

 Eskom	Standard	Technology
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Title: **SPECIFICATION FOR
SUBSTATION TUBULAR
CONDUCTORS**

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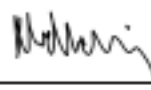


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1. Introduction

Substation tubular conductors are designed to carry rated normal and fault currents. This standard is intended to ensure that substation tubular conductors supplied to Eskom are properly specified to meet the desired performance requirements.

2. Supporting clauses

2.1 Scope

This standard covers the Eskom specific technical requirements for tubular conductors for use in substations with nominal system voltages up to and including 765kV ($U_m = 800\text{kV}$). The substation tubular conductors specified must comply with the minimum requirements set out in the relevant IEC and European (EN and BS) specifications listed.

2.1.1 Purpose

To document, have on record and refer to as required, Eskom's specific technical requirements for station tubular conductors for use in substations with nominal system voltages up to and including 765kV ($U_m = 800\text{kV}$).

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

- [1] 240-122922894, Technical Evaluation Standard for Substation Tubular Conductors
- [2] ASTM B807/B807M, Standard Practice for Extrusion Press Solution Heat Treatment for Aluminum Alloys
- [3] ASTM B918/B918M, Standard Practice for Heat Treatment of Wrought Aluminum Alloys
- [4] BS 159, Specification for high-voltage busbars and busbar connections
- [5] EN 573-1, Aluminium and aluminium alloys – Chemical composition and form of wrought products – Part 1: Numerical designation system
- [6] EN 573-2, Aluminium and aluminium alloys – Chemical composition and form of wrought products – Part 2: Chemical symbol based designation system
- [7] EN 573-3, Aluminium and aluminium alloys – Chemical composition and form of wrought products – Part 3: Chemical composition and form of products
- [8] EN 755-1, Aluminium and aluminium alloys – Extruded rod/bar, tube and profiles – Part 1: Technical conditions for inspection and delivery
- [9] EN 755-2, Aluminium and aluminium alloys – Extruded rod/bar, tube and profiles – Part 2: Mechanical properties
- [10] EN 755-7, Aluminium and aluminium alloys – Extruded rod/bar, tube and profiles – Part 7: Seamless tubes, tolerances on dimensions and form
- [11] EN 755-8, Aluminium and aluminium alloys – Extruded rod/bar, tube and profiles – Part 8: Porthole tubes, tolerances on dimensions and form

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- [12] EN 10002-1, Metallic materials – Tensile testing – Part 1: Method of test at ambient temperature
- [13] IEC 60071-2, Insulation Co-ordination – Part 2: Application Guide
- [14] IEC 60468 (BS 5714), Method of Measurement Determination of Resistivity of Metallic Materials
- [15] IEC 60694, Common specification for high-voltage switchgear and control gear standards
- [16] ISO 9001, Quality Management Systems
- [17] ISO 9591, Corrosion of aluminium alloys – Determination of resistance to stress corrosion cracking
- [18] SANS 5544, Dimensions of aluminium and copper strip, sheet, rod, bar, tube, channel and angle

2.2.2 Informative

- [19] 240-55922824, Substation Layout Design Guideline
- [20] 240-68972068, Standard for Tubular Conductor Selection

2.3 Definitions

2.3.1 General

Definition	Description
Accredited testing laboratory/authority	A laboratory which is ISO/IEC 17025 accredited and/or that holds valid certification issued by ILAC (International Laboratory Accreditation Corporation) or one of its members.
Aluminium alloy	Aluminium which contains alloying elements, where aluminium predominates by mass over each of the other elements and where the aluminium content is not greater than 99.00%.
Certified test report	A certificate of tests performed as specified within the specification, and carried out by an accredited authority or by the manufacturer and witnessed by an accredited authority that has been accredited in accordance with ISO/IEC 17011.
Extruded tube	Tube brought to final dimensions by extrusion.
Porthole tube/bridge tube	Tube produced by extrusion of a solid billet through a porthole or bridge die.
Routine test	Tests done to verify the quality and uniformity of the workmanship and materials used in the manufacture of substation tubular conductors.
Seamless tube	Tube which does not contain any line junctures resulting from the method of manufacture.
Tube	Hollow, wrought product with a uniform cross-section, with only one enclosed void and with a uniform wall thickness, supplied in straight lengths. Cross-sections are in the shape of circles and the inner and outer cross-sections are concentric and have the same form and orientation.
Type test	Tests done on the completion of the development of a new design to establish representative performance data. They need to be repeated if the design is changed to modify its performance or if there is a change in the manufacturing process or material used.

2.3.2 Disclosure classification

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

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2.4 Abbreviations

Abbreviation	Description
°C	degree Celsius
Al	Aluminium
Cr	Chromium
Cu	Copper
g	Acceleration due to gravity
Fe	Iron
HV	High Voltage
kA	kilo Ampere
kg	Kilogram
kV	Kilovolt
m	meter
m ²	square meter
Mg	Magnesium
Mn	Manganese
mm	millimetre
MPa	Mega Pascal
SANS	South African National Standard
Si	Silicon
Ti	Titanium
Um	Maximum system voltage
Zn	Zinc

2.5 Roles and responsibilities

Suppliers are responsible for manufacturing, testing and supplying products in accordance with this document. All personnel involved within the substation environment shall ensure compliance to these requirements.

2.6 Process for monitoring

Not applicable.

2.7 Related/supporting documents

This document supersedes TSP41-1004.

Offered tubular conductors must be evaluated in accordance with 240-122922894.

3. Specification for substation tubular conductors

Aluminium alloy tubular conductors are required for carrying continuous rated normal and short-time busbar currents in substations.

3.1 General

All tender information must be supplied in English.

3.1.1 Manufacturer/supplier Credentials

The manufacturer/supplier shall have access to the engineering facilities necessary to provide local technical service and information, advice and after-sales service related to the products under consideration. The manufacturer/supplier must have adequate local technical competency to deal with technical and quality issues related to their products offered.

The manufacturer/supplier is requested to provide a list of references indicating the country, name of the customer, system voltage, quantity and year of delivery for substantial previous orders. Eskom will perform a comparison of these details against the enquiry.

3.1.2 Product acceptance

Only substation tubular conductors that have been evaluated and accepted by Eskom will be procured for use on the Eskom system.

The manufacturer/supplier shall be fully responsible for his designs and their satisfactory performance in service. Acceptance by Eskom shall not absolve the supplier of the responsibility for the adequacy of the design, dimensions and other details.

Manufacturers'/supplier's catalogues shall not refer to any product as "Eskom approved" or "Eskom accepted".

3.1.3 Quality system assessment

Quality assessments will be done in conjunction with the technical acceptance. This assessment shall not override any quality requirements that are specified in a contract document.

3.2 Technical requirements

3.2.1 Service conditions

The tubular conductors shall be suitable for use in outdoor substations under the following service conditions:

- Altitude (max) 1800 m
- Ambient temperature:
 - minimum -10°C
 - maximum 45°C
 - daily average 30°C
- Maximum solar radiation 2300 Watts/m²
- Pollution level Very heavy in accordance with IEC 60071-2
- Seismic requirement 0.3g

3.2.2 Material

The tubular conductor shall be made of aluminium alloy.

The alloy type shall be 6061 (EN equivalent AlMg1SiCu) with temper of T6. The alloy shall be suitable for use as substation tubular busbar conductor and shall meet both specified electrical and mechanical requirements. The type of alloy used, temper and designation shall be specified in Schedule B.

The tube shall have a smooth-finished surface.

The material shall not be prone to stress corrosion, cracking or layer corrosion in accordance with ISO 9591.

The tube shall be resistant to atmospheric corrosion.

3.2.3 Material chemical composition

The tube shall be free of any material defects.

The aluminium alloys shall have the chemical composition limits specified in the relevant clauses of EN 573-3.

Eskom reserves the right to request the testing of samples to verify the chemical composition. Conformance shall be determined by analysing samples taken from the ingots or analysing samples taken from the finished or semi-finished product.

The determination of chemical composition shall be made in accordance with suitable chemical or spectrochemical methods.

Raw material certificates must be supplied with the tender stating the material chemical composition.

3.2.4 Manufacturing

The extruded tube shall be produced by the die/mandrel method or tube porthole/bridge method.

Only single extruded tubes without any joints (welded or otherwise) will be accepted.

The tube shall be solution-treated in accordance with ASTM B807.

The tube shall be heat-treated in accordance with ASTM B918.

The tube shall have a smooth-finished surface and shall be free of any material defects.

3.2.5 Tube dimensions

Tubes shall have outer diameters ranging from 80mm to 250mm. The required outer diameter will be specified.

The wall thickness of the tubes shall be up to a maximum of 10mm. The required wall thickness will be specified.

The length and quantities required will be specified.

Tube dimensions shall be determined in accordance with the method specified in SANS 5544.

Eskom reserves the right to verify any dimension by itself or by employing the services of an independent third party.

3.2.6 Tolerances on tube dimensions

3.2.6.1 Tolerance on diameter

Tolerance on outer diameter shall in accordance with the requirements of EN 755-7 for seamless tubes and EN 755-8 for porthole tubes.

3.2.6.2 Tolerance on wall thickness

The tolerance of the wall thickness of the tubular conductor shall be in accordance with the requirements of EN 755-7 for seamless tubes and EN 755-8 for porthole tubes.

3.2.6.3 Tolerance on lengths

Tolerance on lengths shall be in accordance with the requirements of EN 755-7 for seamless tubes and EN 755-8 for porthole tubes.

3.2.6.4 Tolerance on straightness

Tolerance on local and whole length straightness deviations shall be in accordance with the requirements of EN 755-7 for seamless tubes and EN 755-8 for porthole tubes.

3.2.7 Electrical requirements

3.2.7.1 Electrical resistivity

The electrical resistivity of the material shall not exceed $0.037 \times 10^{-6} \Omega\text{m}$ at 20°C.

3.2.7.2 Current ratings

The conductor shall be able to continuously carry specified rated current without exceeding a temperature rise of 40°C above an ambient temperature of 45°C. The maximum rated tubular conductor current shall be stated in Technical Schedule B.

Tubes with outer diameters of <200mm and wall thickness of $\geq 4\text{mm}$ shall have the following current ratings:

- Continuous current rating of not less than 2480A at 85°C,
- 1s short time current rating of not less than 40kA rms (thermal),
- 1s short time current rating of not less than 100kA peak (mechanical).

Tubes with outer diameters of $\geq 200\text{mm}$ and wall thickness of $\geq 6\text{mm}$ shall have the following current ratings:

- Continuous current rating of not less than 4750A at 85°C,
- 1s short time current rating of not less than 63kA rms (thermal),
- 1s short time current rating of not less than 160kA peak (mechanical).

3.2.7.3 Temperature Rise

Under normal operating conditions, the tube shall not exceed a temperature rise of 40°C above an ambient temperature of 45°C under the service conditions specified in 3.2.1.

Under short-circuit conditions up to and including 1 second the tube temperature rise shall not exceed 200°C.

3.2.8 Mechanical requirements

3.2.8.1 Tensile strength

The tube shall have a minimum tensile strength of 260MPa in accordance with EN 755-2.

3.2.8.2 Proof strength

The tube shall have a minimum 0.2% proof strength of 240MPa in accordance with EN 755-2.

3.3 Test requirements

Suppliers shall comply with all test requirements stated in this document and any other test that the supplier may deem necessary.

Eskom shall have the right to witness any testing. Where type tests have been requested, the supplier shall inform Eskom twelve weeks in advance before the date of commencement of testing.

If the tubes offered have been tested for compliance with an internationally accepted standard, such test reports may be accepted by Eskom in lieu of the tests specified herein.

Eskom specifies the tubular conductor material, temper and design (outer and inner diameters) based on the desired environmental performance and current rating requirements.

Only products complying with these requirements shall be accepted and Eskom acknowledges that it is therefore not necessary to submit continuous current rating and short-circuit withstand (thermal withstand) test results. In addition, because the material specified is marine grade it is also not necessary to submit stress-corrosion cracking test results

All testing shall be done by an independent testing laboratory or witnessed and approved by an independent testing authority if done in-house.

3.3.1 Electrical test

3.3.1.1 Resistivity test

The electrical resistivity of the tube shall be determined by direct measurement as stipulated in IEC60468.

3.3.2 Mechanical tests

3.3.2.1 Tensile strength test

The tensile strength tests shall be undertaken in accordance with the test methods outlined in EN10002-1.

The test specimen shall be able to withstand a minimum pressure of 260MPa without any damage.

3.3.2.2 0.2% Proof strength test

The 0.2% proof strength tests shall be undertaken in accordance with the test methods outlined in EN 10002-1.

The test specimen shall be able to withstand a minimum pressure of 240MPa without any damage.

3.3.2.3 Elongation test

The A₅ elongation tests shall be undertaken in accordance with the test methods outlined in EN10002-1.

The A₅ percentage elongation shall not exceed the value stated by the manufacturer in Schedule B.

3.3.3 Test samples

When routine tests are required material of the same dimensions, produced in the same way and of the same composition, shall be grouped into batches of 2000kg, unless the heat-treatment batch is smaller in which event that shall constitute the batch. One test sample shall be cut from a bar or section selected from each batch.

3.3.4 Witnessing of testing and inspection of samples

Eskom reserves the right to inspect and witness testing of tubes samples. Should such witnessing and inspection be deemed necessary, the manufacturer shall be informed accordingly within a reasonable period of time. The manufacturer shall give Eskom staff or its appointed representative access to the manufacturing and testing facilities.

3.3.5 Test Certificates and reports

Type test certificates are only valid for as long as the material composition, design and manufacturing method stay unchanged. As soon as any one of these parameters changes, the applicable test certificates will no longer be valid and the applicable substation tubular conductor/s are to be retested.

A copy of all type-test reports/certificates shall be submitted to Eskom at the tender/enquiry stage, unless Eskom waives this requirement due to a previous evaluation of the specific product from a specific manufacturer.

Copies of routine test certificates shall be submitted to Eskom on request. Routine tests will be stipulated as and when required.

All test certificates/reports shall be in English.

3.4 Packaging and Transportation

The supplier shall be responsible for transporting and off-loading of the tubes to the destination specified in the contract. Arrangements for acceptance, off-loading and trans-shipping including off-loading at the final destination shall be pre-arranged and will be the responsibility of the supplier.

The tubes shall be packed in such a manner that they are adequately protected to avoid damage during transport and storage.

A suitable label bearing Eskom's order and item number, the quantity and the delivery address shall be securely attached to the lot. The marking shall not be destroyed during storage (NB: it must withstand outdoor storage conditions) and transport.

The tubes must be stacked in such a way that they are not damaged during on and off-loading or when being moved using forklifts. The onus shall be on the supplier to ensure that the tubes are not damaged during transportation to site and off-loading.

4. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Athelene Gouws	Senior Engineer, Design and Standards Implementation, G OU
Best Khoza	Engineer, Network Engineering & Design, WC OU
Braam Groenewald	Corporate Specialist, Substation Engineering, Tx
Christy Thomas	Senior Engineer, Substation Engineering, Tx
Derrick Delly	Chief Engineer, Substation Engineering, Tx
Dickey van Eeden	Senior Technician, Network Engineering & Design, FS OU
Enderani Naicker	Chief Engineer, Substation Engineering, Tx
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Name and surname	Designation
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5. Revisions

Date	Rev	Compiler	Remarks
Feb 2021	2	TJ Marais	2.2.1 Normative References: BS 2898 removed as it is superseded by BS EN 755-7:2016. 2.6 Process of monitoring: Updated. 3.3 Test requirements: updated. Continuous current rating, short-circuit withstand (thermal withstand) and stress-corrosion cracking test requirements removed. Independent testing authority added. Annex A: section 8 updated. Annex C Type Test Schedule added
March 2017	1	TJ Marais	Original document (TSP41-1004) converted to new format and renumbered to 240-122922610. Reference documents, definitions and Annex A and B updated. 3.1 General requirements added. 3.2.2 Alloy type 6063A (EN equivalent AlMg0.7Si(A) and German equivalent AlMgSi0.5F25) removed as material option. 3.2.7 Electrical requirements reworded and updated. 3.3.5 Test certificate validity clause added. Annex A updated.

6. Development team

The following people were involved in the development of the original document (TSP41-1004):

- Phineas Tlhatlhetji, Senior Manager – Substation Engineering
- Sibongile Maphosa, Chief Engineer – HV Plant

7. Acknowledgements

Not applicable.

Annex A – Technical Schedules A & B: Busbar Tubular Conductor

Schedule A: Eskom's particular requirements

Schedule B: Guarantees and technical particulars of product offered

Note: Details provided in Schedule B must be for only one item per sheet. Print and complete a new sheet for each separate item tendered for.

Item	Clause	Description	Unit	Schedule A	Schedule B
1		Manufacturer's Details			
		Manufacturer			
		Manufacturer's local agent			
		Manufacturer's Type Reference			
2	3.2.1	Service Conditions			
2.1		Nominal system voltage	kV	As stipulated	
2.2		Maximum system voltage	kV	As stipulated	
2.3		Altitude (Max)	m	1800	
2.4		Ambient Temperature:			
		Minimum	°C	-10	
		Maximum	°C	45	
		Yearly average	°C	30	
2.5		Solar radiation	W/m ²	2300	
2.6		Pollution level		Very high	
2.7		Seismic requirement	g	0.3	
3		Tubular Conductor Properties			
3.1		Material		Aluminium alloy	
3.2	3.2.2	Type of Alloy (indicate which)		6061	
3.3	3.2.2	Temper		T6	
3.4	3.2.2	Designation (in accordance with EN 573-2)			
3.5	3.2.3	Chemical composition limits of alloy			
		Silicon (Si)	%		
		Iron (Fe)	%		
		Copper (Cu)	%		
		Manganese (Mn)	%		
		Magnesium (Mg)	%		
		Chromium (Cr)	%		
		Zinc (Zn)	%		
		Titanium (Ti)	%		
		Other elements	%		
		Aluminium (Al)	%		

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Item	Clause	Description	Unit	Schedule A	Schedule B
4	3.2.4	Tube Manufacturing Method			
4.1		Indicate tube manufacturing method			
4.2		Indicate in accordance with which standard			
5	3.2.5	Tube Shape and Dimensions			
5.1		Shape		Round	
5.2		Outer diameter (as per enquiry)	mm		
5.3		Wall thickness (as per enquiry)	mm		
5.4		Length (as per enquiry)	m		
5.5		Weight	kg/m		
5.6		Quantity (as per enquiry)			
6	3.2.6	Tube Dimensional Tolerances			
6.1	3.2.6.1	Tolerance on outer diameter	mm		
6.2	3.2.6.2	Tolerance on wall thickness	mm		
6.3	3.2.6.3	Tolerance on length:	mm		
6.4	3.2.6.4	Tolerance of straightness	mm		
7	3.2.7	Tube Electrical Requirements			
7.1	3.2.7.1	Electrical resistivity @ 20°C	Ωm	0.037 x 10 ⁻⁶	
8		Type Test Reports (test passed & report submitted)			
8.1	3.2.3	Material composition and temper test report		Mandatory	
8.2	3.3.1	Electrical Tests			
	3.3.1.1	Resistivity test		Mandatory	
8.3	3.3.2	Mechanical			
	3.3.2.1	Tensile Strength Test		Mandatory	
	3.3.2.2	0.2% Proof Strength Test		Mandatory	
	3.3.2.3	Elongation Test		Mandatory	

Annex B – Deviations and Declarations

Notes:

- 1) For each item, all deviations to any requirement in this specification and associated technical schedule or annex must be listed above with clear explanations/ justification with regards to fitness for use for the full expected life of the product
- 2) All documents to be provided in hard copy in addition to any soft copies offered, as per tender requirements.
- 3) If no deviations / modifications / alternatives are offered, this Schedule must be marked N/A and signed.

SPECIFICATION / SCHEDULE PAGE NUMBER	SPECIFICATION / SCHEDULE CLAUSE NUMBER	PROPOSED DEVIATIONS / MODIFICATIONS / ALTERNATIVES

Declaration by supplier:

With the exception of the above deviations, this specification, associated technical schedules, factory evaluation and annexes together with the requirements contained within, will be fully complied with in the manufacture, testing, supply, provision of drawing and documents, packaging, labelling, transport and delivery of the product being offered, amongst others. Further it is declared that all information provided has been checked and is correct.

Full Name and Designation of Authorised Representative: _____

Signature: _____ Date: _____

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Annex C – Type Test Schedule

The following must be noted:

- 1) This section must be read together with Sections 3.2.2 and 3.3 of this document.
- 2) A separate type test schedule shall be completed per conductor.
- 3) List all the type test report numbers applicable.

Item	Clause	Description	Report No.
1	3.2.2	Material composition and temper test report	
2	3.3.1	Electrical resistivity/conductivity test report	
3	3.3.4	Dimensional tolerances test report	
4	3.3.2.1	Tensile Strength Test	
5	3.3.2.2	0.2% Proof Strength Test	
6	3.3.2.3	Elongation Test	