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Title: **SPECIFICATION FOR THE
INSTALLATION OF TUBULAR
ALUMINIUM CONDUCTORS**

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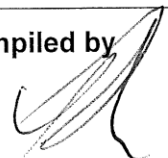

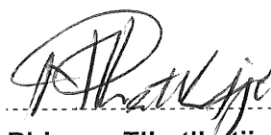

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1. Introduction

Tubular aluminium conductors are designed to carry normal current under healthy system conditions and to short-circuit currents under fault conditions. To ensure integrity of the busbar installations, it is imperative that Eskom's technical requirements are specified. This specification sets out technical requirements which must be complied with during installation of tubular conductor busbars.

2. Supporting clauses

2.1 Scope

This specification covers the installation of post insulators, tubular aluminium conductors, busbar clamps, damping conductors and end caps. Post insulators, tubular aluminium conductors, clamps, damping conductors and end caps shall be supplied by Eskom. The post insulators, tubular aluminium conductors, clamps, damping conductors and end caps shall be installed as per the attached busbar layout drawings (section 9 of Annexure A).

2.1.1 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] ISO 9001:2008 Quality Management Systems.
- [2] ISO 15607:2003: Specification and qualification of welding procedures for metallic materials — General rules
- [3] ISO 15609-1:2004: Specification and approval of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding.
- [4] ISO 15614-2: 2005: Specification and qualification of welding procedures for metallic materials — Welding procedure test: Part 2: Arc welding of aluminium and its alloys
- [5] SANS 121:2000: Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
- [6] SANS 1700 SERIES: ISO metric bolts, screws and nuts (hexagon or square) (coarse thread free fit series)
- [7] Occupational Health and Safety Act No. 85, 1993 – Construction Regulations 2014
- [8] IEEE-Standard 524-2003, IEEE guide to the installation of overhead transmission line conductors
- [9] PDPMAN-SP-28: Quality requirements for organisations
- [10] 32-421: Eskom Life Saving Rules
- [11] 32-726: SHE Requirements for the Eskom Commercial Process
- [12] Occupational Health and Safety Act (No. 85 of 1993)
- [13] ESKPVAEY6: 2005: Operating Regulations for High Voltage Systems

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

Definition	Description
Clamp	A device that joins two or more conductors for the purpose of providing a continuous electrical path.
Tube	A hollow cylindrical aluminium conductor of specified diameter and wall thickness designed to carry current

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
ASME	American Society Mechanical Engineers Standards
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organisation for Standardization
MIG	Gas Metal Arc Welding
OHS	Operational, Health and Safety
ORHVS	Operational Regulations for High Voltage Systems
PI	Post Insulator
SANS	South African National Standards
TIG	Gas Tungsten Arc Welding

3. Installation of Tubular Conductor Busbar System

3.1 General

The scope of work covers the following:

- erection of post insulators on prepared steel support structures. Fixing bolts for post insulators shall be supplied by the contractor.
- cutting and trimming of tubular conductors to correct lengths.
- erection of tubular aluminium conductors. Fixing bolts for clamps to be supplied by contractor.
- installation of damping conductors,
- installation of corona rings
- installation of flat end caps and corona-free end caps
- termination of damping conductors to end caps and compression tubes and end caps onto the tubes.

Post insulators, tubular aluminium conductors, clamps, damping conductor and end caps shall be supplied by Eskom. All quantities are specified in Schedule A.

The contractor shall be responsible to cut and trim the tubular aluminium conductors to the desired length as shown on the busbar layout drawings. Eskom shall supply the contractor with the relevant busbar layout drawings (section 9 of Annexure A).

3.2 Erection of Post Insulators

- a) Post insulators shall be supplied by Eskom. Quantities of post insulators to be installed are stated in Schedule A.
- b) Post insulators shall be mounted on support structures already erected on site. The contractor shall ensure that prior to the installation of post insulators, support structures are level.
- c) The Contractor shall submit to Eskom for general information, review, acceptance and approval, an erection method statement with full details of the erection procedure for post insulators. Post insulators shall be erected in accordance with the manufacturer's installation procedure.
- d) The Contractor shall erect such equipment as indicated on the relevant drawings.
- e) The Contractor shall supply all bolts, nuts and washers for fixing post insulators to steel support structures.
- f) The Contractor shall ensure that the correct size of fixing bolts, nuts and washers are used during installation of post insulators.
- g) The contractor shall ensure that only bolts and nuts of the correct and same grade as specified in the relevant drawings are used together. Bolts of different classes and same diameter shall not be used on the same structure.
- h) All matching holes for bolts shall be aligned with each other such that the bolts can be inserted freely through the assembled members in a direction at right angles to the faces in contact.
- i) Drifting to align the holes shall be in such a way that the metal is not distorted and the holes are not enlarged.
- j) The contractor shall ensure that bolts and nuts for fixing post insulators are tightened to the correct torque as specified in the relevant drawings.
- k) Any bolt assembly that is damaged during tightening shall be replaced.
- l) The contractor shall ensure that post insulators are not damaged during installation. Damaged post insulators shall not be installed.

3.3 Requirements of Fixing Bolts Nuts and Washers

3.3.1 Bolts

- a) Bolts shall be made of steel of Grade 8.8
- b) Bolts shall comply with the requirements of SANS 1700-7-1 or SANS 1700-7-3.
- c) Bolts shall be hot dip galvanized in accordance with the requirements of SANS 121:2000.
- d) Bolts shall have hexagonal heads.
- e) Bolts shall be of a quality that enables the desired torque levels to be achieved without damage and without compromising contact pressure.
- f) Only bolts of sizes indicated in the relevant drawings shall be used.
- g) The maximum tightening torque on any size of bolt shall be in accordance with the following:
 - 1) shall not exceed 75 Nm
 - 2) shall not exceed 75 % of the value at which fracture of permanent distortion of the bolts, or fracture of the clamp, occurs. Bolt fracture shall occur before the threads strip.
 - 3) the maximum specific surface pressure under flat washers shall not exceed 120 N/mm²,
 - 4) whichever of the above that results shall be the limiting case.

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- h) The bolt length shall be chosen such that, after tightening, at least one thread plus the thread run out will be clear between the nut and the unthreaded shank of the bolt and at least three clear thread shall show above the nut.

3.3.2 Nuts

- a) Nuts shall be of at least not less than the strength grade of the bolt with which they are used.
- b) Nuts shall comply with the requirements of [6].

3.3.3 Washers

- a) Only plain washers shall be used.
- b) Plain washers shall comply with the requirements of SANS 1700-16-2.

3.4 Erection of Tubes

- a) All tubes shall be cleaned prior to erection.
- b) Fixing bolts and nuts for clamps shall be supplied by the contractor.
- c) All lifting gear, boatswain's chairs, ropes, slings, cradles or other tools required for the job, shall be supplied by the contractor. Under all circumstances these items shall be under his immediate control and shall be removed from site on completion of the job.
- d) Quantities and dimensions of tubes to be installed are stated in Schedule A.
- e) Tube lengths indicated are between 100 and 200 mm longer than finished length to allow for dimensional variations on site. Each tube shall be trimmed to suit individual spans as indicated on the relevant drawings.
- f) Item numbers indicated in Schedule A correspond to those indicated in the tubular conductor schedule of the relevant busbar layout drawing

3.4.1 Bolted Clamp Connections

- a) Clamp bolts shall be tightened to the recommended torque given in Table 1 below.
- b) Care shall be taken during tightening to avoid over-stressing the bolts or components of the clamps.
- c) A torque wrench shall be used for tightening each bolt to the recommended torque.

NOTE: UNDER NO CIRCUMSTANCES SHALL BOLTS BE RETIGHTENED ONCE CURRENT HAS PASSED THROUGH THE JOINT.

Table 1: Recommended Torque for Bolt Connections

Aluminium Bolts		Stainless Steel Bolts		High Tensile Steel Bolts *	
Grade 7075 P60		Grade 304		Grade 8.8 Galvanised	
Diameter (mm)	Torque(Nm)	Diameter (mm)	Torque(Nm)	Diameter (mm)	Torque(Nm)
8	10	8	15	8	15
10	21	10	26	10	26
12	36	12	45	12	45
14	55	14	60	14	60
16	70	16	75	16	75

* Holding down bolts at base of Post Insulators shall be fixed on top cap with grade 10.9 galvanised high tensile steel bolts.

3.4.2 Damping Conductors

- a) Damping conductor shall be supplied by Eskom.
- b) Damping conductor of the specified dimensions shall be inserted inside the tube as indicated in the relevant drawing to be supplied by Eskom.
- c) Conductor type, dimensions and quantities of damping conductor are stated in Schedule A.
- d) Damping conductors shall be terminated using a special ferrule to prevent the conductor strands from unravelling. The ferrules shall be supplied by Eskom.

3.4.3 End Caps

- a) End caps shall be provided by Eskom. Types and quantities of end caps to be installed are shown in Schedule A.
- b) End caps shall be installed at locations indicated on the relevant drawings.
- c) End caps shall be tack-welded in three places to improve the integrity of the installation.
- d) The contractor shall ensure that end caps are installed on the correct phase as colour-coded and indicated on the relevant drawing.

3.5 Welding of Tubes

- a) Welding, if required, is to be carried out as specified in 3.5.1.
- b) Welding inserts, where applicable, shall be supplied by Eskom.
- c) Only approved welders to ASME Boiler and Pressure Vessel Code Section 9 IG position shall be used and copies of their approvals shall be submitted with the tender.
- d) Any welding operation shall include comprehensive inspection and non-destructive testing to ensure that all welds are mechanically and electrically sound.

3.5.1 Welding Specification / Procedure

- a) The general rules specified in [2] shall apply to this specification.
- b) All welding shall be done in accordance with the requirements of [3] and [4].
- c) Continuous lengths of tube are specified but, should it be necessary to weld tube sections together to acquire the lengths as indicated on the relevant elevation drawings listed in Schedule A, then for all straight joints short lengths of aluminium tube inserts of suitable diameter shall be used. The length of the inserts shall be twice the diameter of the tube being jointed, fitted symmetrically about the joint centre line.
- d) All welding shall be done by either the gas tungsten-arc (TIG) or gas metal-arc (MIG) method.
- e) To ensure joints with sufficient mechanical strength and acceptable electrical properties, contractors shall submit a welding specification / procedure, giving details of method of alignment, MIG or TIG detailed weld procedures, including edge preparation, cleaning, filler wire or rod details, proposed welding current values, polarity, etc.
- f) It is to be noted that both the tube as well as the inserts, have been heat-treated to obtain maximum mechanical strength. For this reason any form of pre-heating shall either be limited to as little as possible or totally eliminated if at all possible.
- g) The weld specification / procedure shall be approved by an independent inspection authority.

3.5.2 Non-destructive Testing / Examination

- a) The contractor shall clearly define what method of non-destructive testing he proposes to use.
- b) The contractor shall state the percentage of welds that are to be tested, as well as any steps to rectify defects.
- c) The contractor shall state the qualifications of personnel performing non-destructive testing.

4. Construction Requirements

- a) The contractor shall comply with all the requirements stipulated in the [12] and [7].
- b) The contractor shall adhere to all Eskom Life Saving rules [10]. Failure to adhere to the Eskom Life Saving rules shall lead to the contractor being expelled from site.
- c) The contractor shall ensure that a risk assessment is performed by a competent person appointed in writing before the commencement of any construction work and during construction work. The risk assessment shall form part of the health and safety plan.
- d) The contractor shall ensure that all employees under his or her control are informed, instructed and trained by a competent person regarding any hazard and the related work procedures before any work commences, and thereafter at such times as may be determined in the risk assessment.
- e) The contractor shall appoint a full-time competent employee designated in writing as the construction manager, with the duty of supervising the performance of the construction work.
- f) The construction manager must be duly authorised as a responsible person in accordance with [13].
- g) The contractor's employees shall abide with all the requirements stipulated in [13] at all times whilst on site.
- h) Rigging and lifting shall be performed by qualified rigger. Proof of qualification of rigger shall be submitted to Eskom.
- i) Lifting equipment shall be operated by a competent and qualified operator. Proof of qualification of operator shall be submitted to Eskom.
- j) All lifting equipment shall be tested and certified. Test certificates shall be submitted to Eskom when tendering.

5. Working near Energised conductor

[8] shall be used to ensure safety of workers, during the installation process.

6. Construction Supply

- a) A 400V/230V three-phase construction power supply shall be made available to the contractor by Eskom for construction purposes only. Where Eskom is unable to provide this construction power supply, the contractor must make provision for his own construction power supply.
- b) The contractor shall be responsible for all connections up to the construction power supply. All connections, cabling and usage shall be done safely in accordance with relevant standards and legal requirements. Failure to comply with all relevant regulations to the satisfaction of Eskom will be considered sufficient reason to disconnect supply until such time as compliance with the regulations has been effected.
- c) When the permanent, single-phase and three-phase supplies to portable equipment have been installed, these may be used, provided that the correct plugs (which will be available from Eskom's representative on site) are used.
- d) All portable, electrically-operated tools or machines shall be connected to the supply points in accordance with Drawing 0.00/1705 - Construction Power Supply Safety Requirements.

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7. Inspection and Checking

- a) Eskom reserves the right to inspect any task performed at any given time. Therefore Eskom or its appointed representatives shall have access to the works as and when required to carry out any inspection.
- b) Inspections at hold-points, as indicated on the Inspection and Test Plan to be submitted by the Contractor, are mandatory.

8. Tender Technical Returnables

The following documents shall be submitted when tendering:

- a) List of key personnel, their experiences (include CV detailing project-specific work experience for each employee) and academic qualifications. Also include total number of manpower to be dedicated to this project.
- b) List of relevant and comparable projects undertaken. The list shall include project scope, substation name, completion date, project value and client contact person and details. The contractor shall further include any concessions made during each project execution.
- c) List of all tools and equipment to be used.
- d) Erection method statements (including detailed step-by-step procedures) for the following:
 - 1) Erection of post insulators
 - 2) Handling and transportation of tubes from storage to HV yard
 - 3) Cutting and trimming of tubes to specified sizes
 - 4) Lifting and installation of tubular conductors
 - 5) Installation of end-caps
 - 6) Installation and termination of damping conductors
 - 7) Installation of clamps

The following documents shall be submitted upon tender award, prior to starting with construction:

- a) Proof of training of supervisor as responsible person in accordance with Eskom ORHVS. Copy of ORHVS certificate shall be attached.
- b) Calibration certificates of applicable tools and equipment
- c) Test certificates of lifting equipment
- d) Proof of qualification of rigger
- e) Proof of qualification of operator of machinery
- f) Quality, inspection and test plans(QITP)

9. Authorization

This document has been seen and accepted by:

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10. Revisions

Date	Rev	Compiler	Remarks
Aug 2017	2	R Ramnarain	Section 8, Documents Required, changed to Tender Technical Returnables. Quality, inspection and test plans (QITP) requirement added. The tender returnables are separated into documents required when tendering and documents required upon tender award.
Feb 2016	1	R Ramnarain	First Issue

11. Development team

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

- Mark Pepper Chief Engineer

12. Acknowledgements

Not Applicable.