators has several advantages and disadvantages with regard to insulation co-ordination;

- Advantages;
  - the insulator string may be either polymer or glass
  - the angle of shield from the shield wire is at least 300
- Disadvantages;
  - the structure geometry is less compact than the post insulator structure and for the same conductor attachment height the pole has to be 2,7m taller than the compact structure resulting in:
  - the electrical characteristics and lightning performance of the vulture friendly structure will be slightly negatively affected

3.1.1.3 Earthing

The structure shall be earthed in accordance with [9]: Distribution Standard, Part 6: Sub transmission lines, Earthing.

The following additional points shall be considered;

- Footing resistance tests shall be carried out before the connection of the shield wire as the results obtained from high frequency meters are not as reliable as the conventional 61.8% method.
- The earth electrode design shall be carried out after considering the structure footing resistance, soil resistivity and in-situ soil conditions. As the base of a planted steel structure forms a large electrode, it is often not necessary to add additional earth electrodes to this structure.
- If an additional earth electrode is connected to the structure, the earth conductor shall enter the ground immediately next to the structure and shall not be taken over the concrete base.

3.1.2 Structure requirements

3.1.2.1 Pole Foundations

The type of soil and bearing capacity thereof shall be determined under the supervision of a professional civil engineer, as described in [10]: Foundations and soils. This information shall in turn be used to select a suitable foundation. The foundation shall be constructed in accordance with the above standard. (Note: various options may be used for the for the same soil conditions. The decision on which option to use should depend on what plant and materials are available on site.)

3.1.2.2 Manufacturing

All structures shall be manufactured in accordance with [11]: Distribution specification for steel mono-pole compact line towers for Sub transmission lines and with the relevant manufacturing codes.

All structures shall be supplied complete with the following;

- bird perches (D-DT-7347)
- connecting bolts
- shield wire bracket
- x-arms, two eyed rod and gusset plate (D-DT-7343)

3.1.2.3 Criteria

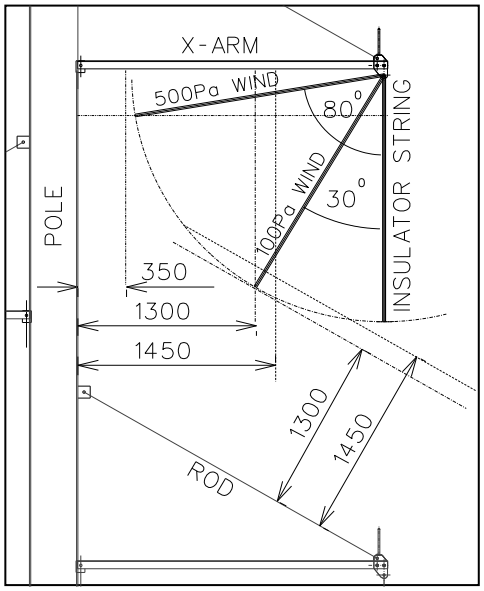
Various empirical formulae are used worldwide for calculating clashing span. The formula used in this standard for calculating clashing (electrical) span is as follows:

Clashing span = $(D-C)/ (4\cos^4\infty+1)$

D= Horizontal distance between conductor

C= Phase to phase clearance. (1680mm for 132kV)

∞ = angle from horizontal i.e. 00 for horizontal conductors and 900 for vertical conductors



3.1.3 Optimisation requirements

3.1.3.1 Tower clearances under wind conditions

The assumption is made that most line optimisation performed by ESKOM will be done using PLS CAD. For that purpose the necessary loading and criteria files are on the DT WEB and not embedded in this document. Some data is, however, provided for manual optimisation and optimisation by packages other than PLS CAD.

The requirement of SABS 0280 (Table C1) for the clearances between the structure and live conductor change for various wind conditions. They are:

- Still air: 1450mm
- Moderate wind: 1300mm
- Worst case wind: 350mm

This can be controlled during optimisation by either limiting the swing angle of the insulator or by applying a maximum weight/wind ratio. These values are given with the strength tables in Annex A.

3.1.4 Construction and maintenance

The following actions shall be adhered to;

a) Once erected, the strain pole shall be aligned at 90° to the direction of the line.

b) Stringing may take place from the end of the x-arm; however care shall be taken that no snagging of the conductor or joints takes place.

c) Longrod insulators shall be handled in accordance with [12]: Guide for the storage, transport and handling of composite insulators.

d) All nuts shall be torqued to the correct values and approved thread sealing paint shall be applied to all bolts before lifting of the pole

The following points may be considered to expedite the construction of the line:

a) Precast concrete rings may used to finish off the foundation.

b) The pole may be completely assembled, with x-arms, insulators, pulleys and stays, whilst still on the ground

c) Stringing and making-off to be planned in order to minimise the amount of times a structure is climbed

3.1.5 Advantages and disadvantages to consider when selecting this structure

3.1.5.1 Advantages

a) Cost effective alternative to lattice structures

b) Safe for large raptor and vulture perching

c) Large electrical span

d) Aesthetically pleasing – low environmental impact

e) Simple assembly due to modular components

f) Sectional steel components that are transportable to most areas

g) Difficult for public to climb

h) Member theft not possible

i) Small footprint

3.1.5.2 Disadvantages

a) Difficult for maintenance staff to climb without special equipment

b) 2,7m taller than compact structure

c) Stains and intermediate angle structures require stays which may be susceptible to tampering or may interfere with:

1) Farming activities

2) Vehicular traffic

3) Livestock/wildlife

3.2 Tests

3.2.1 Structure testing

Structure tests shall be carried out in accordance with [11]: Specification for steel monopole compact towers for sub transmission lines.

3.2.2 Site quality tests

Site quality tests shall be carried out in accordance with [6]: Transmission line towers and line construction and [14]: Quality control and handing over documentation for sub-transmission lines.

3.3 Marking, labelling and packaging

3.3.1 Marking

Marking of steel poles shall be done in accordance with [11]: Steel monopole compact line towers for sub transmission lines.

3.3.2 Labelling

Structure labelling shall be done in accordance with [13]: Standard for the labelling of high voltage equipment.

3.3.3 Packaging

Packaging shall be done in accordance with [11]: Steel monopole compact line towers for sub transmission lines

4. Authorisation

This document has been seen and accepted by:

Name and surname	Designation
Suren Natesan	Chief Engineer Civil
Riaz Vajeth	Senior Manager Lines Engineering Services
B Branfield	Lines SC Chairman

5. Revisions

This revision cancels and replaces revision no 1 of document no. **DISASADC2**.

Date	Rev	Compiler	Remarks
March 2020	2	B. Branfield	No content change. Revision date updated.
March 2015	1	B. Branfield	Document reformatted. No content change. This document supersedes document DST_34-1231 and document number changed Approver changed from B. Branfield to Suren Natesan Authoriser changed from M.N. Bailey to R. Vajeth
Jan 2011	0	B. Branfield	This document replaces DISASADC2
March 2004	1	B. Branfield	Document approved
Sept 2003	0	B. Branfield	Original issue – DISASADC2

6. Development team

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

- P vd Heever North West
- K Rozmiarek Northern
- R Branfield IARC

7. Acknowledgements

Not allocable.

Annex A – Single Circuit Intermediate Structures

(Informative)

Design parameters and information for D-DT-7640 - SINGLE CIRCUIT INTERMEDIATE STRUCTURES (Suspension arm) for Chicadee conductor

Pole Height	Conductor attachment heights					Design wind span	Design weight span	Clashing span
	Plant depth	Bottom	Centre	Top	Shield Wire			
21.5m	2.7m	11.4m	13.2m	15.0m	18.8m	350m	455m	* 650m
22.5m	2.8m	12.3m	14.1m	15.9m	19.7m	350m	455m	* 650m
23.5m	2.9m	13.2m	15.0m	16.8m	20.6m	350m	455m	* 650m
24.4m	2.9m	14.1m	15.9m	17.7m	21.5m	350m	455m	* 650m
25.3m	3.0m	14.9m	16.7m	18.5m	22.3m	350m	455m	* 650m
26.3m	3.0m	15.9m	17.7m	19.5m	23.3m	350m	455m	* 650m

Clashing (Electrical) span has been based on an assumption of a minimum cross-arm length of 2.2m

100Pa wind angle of swing 30°

500 Pa angle of swing 75°

Shield wire used for above parameters is 7/3.35

Single Circuit Intermediate Structures

Design parameters and information for D-DT-7640 - SINGLE CIRCUIT INTERMEDIATE STRUCTURES (Suspension arm) for Chicadee conductor

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22.5m	2.8m	12.3m	14.1m	15.9m	19.7m	350m	455m	* 650m
23.5m	2.9m	13.2m	15.0m	16.8m	20.6m	350m	455m	* 650m
24.4m	2.9m	14.1m	15.9m	17.7m	21.5m	350m	455m	* 650m

25.3m	3.0m	14.9m	16.7m	18.5m	22.3m	350m	455m	* 650m
26.3m	3.0m	15.9m	17.7m	19.5m	23.3m	350m	455m	* 650m

- Clashing (Electrical) span has been based on an assumption of a minimum cross-arm length of 2.2m
- 100Pa wind angle of swing 30°
- 500 Pa angle of swing 75°
- Shield wire used for above parameters is 7/3.35

Annex B – 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: Document revision only – format change but no material change to contents.

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: Document revision only – format change but no material change to contents.

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

Comment: Document revision only – format change but no material change to contents.

2.4 When will new stock be available?

Comment: Document revision only – format change but no material change to contents.

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

Comment: Document revision only – format change but no material change to contents.

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: Document revision only – format change but no material change to contents.

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

Comment: (N/A during commenting phase)

3) Implementation timeframe

3.1 Time period for implementation of requirements.

Comment: Document revision only – format change but no material change to contents.

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

Comment: Document revision only – format change but no material change to contents.

4) Buyers Guide and Power Office

4.1 Does the Buyers Guide or Buyers List need updating?

Comment: Document revision only – format change but no material change to contents.

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

Comment: Document revision only – format change but no material change to contents.

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

Comment: Document revision only – format change but no material change to contents.

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: Document revision only – format change but no material change to contents.

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: Document revision only – format change but no material change to contents.

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

Comment: Document revision only – format change but no material change to contents.

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

Comment: Document revision only – format change but no material change to contents.

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

Comment: Document revision only – format change but no material change to contents.

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

Comment: Document revision only – format change but no material change to contents.

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: Document revision only – format change but no material change to contents.

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

Comment: Document revision only – format change but no material change to contents.

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

Comment: Document revision only – format change but no material change to contents.

6) Training or communication

6.1 Is training required?

Comment: No (If NO then 6.2 – 6.6 will be N/A)

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: Document revision only – format change but no material change to contents.

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: Document revision only – format change but no material change to contents.

7.2 Are there stock numbers available for the new equipment?

Comment: Document revision only – format change but no material change to contents.

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

Comment

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:

……

……

……

Impact assessment completed by:

Name: _____R Branfield_____

Designation: _____Snr Consultant_____