

Title: **STRINGING, CABLING,  
EARTHING AND ERECTION  
SPECIFICATION FOR  
TRANSMISSION SUBSTATIONS**

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## **1. Introduction**

Stringing, cabling, earthing and erection in substations are a much specialised type of construction methodology. This involves the use of specialised equipment and tools that are tailor made to carry out this work.

## **2. Supporting clauses**

### **2.1 Scope**

This technical specification details Eskom's requirements for works related to stringing, cabling, earthing and erection in Transmission substations. The works include, but are not limited to the following:

- a) The erection of post insulators on prepared steel support structures.
- b) Stringing of conductors in high voltage (HV) and extra high voltage (EHV) yards.
- c) Erection of minor equipment.
- d) Laying and termination of cables (AC, Low Voltage, Telecoms, DC).
- e) Earthing of equipment in HV and EHV yards.

#### **2.1.1 Applicability**

This document shall apply within Substation Engineering in Group Technology for Transmission of upto 800kV Substations.

### **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] 32-846: Operating regulations for High Voltage Systems
- [2] 32-421: Eskom Cardinal Rules
- [3] 41-435: Transmission Environmental Policy
- [4] TST41-168: Quality assurance requirements for the procurement of assets, goods and services
- [5] 240-53113927: Specification for Substation clamps for stranded aluminium conductors
- [6] TSP41-877: Transmission substation design earthing standard
- [7] SANS 1700 SERIES: ISO metric bolts, screws and nuts (hexagon or square) (coarse thread free fit series)
- [8] SANS 51808: Safety requirements on suspended access equipment – Design calculations, stability criteria, construction – Tests.
- [9] SANS 1903: Safety requirements on suspended access equipment – Design calculations, stability criteria, construction – Tests.
- [10] SABS ISO 9001:2008, Quality systems – model for quality assurance in design, development, production, installation, and servicing.
- [11] 0.54/393: Eskom earthing standards
- [12] TST41-61: Occupational Health and Safety Requirements to be met by Eskom, Contractors and Sub-Contractors during Maintenance and Construction Work.

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[13] Occupational Health and Safety Act No. 85, 1993 (OSH Act)

### 2.2.2 Informative

None

## 2.3 Definitions

### 2.3.1 General

Definition	Description
<b>Dynamometer</b>	A device used for measuring mechanical force.
<b>Ferrule</b>	A ferrule is any of a number of types of objects, generally used for fastening, joining, sealing or reinforcement. They are often narrow circular rings made from metal, or less commonly, plastic.
<b>Galvanise</b>	Coat (iron or steel) with a protective layer of zinc.
<b>Rigger</b>	A rigger is a person that uses hoists and pulleys or anyone engaged in the lifting, moving and transporting, positioning, pulling and securing of heavy equipment, machines and oversized loads.
<b>Trained</b>	Means to be trained, assessed and found competent

### 2.3.2 Disclosure classification

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

## 2.4 Abbreviations

Abbreviation	Description
<b>BS</b>	British Standard
<b>CV</b>	Curriculum vitae
<b>HV</b>	High Voltage
<b>NCR</b>	Non-conformance report
<b>OHS</b>	Occupational Health and Safety
<b>ORHVS</b>	Operating Regulations for High Voltage Systems
<b>SABS</b>	South African Bureau of Standards
<b>SANS</b>	South African National Standards
<b>UV</b>	Ultraviolet

## 2.5 Roles and responsibilities

Not applicable.

## 2.6 Process for monitoring

Not applicable.

## **2.7 Related/supporting documents**

Not Applicable

## **3. Document content**

### **3.1 Health and Safety Requirements**

- a) The contractor shall comply with all the requirements stipulated in the OHS Act of 1993 and Construction Regulations 2014.
- b) The contractor shall adhere to all Eskom life changing rules. Failure to adhere to the life changing rules shall lead to the contractor being expelled from site.
- c) The contractor shall submit a health and safety plan to Eskom for review and approval.
- d) The contractor shall ensure that the approved health and safety plan is implemented. Eskom will undertake audits at intervals agreed with the contractor to monitor implementation of the health and safety plan.
- e) 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.
- f) 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.
- g) The contractor shall not allow or permit any employee to enter any site, unless such person has undergone site specific health and safety induction training pertaining to the hazards prevalent on the site at the time of entry.
- h) The contractor shall ensure that no person works in an elevated position, unless such work is performed safely as if working from a scaffold or ladder.
- i) The contractor shall appoint a full-time competent employee designated in writing as the construction supervisor, with the duty of supervising the performance of the construction work.
- j) The construction supervisor shall be duly authorised as a responsible person in accordance with 32-846 (Eskom's ORHVS).
- k) The contractor's employees shall abide with all the requirements stipulated in 32-846 at all times whilst on site.
- l) The contractor shall appoint a competent construction safety officer in writing to assist in the control of all safety related aspects on the site.
- m) Rigging and lifting shall be performed by qualified rigger. Proof of qualification of rigger shall be submitted to Eskom on request.
- n) Lifting equipment shall be operated by a competent and qualified operator. Proof of qualification of operator shall be submitted to Eskom on request.
- o) All lifting equipment shall be tested and certified. Test certificates shall be submitted to Eskom on request.
- p) No climbing of structures shall be permitted.
- q) Where trench covers have been removed, the trenches shall not be left open without being barricaded.
- r) Failure to comply with the abovementioned safety requirements shall lead to work being stopped, and depending on the circumstances, Eskom reserves the right to expel a contractor from site.

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## **3.2 Technical Requirements**

### **3.2.1 Scope of work**

#### **3.2.1.1 Stringing of Busbars, Stringers, Droppers and Jumpers**

Means stringing, securing and termination of conductors on steelwork structures and equipment as per referenced drawings.

#### **3.2.1.2 Erection of equipment**

Involves the erection and making ready for cold commissioning the equipment on concrete foundations and/or steel support structures.

#### **3.2.1.3 Installation of Cables**

- a) The drilling of gland plates, laying, terminating, ferruling, testing and tagging of cables plus any loops or bridge pieces specified in the relevant cable diagram.
- b) The supply and fitting of glands, ferrules, lugs and brass or copper number tags for all cables.
- c) The supply and installation of clamps for securing cables to vertical surfaces where necessary. (See Clause 3.2.6.10). (T bar support clamp 0.54/3694)
- d) The removal, safe keeping and re-installation of trench cover slabs as described in Clause 3.2.6.8 of the specification.
- e) Cable rollers, digging cable jacks, trenching 500mm compaction of ground, replacing yard stone, and spare cores must be earthed.

#### **3.2.1.4 Earthing of equipment**

The earthing of apparatus as detailed in Clause 3.2.7 of this specification.

### **3.2.2 Stringing of Conductor and Earth-wire**

Conductors for stringing shall be supplied by Eskom.

The contractor shall submit to Eskom for review and acceptance, an erection method statement with full details of the erection procedure for stringing of conductors and earth-wire.

- a) All earth-wire specified and shown on the Key Plan and/or Earth-wire Arrangement shall be erected.
- b) All stranded conductor busbars specified and shown on the Key Plan shall be erected.
- c) All stringing specified in the Works Information shall be erected including that for unequipped bays, where indicated in the Bay Layout and Plant Schedule. Stringing for future bays shall be made off just beyond the strain clamps.
- d) Multiple conductor bundles for busbars, stringers and droppers shall be fitted with conductor spacers at intervals of seven (7) metres for busbars and stringers, and two (2) metres for droppers. A spacer shall be installed not more than 100mm from the clamp (measured from the end of the clamp to the beginning of the spacer position).
- e) Corona rings shall be fitted to all strain and suspension terminations.
- f) All stranded aluminium connections between apparatus in bays that are being equipped shall be done in accordance with the Works Information, including the droppers from the closing spans of transmission lines to Plant.

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- g) On the Bay Layout drawings for the substation, a letter and number code is used to indicate the insulator string as well as clamp and connector assemblies to be used for making connections except for earth wire clamps. The key drawing detailing each assembly under its code name is the latest revision of standard 474-218, Specification for stranded flexible conductor clamps / connectors.
- h) All the clamps and connectors to be used for non-current carrying equipment shall be of the bolted-bolted type and for current carrying equipment crimped-bolted clamps shall be used and no welding, soldering, sweating or brazing shall be allowed.
- i) Where U-bar assemblies are shown in the various bay layouts the Contractor is required to assemble these as per standard 474-218, Specification for stranded flexible conductor clamps / connectors.
- j) The order in which the yards and bays are to be strung will be advised by Eskom prior to any work being undertaken.

### **3.2.3 Stringing Procedure**

- a) Conductors shall be run out from the drums onto cable rollers in such a manner so as to prevent damage due to contact with the ground. The use of wooden packing material/crates shall not be permitted.
- b) The conductor shall be pulled up to a specific tension (busbar and stringer tensions are specified on the Key Plan) and held for at least 30 minutes. After that period, the tension shall be adjusted to compensate for any settling of the conductor and then clamped into the strain clamp. A dynamometer with a valid calibration certificate shall be used.
- c) Care shall be taken to avoid over-tensioning when a second span, in the opposite direction, is strained onto a structure common to the two spans. (Due to the deflection of structures, the initial span is likely to become over-tensioned when the second span is pulled up to the correct tension).
- d) The correct tension should be restored in the initial span either by slackening and re-bolting the strain clamps, or by slackening the U-bolt to which the insulator assembly is anchored.
- e) Droppers not connected to Plant shall be tied to steelwork in such a manner that they do not interfere with erection work that may be carried out by others.
- f) Droppers shall first be connected to the busbar/stringer before connected to the equipment.
- g) All conductors, after erection, shall be undamaged, smooth and free from 'bird-caging' and kinks.

#### **3.2.3.1 Stringing of conductor and earth-wire in live yards**

It is essential for the safety of personnel carrying out work in live yards, that the procedures detailed below are strictly adhered to. This is particularly the case when stringing long lengths of conductor and earth-wire running parallel, and in close proximity to live high current carrying and/or high voltage conductors. This is in order to safeguard personnel in contact with the conductors being erected, against induced currents and voltages due to electromagnetic and electrostatic coupling respectively.

- a) Long lengths (greater than 10 meters) of conductor shall be earthed at both ends using appropriately dimensioned flexible portable earths.
- One end of the portable earths shall first be connected to a conveniently positioned earth-tail connected to the already buried earth-mat, or to a structure that is solidly connected to the earth-mat.
  - The opposite end of the portable earths shall then be attached to the ends of the conductor runs making use of an earthing stick / link to avoid direct contact with the conductors. When raising conductors into position, the Contractor shall ensure that the earth connections remain in place at all times, and that they are under no circumstances should be disconnected.



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- b) Conductors that have been erected into position shall remain earthed until such time that the work requiring contact with, or is in close proximity to these conductors, is complete.
  - c) Portable earths shall be removed by first disconnecting them from the erected conductors using an earthing stick. (This should be tested as per requirements) Under no circumstances shall the earths be removed directly by hand.
  - d) Should the work required to be carried out involve unearthed conductors or earth-wires (e.g. the connection of droppers from stringers or busbars to items of Plant), then the appropriate earthing procedures as detailed above shall first be applied to ensure that conductors are safe to work on.

#### **3.2.3.2 Preparation of Metal to Metal Contact Surfaces and Current Carrying Clamp Tightening Procedure**

All current-carrying connections, contact surfaces, clamps, conductor and terminals shall be prepared as follows:

- a) Wipe the mating surfaces free from grease and dirt. (Except the bores of compression sleeves).
- b) Apply 1 mm thick coating of approved jointing compound to the surfaces using a non-metallic spatula or similar tool.
- c) Scrub all the coated surfaces thoroughly with a wire brush which is new or which has been used solely for this purpose.
- d) Wipe off the jointing compound.
- e) Apply a fresh 1mm thick coating of compound.
- f) After a period of not more than one minute, make the connection in the normal manner and remove excess extruded compound.
- g) For bundle conductor clamps, a spacer shall be installed not more than 100mm from the clamp (measured from the end of the clamp to the beginning of the spacer position).
- h) No compound squeezed out by clamping pressure shall be used in making further joints.
- i) Plated surfaces on terminal stems should be cleaned with a clean soft cloth and coated with jointing compound as a sealant only.
- j) New clamps shall be kept in their protective coverings and out of sunlight, to avoid UV degradation of the covering, until use. Clamps in damaged protective covers or with damaged compression tubes shall not be used.
- k) The Contractor shall supply all 'approved compound' necessary for making the connections by the method outlined above.

#### **3.2.3.3 Bolted Connections**

- a) Firstly all bolts shall be tightened alternately by hand. Care shall be taken during tightening to avoid over-stressing the bolts or components of the clamps.
- b) A torque wrench shall be used for tightening each bolt to the required torque as specified in Table 1 below unless otherwise stated by the equipment manufacturer:



Table 1: Recommended Torque for Bolt Connections

Aluminium Bolts		Stainless Steel Bolts		High Tensile Steel Bolts	
Grade 7075 T73		Grade 316 (A4)		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

- c) The following procedure shall be followed when making bolted connections
- Tighten bolts to the recommended torque.
  - Ensure that the gap between the clamping cover and the base is uniform.
  - Leave clamps for 24 hours to allow aluminium conductor to expand and contract.
  - Check all bolts to ensure that they remain at the required torque.
- d) Under no circumstances shall bolts be re-tightened once current has passed through the connection. Replace all bolts if re-tightening is required.

### 3.2.3.4 Compression Connections

- a) For carrying out compressed joints, the Contractor shall provide a suitable compression unit complete with the necessary dies, compression head, hose and pump, which is agreed with Eskom prior to any work being undertaken.
- b) The Contractor shall ensure that the dies have the correct width. Position, spacing, width and number of compressions required per sleeve are indicated on all clamps in the form of printed black lines.
- c) The hydraulic pump unit and compression head shall feature an interlocked valve system that can only be released when the compression operation has been fully executed.
- d) The dies shall be embossed with the sleeve diameter for which they are intended so that this number appears raised on the finished compression.
- e) It is the Contractor's responsibility to use the correct dies for the various types of clamps. The die sizes shall be verified by Eskom prior to the first compression of each size that is to be kept as a sample. Verification of the die size shall be done by measuring across the flats of the compression as illustrated in Figure 1 below, by means of an accepted vernier or micrometer, and ensuring that the measurement is within the tolerances stated below. The samples are to be clearly identified and kept by Eskom for future reference and as proof of initial compliance. If the measured dimension lies outside the tolerances specified, NCR is issued and the Contractor shall immediately remove the deficient machinery from site.

### 3.2.3.5 Tolerances

#### 3.2.3.5.1 Hexagon Type Crimped Connections

- a) Hexagonal compressions shall be measured across at least two sets of flats. In each case, the measurement shall lie within the tolerance specified in Table 2 below.

Table 2: Tolerance of hexagonal type crimped compressions

Conductor Type	Tube O/D (mm) Die Size	Nominal (mm)	Dimension 'A' (mm)	
			Min.	Max.
Bull	58	49	48	51
Centipede	42,5	36	35,2	37,5

Table 3: Tolerance of oval type crimped connections

Conductor Type	Tube O/D (mm) Die Size	Nominal (mm)	Dimension 'A' (mm)	
			Min.	Max.
Bull	58	48	47	50

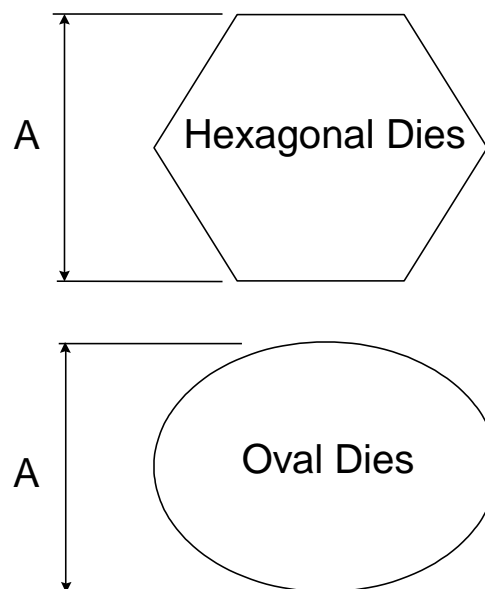


Figure 1: Measuring the Across Flats Dimension (A)

- b) The Contractor shall, prior to effecting the compression, ensure that the conductor to be inserted into the compression tube is cut square and is pushed down the full length of the compression tube.
- c) The Contractor shall keep a record of each compression made. After every 200 compression connections made, the acceptance process described in Clause 3.5.4 shall be repeated in order to ensure continued compliance. Should any deficiencies be found, the operation shall be stopped in order to repeat the above acceptance process. All preceding compressions must then be inspected by the Contractor and witnessed by Eskom.
- d) The Contractor shall ensure that a suitable die size shall be used where applicable.

**Notes:**

- 1) The sleeve size is marked on the clamps provided
- 2) The bores of compression sleeves are pre-greased, thus only the conductor surfaces need preparation as above. The clamp should not be removed from its protective cover until use.
- 3) The die size is marked on the compression sleeves.
- 4) Compression sequence is from the conductor side towards the bolted clamp body.

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### **3.2.4 Erection Tools Required**

The Contractor shall have the following tools available for use when stringing the conductors:-

- a) Come-along conductor clamps for all sizes of conductors to be used.
- b) The largest stranded conductor used has a diameter of 38,3mm and a mass of 2,39kg per metre.
- c) A sufficient number of dynamometers of at least two sizes; one with a mid-scale reading of the order of 2 250 N to string the earth-wire and a second to string the busbars and stringers at 9 000 and/or 4 500 N (as shown on the Key Plan).
- d) The contractor shall only use dynamometers that have been calibrated by an accredited laboratory. Valid calibration certificates shall be submitted to Eskom.
- e) A suitable and safe means to lift workmen and insulator strings to the attachment points.
- f) A suitable compression unit consisting of a compression head, hose and a compressor pump with a sufficient capacity to carry out the required number of compression joints.
- g) Sufficient cable rollers to use for the running out of conductors or cables.
- h) A set of dies for each sleeve size with embossed identification marking. No in-line compression sleeve joints shall be permitted.

### **3.2.5 Erection of HV equipment**

#### **3.2.5.1 Post insulators, CT's, VT's, CVT's, LT's, CB's, Isolators and JB's**

- a) The contractor shall erect such plant as indicated on the relevant drawings.
- b) The contractor shall submit to Eskom for review and acceptance an erection method statement with full details of the erection procedure.
- c) All Equipment shall be erected in accordance with the manufacturer's installation procedure.
- d) The contractor shall ensure that all equipment is not damaged during installation.

#### **3.2.5.2 Fixing bolts, nuts and washers**

##### **3.2.5.2.1 General**

- a) The mechanical properties of bolts, nuts and washers shall be in accordance with SANS 1700-5-1.
- b) The contractor shall ensure that only bolts, nuts and washers of the correct and same grade as specified in the relevant drawings are used together.

##### **3.2.5.2.2 Bolts**

- a) Bolts shall comply with the requirements of SANS 1700-7-1 or SANS 1700-7-3
- b) Bolts shall have hexagonal heads.
- c) Bolts shall be made of high tensile steel (Grade 8.8 Galvanised) or stainless steel (Grade 316 (A4)). Bolts made of any other material shall only be used upon approval by Eskom or as requested and specified by Eskom.
- d) The type of bolts to be used will depend on the site and this will be specified by Eskom.
- e) Bolts shall be of a quality that enables the desired torque levels to be achieved without damage and without compromising contact pressure.
- f) No bolt shall have a diameter of less than 10 mm unless otherwise approved by Eskom.
- g) The design torque that is to be applied to the bolts for optimum performance shall be stated in Table 2, together with the minimum torque at which satisfactory operation is guaranteed.

- h) The maximum tightening torque on any size of bolt shall be in accordance with the following:
- Shall not exceed 75 Nm.
  - Shall not exceed 75% of the value at which fracture or permanent distortion of the bolts, or fracture of the clamp, occurs. Bolt fracture shall occur before the threads strip.
  - The maximum specific surface pressure under flat washers shall not exceed  $120 \text{ N/mm}^2$ ,
  - Whichever of the above that results shall be the limiting case.

#### **3.2.5.2.3 Bolt length**

- a) The bolt length shall be chosen in such a way that, after tightening, at least three threads show above the nut.
- b) Unless otherwise stated in the specification data, the maximum protrusion beyond the nut shall be 10mm.

#### **3.2.5.2.4 Nuts**

- a) Nuts shall be made of stainless steel or galvanised steel.
- b) Nuts shall comply with the requirements of SANS 1700-14-2 or SANS 1700-14-3.

#### **3.2.5.2.5 Washers**

- a) Stainless or galvanised steel, plain and spring washers shall be used.
- b) Plain washers shall comply with the requirements of SANS 1700-16-2.

### **3.2.6 Installing of Cables and Accessories**

#### **3.2.6.1 General**

- a) Cables shall be removed from the drum in accordance with the actual measured lengths required, and in such a manner that any surplus will be in the minimum number of separate lengths.
- b) The needs of all long cable runs shall be satisfied before any short lengths of cable are cut from any drum.
- c) Following the cutting of a cable, the end shall, where necessary, be sealed immediately with a cable end cap
- d) All cables shall be drawn into position using a sufficient number of rollers, together with suitable apparatus for negotiating corners, without excessive bending or damage to the cable serving etc. Cables shall not be bent to smaller radii than 20D in pipes and 15D laid direct, where D is the overall diameter of the cable.
- e) Should Eskom be responsible for supplying cable, all scrap material resulting from the termination of cables shall be removed from the working site on completion of each working day and handed over to Eskom at completion of the contract.

#### **3.2.6.2 Cable routes and cable block diagrams**

- a) The Contractor shall follow the exact cable routes indicated to him by Eskom.
- b) The cable within the control room shall follow the route of the panel arrangement within the control room layout, not the shortest route.

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- c) The cable block diagrams indicate each cable represented by a single line, together with its number and type of cable. Each item of Plant such as a transformer, circuit breaker, junction box, etc, that requires a cable connection is represented on the cable block diagram. The contractor shall follow the shortest electrical route within the cable trenches within a bay. Where no cable trenches exist, the cable shall follow the shortest electrical route between the primary equipment and the bay junction box.

#### **3.2.6.3 Cabling schedules**

Eskom will provide cabling schedule for the connection of the cores to the terminals.

#### **3.2.6.4 Mechanical cable glands and cable boxes**

- a) Cable glands shall be self-centring conical bush type, with weatherproof shroud.
- b) All electrical Plant requiring cabling is provided with blank removable plates of adequate size to accommodate the necessary glands. The drilling of these plates shall be undertaken by the Contractor.
- All particles, metallic or otherwise, resulting from the cutting and drilling of plates shall be totally removed.
  - All exposed metal surfaces resulting from the cutting or drilling of the plates shall be re-coated with a similar and/or compatible covering, and which shall have at least the same adhering strength as the original covering.
- c) The Contractor will supply all cable gland earth tags where cable glands are fixed to non-metallic or painted gland plates.
- d) SABS Approved Glands to be used.

#### **3.2.6.5 Through and tee joints**

- a) No intermediate joints will be permitted in any length of cable.
- b) The through reducer and the joints for power cables, as indicated on the relevant drawings, shall be carried out in accordance with an accepted jointing procedure.
- c) Before any joint is made, the joiner shall satisfy him / herself that the cable dielectric is sound by checking the insulation resistance and testing for moisture.

#### **3.2.6.6 Termination of cable ends**

- a) Details of cable terminations are given on the cable termination drawing provided by Eskom.
- b) All cables shall be tagged in accordance with the relevant drawings and all cable tails shall be numbered by means of numbered ferrules or other accepted means only with prior approval from Eskom's secondary plant responsible person.
- c) All 2,5 mm<sup>2</sup> and above cable tails, shall be identically marked at both ends with an approved type of marking device having black letters and numbers impressed on a yellow background, only one colour per station shall be used.
- d) The letters and numbers shall correspond to the cable tail identification indicated on the cable schedules. The slip-on interlocking type ferrules must be used. Ferrules shall be handed as to read the right way up on the cable terminal strips and to read from left to right.
- e) All cable tails shall be terminated with pre-insulated crimped or approved compression type connectors.

- f) All terminations shall be made with the tool recommended by the manufacturer of the lug. Crimping tools shall be of the type that will not release the termination during normal operation until the conductor crimp has been correctly formed. All finished crimps shall bear identification marks impressed by the tool to permit:
- 1) Visual confirmation that the correct lug/tool combination has been used.
  - 2) Identification of the individual tool used.
  - 3) All crimping tools shall have a test certificate, not older than 6 months, complying with the pull test requirements.
  - 4) Any crimp shall not be wider than 9 mm, as to not be wider than a 10 mm wide terminal.
- g) The contractor shall ensure that the lugs selected are of the correct barrel size for the size of the cable tail with which they are to be used, and that the dimensions of the tongue match the stud, screw or aperture of the terminal to which they will be connected. Table 4 lists type of lug to be used with the various types of terminations.

**Table 4: Types of lugs for use with various terminations**

Type of Terminal	Type of Lug JST Terminal
Stud	Ring, Tongue
Screw type or rotary	Ring, Tongue or flanged
Screw clamp/spring	Hooked blade
Loaded insertion type	Hooked blade

- h) Sample crimped ends, selected at random, may be subjected to tests to prove the mechanical strength. Such tests will consist of an axial pull of approximately 60% of the conductor-breaking load, applied by means of a spring balance or similar device. For the purpose of this specification, the force to be applied when testing crimped terminations of 1,5 mm<sup>2</sup>, 2,5 mm<sup>2</sup>, 4 mm<sup>2</sup> cables shall be approximately 270 N. For 0, 75 mm<sup>2</sup> cables, the force shall be approximately 150 N. If any sample fails the test, all the terminations made using this particular tool are to be re-crimped.
- i) In certain instances for communication and supervisory cables, terminals requiring sweating may be required. Cable tails shall be run within 150 mm of terminal strips, and on leaving the group, shall be looped back onto the terminals to allow 250 mm of slack.
- j) Spare tails shall be left long enough to reach the furthestmost terminal.
- k) Phase colouring shall be indicated on power cable tails.
- l) Tails of miniature cables shall be bound back on themselves or wrapped around the bush to allow 250 mm of slack before being connected to the terminal.
- m) The Contractor shall ensure that the insulation-stripping tool be correctly sized in order to avoid damage to the conducting cores/strands. Any "nicked" wiring will be rejected.
- n) The Contractor shall ensure that the insulation of the conductor cores/strands are stripped to the correct length according to the specific lug used. Any incorrectly stripped cores/strands will be rejected.
- o) Sample lug crimped ends, selected at random, will be inspected for correctness and quality of the crimp. If any sample fails the inspection, all lug crimped ends will be inspected, and if found incorrectly, must be re-lugged and crimped.
- p) The responsible Eskom secondary plant person, in conjunction with the electrical site supervisor, shall verify the lug types, crimping tools, with test certificate and ferrule number type, prior to any work being done by the cable contractor.

### **3.2.6.7 Racking**

Eskom could supply and install the racking in the cable trenches in the control room.

### **3.2.6.8 Cables in concrete trenches**

In the concrete trenches, complete with cover slabs, for the main cable routes in the high voltage yard:

- a) The Contractor shall remove the cover slabs and shall be responsible for their safekeeping and replacement.
- b) A layer of sand or sifted earth approximately 50 mm thick with no stones, shall be placed in the trenches and the cables installed as level as possible.
- c) Single cables from these trenches shall be taken beneath or through slots in the trench walls and buried in ground to the depth specified in Clause 3.2.7.9.

### **3.2.6.9 Cables in ground**

#### **3.2.6.9.1 General**

All cables in the ground shall be laid in trenches at a depth of 500 mm. The contractor shall remove redundant cables as per contract or Bill of Quantity.

#### **3.2.6.9.2 Excavation**

- a) Excavation, back filling and consolidation shall be carried out by the Contractor.
- b) Material unsuitable for back filling shall be removed from Site by the Contractor and disposed off in areas previously agreed with Eskom.
- c) No mixing of Sand and stones.
- d) All cables shall be covered by a minimum of 75 mm of fine earth or sand and the trench shall then be back filled with excavated earth.

#### **3.2.6.9.3 Cable sleeve pipes**

All sleeve pipes under roadways and buildings may be provided by Eskom.

### **3.2.6.10 Cable above ground**

#### **3.2.6.10.1 General**

- a) In the switch operating room block, the cables shall be laid on racks, in the main trenches, and on the floor of secondary trenches (Racks by Others).
- b) Where cables leave the horizontal i.e. cable connected to current transformers, breakers etc., the Contractor shall provide clamps:
  - 1) Details of the clamps or clamping arrangements shall be agreed with Eskom before work commences.(T bar cable support )
  - 2) Clipping points are defined at all points at which cables are secured to steelwork, to racking on walls or floors by means of cleats or saddles. Cables shall be supported every metre in the vertical plane.
  - 3) Each clipping point for multi-core armoured cable shall be in accordance with the relevant drawing and shall include the cleat and rawlbolt or, bolt and nuts and washers, the drilling of concrete or steelwork, spot welding, if required as specified for racking.
- c) Drilling or flame burning of holes in the galvanised structural steelwork for supporting clamps or other fixtures shall not be permitted, but supports may be clamped to such steelwork.
- d) Welding of galvanised steelwork is not permissible.

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#### **3.2.6.10.2 Sealing of holes in floors and walls**

Wherever cables pass through holes in floors and walls, or enter or leave pipes in the floor, the opening shall be sealed with Vermiculite plaster. The opening shall be filled for the full thickness of the floor or wall, except where horizontal, where it shall be domed or raised slightly on the upper surface to prevent the accumulation of water or oil in the seal.

#### **3.2.6.11 Painting and galvanising**

- a) Where additional steelwork, cable boxes, joint boxes and clipping points are provided, and installed indoors by the contractor, such items, and the associated welds shall be wire-brush cleaned. It shall then be painted with one coat of High-Build Alkyd Zinc Phosphate Primer (dry film thickness of 35 micrometers) applied to individual parts before assembly.
- b) Finally after assembly, apply one coat of Alkyd High Gloss enamel to SANS 630 Type 1. Dry film thickness 30 micro-metres. The colour shall be to BS 381C - 631 Light Grey. The colour may alternatively be to SANS 1091-G29 Light Grey. All paint shall be applied by means of a brush.
- c) In certain cases it may be necessary to drill galvanised steelwork provided by Eskom to fit cable clamps. All galvanised steel-work that has to be drilled shall have the exposed steel repaired in accordance with SANS 32 & 121 (i.e. by zinc spraying, hot patch soldering or coating with a zinc rich paint) within four hours of drilling.
- d) In the case of ferrous cable clamps or steel-work mounted outdoors all ferrous parts shall be coated with a High-Build Alkyd Zinc Phosphate Primer (dry film thickness 35 of micro-metres per coat) before and after installation to prevent rusting.

#### **3.2.6.12 Site tests**

The following tests shall be carried out after the installation of cables is completed, but before the cable cores are connected to any terminal or Plant. The specified lead times for notification to Eskom to witness tests shall be required by the Contractor.

##### **3.2.6.12.1 Insulation resistance**

On all cables, the insulation resistance of each core to sheath or conduit and between cores shall be measured and recorded. A 1 000-volt Megger shall be used for all cables having 660-volt grade insulation or higher. A 500-volt Megger shall be used for all cables having 250-volt grade insulation.

##### **3.2.6.12.2 Conductor resistance**

Conductor resistance shall be measured on any completed cable run. Such resistances shall be recorded.

#### **3.2.7 Earthing**

- a) Copper tails shall be brought out at specified positions for the connection to earth bars and to Plant to be earthed.
- b) The Contractor shall earth all equipment Plant detailed in the Works Information. All copper rod and copper strap shall be provided by the Contractor. The jointing and fixing of earth connections shall be carried out in accordance with the relevant drawings and Earthing standards (0.54/393).
- c) Where earthing straps are required to run up Plant support structures, the strap shall be terminated at both ends and fixed to the structure at the top and on each alternate lacing down the structure, but not exceeding 1 100 mm apart. Surge arrestors shall be earth as per relevant drawings.
- d) Bolt-holes are generally provided in the lacing but, the Contractor is required to provide suitable means of securing the earth strap to the structure as agreed with the Supervisor prior to the work being undertaken. Drilling of holes in the galvanised structural steelwork shall not be permitted.
- e) Horizontal earth straps between flexible connection terminals on isolators with earth blades shall be secured to the isolator structure at intervals not exceeding 1 metre utilising existing bolt holes.

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- f) When earthing the neutral terminal on transformers, the cleats provided on the tank shall be used for securing the copper strap.
- g) All ferrous material used for clamping shall be galvanised.
- h) During installation of the earth-mat, visual inspection of the exothermally welded or brazed joints shall be verified by Eskom.
- i) Non oxide grease shall be used for dis-similar Metals.
- j) After installation the following tests are recommended to verify that the installed earth-mat is as per design.
- Measurement of the earth-mat resistance using the slope method.
  - Continuity measurements between a selected point on the earth-mat and all earthed steelwork and plant. The four-point method is recommended.

### **3.3 Quality of work**

Crates, packing cases, etc, used for the delivery of material shall be stacked neatly in a place on the site indicated by the Supervisor.

### **3.3 Inspection and checking**

#### **3.3.1 Cable Drum Schedule**

The Contractor shall maintain on site a cable drum schedule for each drum of cable supplied by Eskom. This schedule shall show the type of cable and initial length, the actual measured length of each section of cable removed, together with the cable schedule number of the cable. A running total of the cable on each drum shall be maintained.

- a) Eskom reserves the right to inspect any task performed at any given time. Therefore Eskom or its appointed representative 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.

### **3.4 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) Test and measurements methods (procedures) for the various tests and measurements stated in this specification:
- Earth resistance measurements.
  - Earth continuity measurements.
  - Insulation testing.

e) Erection method statements (including detailed step-by-step procedures) for the following:

- Stringing and termination of conductors.
- Stringing and termination of earth-wire.
- Installation of HV equipment.
- Cable installations.
- Cable terminations.
- Earthing.
- Brazing of earth connections.
- Crimping.

f) Procedure for compression 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) Proof of qualification of rigger.
- c) Proof of qualification of operator of machinery.
- d) Calibration certificates of applicable tools and equipment.
- e) Test certificates of lifting equipment.
- f) Quality, inspection and test plans(QITP)

## **4 Authorization**

This document has been seen and accepted by:

<b>Name and surname</b>	<b>Designation</b>
Derrick Delly	Chief Engineer Substation Engineering
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## 5 Revisions

Date	Rev	Compiler	Remarks
Aug 2017	2	R Ramnarain	Document 240-53113927: Specification for Substation clamps for stranded aluminium conductors, unique identifier updated. Section 3.5, 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.
Sept 2016	1	R Ramnarain	2.2.1 updated Unique Identifier changed from 41-727 to 240-82736997 Compiler changed from S Maphosa to R Ramnarain. Approver changed from K Kleinhans to NP Tlhatlhetji. Authorized changed from R Cormack to NP Tlhatlhetji. Supported by NP Tlhatlhetji. New document format applied.
Jan 2011	0	S Maphosa	First Issue

## 6 Development team

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

- Braam Groenewald Corporate Consultant – Substation Engineering
- Percy Seboco Senior Technologist - Substation Engineering

## 7 Acknowledgements

Not Applicable.