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1. Introduction

1.1 Purpose

The purpose of the Substation Construction Method Statement is to instruct a method of construction that minimizes the risks and hazards on site as seen in the past, enforcing meticulous planning by the contractor to abide by these methods and to limit omissions of practices set in place to reduce risks. The procedures are to be used as an informative reference for the contractors; it will provide a starting place for the contractors to compile their own safe work procedures. The safe work procedure will conform to the legislation and specifically the Construction Regulations as part of a Health and Safety Plan.

1.1.1 Equipment

For each activity type, the Safe work procedure should contain an equipment list with the type of equipment and the capacity - clearly distinguish between safe working load (SWL) and ultimate breaking load (UBL).

All equipment should be tested as a pure visual inspection is not sufficient to demonstrate safely the safe working capacity of the tools used in any activity.

1.1.2 Inspections

a) The designer of a structure shall carry out sufficient inspections at appropriate times of the construction work involving the design of the relevant structure in order to ensure compliance with the design and a record of those inspections is to be kept on site as per the requirements of the Construction Regulations.

b) After the equipment structure has been assembled as stipulated in the corresponding method as stated below, it should be inspected and signed off on the corresponding check sheet by the supervisor appointed in terms of the Construction Regulations act as an on-site representative of the designer/client as well as by the contractor.

c) After the equipment has been erected as stipulated in the corresponding method as stated below, it should be inspected and signed off on the corresponding check sheet by the supervisor appointed in terms of the Construction Regulations as an on-site representative of the designer/client as well as by the contractor.

d) After the earthing of each structure, as stipulated in the corresponding method as stated below, it should be inspected and signed off on the corresponding check sheet by the supervisor appointed in terms of the Construction Regulations as an on-site representative of the designer/client as well as by the contractor.

e) After the stringing of equipment has been completed as stipulated in the corresponding method as stated below, it should be inspected and signed off on the corresponding check sheet by the supervisor appointed in terms of the Construction Regulations as an on-site representative of the designer/client as well as by the contractor.

f) After the installation of tubular aluminium conductor as stipulated in the corresponding method as stated below, it should be inspected and signed off on the corresponding check sheet by the supervisor appointed in terms of the Construction Regulations as an on-site representative of the designer/client as well as by the contractor.

g) After the installation of cable as stipulated in the corresponding method as stated below, it should be inspected and signed off on the corresponding check sheet by the supervisor appointed in terms of the Construction Regulations as an on-site representative of the designer/client as well as by the contractor.

h) The check sheets together with the inspection notification form should be sent to the designer with seven days' notice.

i) Although the designer only inspects the first-off structure type/earthing/stringing/installation of tubular conductor and cables, the supervisor should inspect and complete the same form with inspection for each structure and file on site as this forms part of the as-built documents.

j) Once this first off inspection is carried out by the designer, the construction/installation of similar structures/ equipment/stringing/earthing/cabling and tubular aluminium conductor processes can continue.

k) The ITP and check sheets signed by the designer and the supervisor is to ensure that construction work is carried out in accordance with design and designs standards.

l) The ITP and check sheets submitted by the contractor as part of their contract quality plan is to ensure quality of their construction techniques and should refer to their submitted method statements. Their method statements should be a detailed execution plan abiding by the high level sequence of events laid out in the relevant Eskom Specification – Method Statements and mitigating the risks highlighted by the designer.

m) The contractor's method statements and corresponding ITPs should be signed off by an ECSA registered professional engineer who should periodically visit the site to ensure conformance to his methods by means of inspection.

2. Supporting clauses

2.1 Scope

This guideline details the construction methods for erecting/installation of substation equipment, earthing, stringing, cabling and installation of tubular conductor.

2.1.1 Applicability

This guideline shall be applicable to all Transmission Substations in Eskom.

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] Occupational Health and Safety Act No. 85, 1993 – Construction Regulations 2014

[2] 240-114967625: Operating Regulations for High Voltage Systems

[3] 240-82736997: Stringing, Cabling, Earthing and Erection Specification for Transmission substations

[4] 240-89926574: Specification for the Installation of Tubular Aluminium Conductors

[5] 240-45683927: Compaction Testing of Cable Systems Installations

[6] CIGRE : Management of Risk in Substations working group B3.38 June 2018

[7] ISO 31000 Risk Management – Principles and Guidelines and ISO 31010 Risk Management – Risk Assessment Techniques.

[8] D-DT 8075: Bonding Lead

[9] D-DT 0893: HV Cable Bonding and Earthing Arrangement

[10] D-DT 0892: HV Power Cable Trench Details

[11] D-DT 0854: MV and LV Power Cable with Electrical Services Detail

[12] D-DT 0890: HV XLPE Cable Termination

[13] 0.54/393 Eskom Earthing Standards

[14] TST 41-1062:Standard for Electronic Protection and Fault Monitoring Equipment for Power Systems

[15] 240-64100247: Standard for Earthing Secondary Plant Equipment in Substations

[16] 240-101940513: Substation Earth Electrode Resistance Measurement

[17] 240-84854974: Continuity Measurement of Transmission Substation on Earthmat System

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

Definition	Description
Risk	ISO [6] defines risk as the 'effect of uncertainty on objectives'. This definition includes uncertainties in events which may or may not happen and uncertainties caused by ambiguity or a lack of information. It also includes both negative and positive impacts on business objectives. Mathematically, risk is quantified as an expectation from an event.
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
Thermal resistance	Thermal resistance is a heat property and a measurement of a temperature difference by which an object or material resists a heat flow

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
ECSA	Engineering council of South Africa
ITP	Inspection Test Plan
LDV	Light duty vehicle
PPE	Personal protective equipment
TIG	Tungsten inert gas
ITP	Inspection and Test Plans
SANS	South African national standards
SHEQ	Safety, Health, Environment and Quality
SWL	Safe working load
UBL	Ultimate breaking load
K.m/W	Kelvin.meter / Watt
C	Current lead
V	Voltage lead
LV	Low voltage
HV	High voltage

Abbreviation	Description
MV	Medium voltage
EHV	Extra High voltage

2.5 Roles and responsibilities

2.5.1 Responsibility of the contractor:

According to the construction regulations –

9. Structures (1) a contractor shall ensure that –

a) all reasonably practicable steps are taken to prevent the uncontrolled collapse of any new or existing structure or any part thereof, which may become unstable or is in a temporary state of weakness or instability due to the carrying out of construction work; and

b) no structure or part of a structure is loaded in a manner which would render it unsafe.

2.5.2 Responsibility of the designer:

(2) The designer of a structure shall -

a) Before the contract is put out to tender, make available to the client all relevant information about the design of the relevant structure that may affect the pricing of the construction work;

b) Inform the contractor in writing of any known or anticipated dangers or hazards relating to the construction work, and make available all relevant information required for the safe execution of the work upon being designed or when the design is subsequently altered;

c) Subject to the provisions of paragraph (a) and (b) ensure that the following information is included in a report and made available to the contractor:

   1) A geo-science technical report where appropriate;

   2) The loading the structure is designed to withstand; and

   3) The methods and sequence of construction.

d) Not include anything in the design of the structure necessitating the use of dangerous procedures or materials hazardous to the health and safety of persons, which could be avoided by modifying the design or by substituting materials;

e) Take into account the hazards relating to any subsequent maintenance of the relevant structure and should make provision in the design for that work to be performed to minimize the risk;

f) Carry out sufficient inspections at appropriate times of the construction work involving the design of the relevant structure in order to ensure compliance with the design and a record of those inspections is to be kept on site;

g) Stop any contractor from executing any construction work which is not in accordance with the relevant design;

h) Conduct a final inspection of the completed structure prior to its commissioning in order to render it safe for use and issue a completion certificate to the contractor; and

i) Ensure that when preparing the design, cognizance is taken of ergonomic design principles in order to minimize ergonomic related hazards in all phases of the life cycle of a structure.

These and all other aspects of the construction regulations should be adhered to under all circumstances.

3. Risk Management

There are numerous risks in construction, some of which can be categorized as follows:

3.1 Environmental

- Sharp objects like steel, conductor ends, planks with nails etc.
- Nip points on ring views, block and tackles, press etc.
- Noise from equipment.
- Mud, wet steel, long grass, loose stones, soil and uneven surfaces, excessive wind.
- Crane can sink into the ground.
- Moving trucks and LDV's.
- Hazardous materials,
- Heatstroke

3.2 Human Error

- Inappropriate designs
- Miscommunication between winch/tensioner/crane operators/site supervisors.
- Falling objects like tools, bolts and nuts etc.
- Working at heights on structures and conductors.
- Climber attaches to a portion of the structure suspended by the crane.
- Poor rigging practice – incorrect use of shackles, attachment below centre of gravity, overloading of crane etc.
- Employees not using PPE / climbing equipment correctly.
- Risk of Electric Shock

3.3 Equipment

- Failures of equipment due to poor maintenance/inappropriate use/untested.
- Lifting of equipment and materials with slings / cranes – slings can break / crane faulty etc.
- Sudden release of tension in slings/conductor/stay-wires.
- Winching of the conductor/moving wires.
- Overloading of the structure in a temporary state of weakness because of loose bolts etc. during erecting / loading during stringing.

These risks can however be managed with a formal risk management process, quantified in the case of health and safety hazards, and appropriate responses evolved where required.

3.4 Process for monitoring

Not applicable.

3.5 Related/supporting documents

Not applicable.

4. Stringing Method Statement

This section covers the various methods and practices to be employed in stringing substation conductor.

4.1 Risks

The following is some of the risks identified for the specified activities.

4.1.1 Environmental:

- Weather conditions.
- Noise from equipment.
- Moving vehicles.
- Working in close proximity with live equipment.

4.1.2 Human Error:

- Inappropriate designs.
- Miscommunication between winch/tensioner/crane operators/site supervisors.
- Falling objects like tools, bolts and nuts etc.
- Working at heights on structures.
- Poor rigging practice – incorrect use of shackles, attachment below centre of gravity, overloading of crane etc.
- Employees not using PPE/climbing equipment correctly.
- Work in elevated positions.
- Integrity of structures.
- Work position of workers and specific tasks.
- Overall supervision.

4.1.3 Equipment:

- Failures of equipment due to poor maintenance/inappropriate use/untested.
- Lifting of equipment and materials with slings/cranes – slings can break/crane faulty etc.
- Sudden release of tension in slings/conductor.
- Winching of the conductor/moving wires.
- Overloading of the structure in a temporary state of weakness because of loose bolts etc. during erecting / loading during stringing.

4.2 Safety Requirements

- Ensure the correct height of conductor drums for running out of conductor.
- Enough personnel to run out conductors.
- Enough people to string and connect conductors.
- Barricade the work site if required.
- Ensure isolation and sufficient earthing.
- Be aware of obstacles (Fences etc).
- No person to be below the drums being loaded /unloaded.
- No unauthorised entry is allowed on the site being worked on.

- Correct and complete PPE to be used.

4.3 Stringing – Phase Conductor

4.3.1 Pre - Stringing Procedure

The **Contractor** shall acquire the following from the construction drawings:

- The number and size of conductors per phase.
- The number of insulator discs/insulators to be installed.
- The type of strain and suspension assemblies to be utilized.
- The conductor tension to be used.

The **Contractor** shall record the drum number and location of every installation.

The **Contractor** shall check the drum for visible damage.

4.3.2 Stringing Procedure

- The **Contractor** shall position the conductor drum in a suitable position for lowering drum onto jacks.
- Drum jacks shall be erected in stable position.
- Lower conductor drum onto jacks.
- Check for stability prior to removal of slings.
- Remove protective wooden slats from drum.
- Check exposed conductor for damage.
- Place conductor rollers or suitable protective material in position.
- Run out required length of conductor, checking that conductor does not scrape and there is no visible damage as conductor is exposed.
- Measure length of conductor required and tape conductor with insulation tape on either side of cut mark to prevent unravelling.
- Cut conductor to required length using conductor shears.
- Repeat for the number of conductors per phase as above.
- Mark up conductor register with lengths used.

4.3.3 Stringing - Stringers

- Run out conductor and assemble hardware as per general instruction.
- Check strain assemblies for correctness against bay layout drawings.
- Check strain assemblies fasteners –i.e. all pins are in position and nuts are tightened to correct torque.
- Position crane with aerial bucket so that the attached point on beam is easily accessible. Ensure that the crane is in a stable position and lower hydraulic stabilises.
- Attach rope block to beam above conductor attachment point and secure rope to steelwork with correctly sized shackle.
- Secure strain assembly securely to hoist end of rope or to truck and lift strain assembly into position.

- Attach strain assembly to steelwork U-bolt, ensuring that the clip is fitted to the attachment pin.
- Attach come-along, dynamometer and lever winch to each conductor and tension to the relevant newton's specified.
- Tension first conductor to stated tension. Repeat for all additional phase conductors.
- Remove come-along, dynamometer and winches and check that the conductors lie flat relative to each other and that tension is equal in each. If tension is equal, then sags will be identical.
- Fit spacers to end of conductor torqueing bolts to correct specification.
- Visually examine each conductor in bay for any kinks or defects.
- Ensure that all items in inspection and test plans have been fulfilled and signed off.

4.3.4 Current carrying clamps and hardware

4.3.4.1 Installation of current carrying clamps and hardware

The first compression joint for each sleeve size compressed per contract shall be measured with a Vernier to ascertain that compression is within sleeve manufacturer's tolerance.

All current carrying connections, contact services, clamps, conductors and terminals shall be prepared as follows:

- Scrub the coated surfaces thoroughly with a wire brush.
- Apply fresh 1 mm coating of compound.
- Any plated services on terminal stems shall be cleaned with a clean cloth and coated with a jointing compound as a sealant only.

a) Bolted Connections

- Bolts shall be tightened by hand as an alternative.
- A torque wrench shall be used for tightening each bolt to the required torque as specified.
- Tighten bolts to the recommended torques.
- Ensure that the gap between the clamping cover and base is uniform.

b) Compression Connections

- The bores of compression sleeves are pre-greased, thus only the conductor surfaces need preparation as above.
- Position, spacing, width and number of compressions are indicated on all clamps in the form of painted black lines.
- Start compressing from the conductor side towards the bolted clamp body.

c) Tightening and torqueing of bolts as follows:

- Torque wrenches shall be calibrated against a known standard and checked at regular intervals during final tightening of bolts
- All multi-bolted connections shall first have all bolts finger tightened and then tightened sequentially to the required degree of torque.
- After final tightening, all clamps joint faces must be checked to ensure that the gap is equal.

4.3.5 Stringing – Busbars

- Stringing of busbars is identical to the stringing of stringers with the exception of the installation of suspension assemblies and clamps.

- Run out conductor and assemble hardware.
- Check suspension assemblies for correctness against bay layout drawings.
- Fit conductor sheave wheels in place of suspension clamps on suspension assembly.
- Check suspension assemblies fasteners, i.e. all pins are in position and nuts are tightened to correct torque.
- Move suspension assemblies to busbar area and place in position beneath suspension attachment points on suspension beams.
- Prepare conductor, fit strain assemblies and secure start end to strain beam as per stringing instruction.
- Attach rope block to other strain beam, secure strain assembly to rope end and start slowly to hoist.
- As conductors rise from the ground, fit suspension assemblies to the conductor bundle and hoist them together with the conductor.
- Attach strain assembly to attachment point on beam ensuring that the clip is attached to attachment pin.
- Raise suspension assemblies and secure the suspension U-bolts on suspension beams. Check that suspension pin is secure and clip is fitted.
- Ensure that each conductor in phase bundle is able to move freely within conductor wheels.
- Repeat for each suspension point on conductor run.
- Tension and make off conductors as above.
- Utilising the crane and aerial basket proceed along busbar replacing conductor sheave wheels with conductor suspension clamps, or all work to be conducted by hand with the use of rope blocks and tools.
- At each suspension point, ensure that the suspension assembly is vertical and clamp and conductor is in position. Torque clamping bolts to specified torque.
- Fit spacers at specified intervals using crane and aerial basket top raise personnel into position, or crawl onto conductor and carry out work by hand.
- Ensure that all items in inspection and test plans have been fulfilled and signed off.

4.3.6 Stringing – Droppers

- Check clamps and connectors for visible damage and suitability for use in equipment installed.
- Move clamps and connectors to installation area and place in a safe place, avoiding damage to material.
- Position crane and aerial basket in stable position so that attachment points are easily accessible.
- Measure dropper length allowing for electrical clearances for ground and earth.
- Run out conductor for one connection and cut to length.
- Prepare and attach clamp to conductor at highest point as per clamping instruction.
- Attach clamp and conductor to crane with rope sling and raise to connection point or by scaffolding and hand.
- Fit clamp loosely to connection point and form conductor to required curvature such that equipment is subject to least strain.

- Check clearances and form of conductor and when satisfied with correctness, prepare and attach clamp to conductor as per clamping procedure.
- Attach and tighten clamps to connections as per instruction and to correct torque using pre-set torque.
- Visually inspect for form and measure clearances if necessary, I satisfactory, proceed with cutting and fitting remainder of conductors.
- Examine installation for consistency of conductor form, damage or deformity of conductor alignment. If necessary, correct and adjust.
- Fit spacers at specified intervals using crane and aerial basket to raise personnel into position. Torque clamping bolts to specified torque.
- Ensure that all items in inspection and test plans have been fulfilled and signed off.

4.3.7 Stringing – Earthwires

- Fit strain clamps to either side of earthwire
- Secure clamp and earthwire for first attachment point using a rope and raise conductor to attachment point
- Bend free end of earthwire back onto earthwire run and secure with Crosby clamp.
- Attach come-along to conductor and lever wrench to steelwork above attachment point with slings and shackles.
- Tension earthwire until slack is removed.
- Reposition strain on earthwire to take up slack, torque bolts and fit security clip. Bend free end of earthwire back onto earthwire run and secure with Crosby clamp.
- Repeat for remaining earth runs.
- Ensure that all items in inspection and test plans have been fulfilled and signed off.

5. Erection Method Statement

This section covers the various methods and practices to be employed in erecting the equipment.

5.1 Risks

The following is some of the risks identified for the specified activities.

5.1.1 Environmental:

- Weather conditions.
- Noise from equipment.
- Moving vehicles.
- Working in close proximity of live equipment.

5.1.2 Human Error:

- Inappropriate designs.
- Miscommunication between winch/tensioner/crane operators/site supervisors.
- Falling objects like tools, bolts and nuts etc.
- Working at heights on structures.

- Poor rigging practice – incorrect use of shackles, attachment below centre of gravity, overloading of crane etc.
- Employees not using PPE / climbing equipment correctly.
- Work in elevated positions.
- Integrity of structures.
- Work position of workers and specific tasks
- Overall supervision.

5.1.3 Equipment:

- Failures of equipment due to poor maintenance/inappropriate use/untested.
- Lifting of equipment and materials with slings / cranes – slings can break / crane faulty etc.
- Sudden release of tension in slings/conductor.
- Winching of the conductor/moving wires.
- Overloading of the structure in a temporary state of weakness because of loose bolts etc. during erecting / loading during stringing.

5.2 Safety Requirements

- Sufficient personnel for the installation of post insulators.
- Barricade the work site if required.
- Correct and complete PPE to be used.
- Crane inspection sheet should be used at all time.
- All lifting equipment certificate is still valid.
- Ensure all lifting machine operators certificate are valid.
- Supervision as per ORHVS when working in close proximity.
- Ensure that only material slings are used when lifting equipment that has porcelain or any other type of insulating material that can be damaged by the steel chains.
- No person is allowed below the equipment being installed.
- Person responsible for aligning a post and securing and disconnecting load must stay clear of load when suspended.

5.3 Erecting – Equipment

a) The Contractor shall acquire the following from the construction drawings:

- Position of equipment.
- Alignment of equipment.

b) The Contractor shall acquire the following from the erection manuals:

- Weight of equipment.
- Slinging positions.
- Erecting sequence and method.

c) Hoist equipment and move to erecting position.

d) When using a crane to lift equipment onto structures:

- Position crane in a stable position where equipment can be easily lifted into position.
- Position stabiliser arms and rams to stabilise crane.
- Raise equipment to erecting position.

e) Fasten holding down bolts into position using torque wrench to tighten bolts to prescribed torque.

f) Remove slings and inspect for damage.

g) Complete erecting and assembly as prescribed by equipment supplier.

h) Perform any tests that are required by the equipment supplier upon completion of erection.

i) Ensure that all items in inspection and test plans have been fulfilled and signed off.

6. Installation of Tubular Aluminium Conductor Method Statement

6.1 Risks

The following is some of the risks identified for the specified activities.

6.1.1 Environmental:

- Weather conditions.
- Noise from equipment.
- Moving vehicles.
- Working in close proximity of live equipment

6.1.2 Human Error:

- Inappropriate designs
- Miscommunication between winch/tensioner/crane operators/site supervisors.
- Falling objects like tools, bolts and nuts etc.
- Working at heights on structures.
- Poor rigging practice – incorrect use of shackles, attachment below centre of gravity, overloading of crane etc.
- Employees not using PPE / climbing equipment correctly.
- Work in elevated positions
- Integrity of structures
- Work position of workers and specific tasks
- Overall supervision

6.1.3 Equipment:

- Failures of equipment due to poor maintenance/inappropriate use/untested.
- Lifting of equipment and materials with slings / cranes – slings can break / crane faulty etc.
- Sudden release of tension in slings/conductor.
- Winching of the conductor/moving wires.

- Overloading of the structure in a temporary state of weakness because of loose bolts etc. during erecting / loading during stringing.

6.2 Safety Requirements

- Sufficient personal for sizing and preparation.
- Proper inspection of Tubular bars prior to installation according to key plan.
- Ensure that only material slings are used when lifting equipment that has porcelain or any other type of insulating material that can be damaged by the steel chains.
- No person is allowed below the equipment being installed.
- Correct and complete PPE to be used.

6.3 Installation of Post Insulators

- Verify that steel structures are plumb.
- Lift post insulator with crane.
- Erector in cherry picker/mobile access platform guides insulator into correct position on the steel structure and inserts the 4 x M16 galvanises bolts from below, places washers and spring washers then fastens nuts.
- Check post insulator is plumb.
- Nuts torqued to the correct torque.
- Nuts marked once torqued.

6.4 Installation of Tubular Clamps

- Clamps inspected and placed at Post insulator structures.
- Erector in cherry picker/mobile access platform with respective clamp moves to position near top of post insulator, places clamp on top flange of post insulator and fixes clamp to post insulator using 4 x M16 bolts from below, places washers and spring washers then fastens nuts.
- Mounting bolts torqued to the correct torque.
- Bolts marked once torqued.
- The top half of the clamp is removed and placed on foundation of structure for installation once tubular conductors have been prepared for installation.

6.5 Installation of Damping Conductors

- The Contractor shall acquire the following from the construction drawings:
    - Dimensions of Tubular conductors and damping conductor
- The damping conductor is placed onto conductor drum stands by means of a crane.
- The conductor drum is lifted by means of a shaft inserted into the centre of the drum.
- Slings are then attached to the two ends of the shaft.
- The drum is then lifted onto the cable stands to the correct height so the drum can turn.
- Crimp sleeve onto one side of the conductor.
- Insert damping conductor into the tube with the sleeve part first.
- Connect the damping conductor to the end cap.

- Insert the end cap into the tubular conductor.
- Setup the TIG welder as per the instruction manual of the TIG welder.
- Clean the end cap in three places about 20mm if end cap is colour coded.
- Secure the end cap with the three bolts and lock into position.
- Tack weld the end cap in three places for about 10mm at each.

6.6 Installation of Tubular Conductors

- The crane truck is used to move and lift the tubular conductor into position.
- Two sky jacks with two operators each are used to reach the clamps on both sides of the tubes.
- Two loose stands are used to rest the tubular conductor on the ground.
- The tube is lifted onto the stands by the erectors by means of slings underneath the tube and one person on each end of the tube.
- As the tube is now on the stand guide, ropes are tied to the two ends of the tube.
- Two safety ropes is also tied from each end of the tube to the crane hook.
- The middle of the tube is measured and the crane is then positioning the cradle in the middle of the tube to ensure the balance of the tube is correct.
- The tube is then lifted and guided by the guide ropes onto the clamps.
- The correct measurement is then taken and with a permanent marking pen.
- The tube is then lifted out of the clamps and lowered onto the stands again.
- The tube is cut with an angle grinder on the correct marking.
- The end cap is fitted and tacked weld in three places.
- The tube is cleaned at the contact points with emery cloth to ensure good connection.
- Greased is then smeared onto the contact points of the clamp.
- The tube is lifted again and guided by the ropes into the clamps.
- Once the tube is lying correctly in the clamp the two top connection of the clamp is inserted.
- The guide and safety ropes are then loaded and the crane unhooks the cradle from the tube and lowers the cradle to the ground.
- The clamps are then torqued correctly.

7. Installing Power Cables and Accessories Method Statement

Cable system includes the following: the cable, the cable trench, cable joints, cable termination, link disconnecting boxes and cable route markers.

7.1 Risks

The following is some of the risks identified for the specified activities.

7.1.1 Environmental:

- Weather conditions.
- Noise from equipment.
- Moving vehicles.

- Working in close proximity of live equipment.
- Cable trenches.

7.1.2 Human Error:

- Inappropriate designs
- Miscommunication between winch/tensioner/crane operators/site supervisors.
- Falling objects like tools, bolts and nuts etc.
- Working at heights on structures.
- Poor rigging practice – incorrect use of shackles, attachment below centre of gravity, overloading of crane etc.
- Employees not using PPE / climbing equipment correctly.
- Work in elevated positions.
- Integrity of structures.
- Work position of workers and specific tasks.
- Overall supervision.
- Working in cable trenches.
- Use of gas and torch for heat shrinking of cable joints or cable terminations.
- Working in confined spaces in cable trenches.

7.1.3 Equipment:

- Failures of equipment due to poor maintenance/inappropriate use/untested.
- Lifting of equipment and materials with slings / cranes – slings can break / crane faulty etc.
- Sudden release of tension in slings/conductor.
- Winching of the conductor/moving wires.
- Overloading of the structure in a temporary state of weakness because of loose bolts etc. during erecting / loading during stringing.

7.2 Safety Requirements

- Correct and complete PPE to be used.
- Ensure the identification of other services.
- When opening trenches beware of snakes, bees and other types of animals

7.3 Power Cable

7.3.1 Pre - Cabling Procedure

The **Contractor** shall:

- Ensure that the correct drawings are on site.
- Ensure that the correct excavation has been made where applicable.
- Ensure that work is carried out within barricaded areas where applicable.
- Ensure correct cable is on site.

- Determine what tools, equipment and transport will be used.

7.3.2 Terminating of Power Cable Ends

- Ensure there is enough cable slack at the terminating points in accordance with the design (at both ends of the cable).
- Ensure to prevent pollution or dust while terminating of the cable is in progress. This can be done by building a tent around the termination structure where the termination of the cable will be performed.
- Ensure that scaffolding is erected to allow for the termination to be terminated.
- Scaffolding to be checked by a civil engineer.
- Ensure qualified jointer/s is/ are available to perform the task.
- Ensure that the cable is terminated in accordance with D-DT- 0890.
- Ensure the correct tools are used.
- Repeat the steps above for all cable ends.
- Ensure that all items in inspection and test plans have been fulfilled and signed off.

7.3.3 Jointing of the Power Cable

- Ensure there is enough cable slack at the joint bays in accordance with the design.
- Ensure to prevent pollution or dust while jointing of the cable is in progress. This can be done by building a tent around the joint bay where the joint of the cable will be performed.
- Ensure qualified jointer/s is/ are available to perform the task.
- Ensure the correct tools are used.
- Repeat the steps above for all cables.
- Ensure that all items in inspection and test plans have been fulfilled and signed off.

Note: The installation of joints will depend on the design of the cable system.

7.3.4 Cable Route Markers

- Ensure correctly labelled route markers in accordance with D-DT 8012 are used.
- The marker shall be installed at a depth of 250 mm below natural ground level.
- Cable route marker shall be installed directly above the cable as follows:
  - at each bend;
  - at each joint;
  - Along straight sections at intervals of not greater than 150 m.
- Cable route markers to indicate the direction of the cable.
- Ensure that all items in inspection and test plans have been fulfilled and signed off.

7.3.5 Link Dis-connecting Boxes

- Ensure the correct link disconnecting box is used.
- Ensure the correct tools are used to perform the task.
- Ensure the link dis-connecting box is installed in accordance with D-DT 0893.

- Ensure bonding (D-DT 8075) leads are as short as possible (not more than 10 m).
- Ensure the link dis-connecting box is connected to the substation earth mat in accordance with D-DT 0893.
- Ensure that all items in inspection and test plans have been fulfilled and signed off.

7.3.6 Power Cables in Concrete Trenches and in Ground

- Make sure all the workers have the correct PPE for pulling cables e.g. Safety shoes etc before you start pulling anything.
- Walk the cable routes that you are going to use to pull the cables and measure the actual length required for each cable.
- The proposed cable route shall be walked; to determine the precise cable route and the positions of joint bays (If joints will be installed depending on the cable design and length).
- The joint bay positioning shall take into consideration the maximum cable drum length that can be supplied for the cable to be used.
- Open up all trench covers according on the route you are going to pull the cables.
- Make sure to remove the yard stone clear out of the way where trenches will be dug.
- Dig the trenches to the equipment where necessary.
- Make sure the trenches are excavated to the correct depth and correct width.
- Ensure that shoring is installed for excavations that exceed 1.5 m in depth.
- Don’t mix the sand and the yard stone.
- Prepare the trench in accordance with D-DT 0892 (for HV and EHV cable trenches).
- The correct backfilling soil should be use to prepare the bedding layer of the cable trench in accordance D-DT 0892 (for HV and EHV cable trenches).
- Ensure the backfilling soil that will be used for the bedding layer is sifted, and does not have little stones.
- Ensure the thermal resistivity of the bedding soil is not more than 1.2 K.m/W.
- Prepare the bedding layer in accordance with D-DT 0892 (for HV and EHV cables).
- Ensure the bedding layer is compacted.
- Ensure that all items in inspection and test plans have been fulfilled and signed off.

7.3.7 Pulling the Power Cables

- Place the cable winches with dynamometers that will be appropriate for pulling all the cables near the point.
- Place cable rollers not more than 2 m apart.
- Ensure the availability of the following: skid plates, corner rollers and pulling eye with swivel.
- Move all your cable drums close to the trench where the cable will be pulled into.
- Ensure the pulling arrow of the cable drum is facing the correct direction.
- Ensure the correct pulling eye is fixed on the cable to ensure ease of pulling the cable.
- Ensure there are workers placed along the cable route to ensure that the cable is on the cable rollers while the cable is being pulled. This is to prevent scratching of the cable outer-sheath.
- Once all is in place; then the cable can be pulled.

- Loosen the end of the cable from the drum.
- Pull the cable to the end. Mark the cable once at the end of the cable route.
- Ensure compliance to the required bending radius.
- The cable can now be taken off the cable roller. To allow for pulling of the next cable.
- Repeat the steps above until all cables are pulled into the trench in accordance with the design.
- Mark the end of the cable with the correct number two or three times according to the drawing.
- Cover the cable ends with cable end caps.
- Ensure to leave enough cable slack according to the design. This will ensure that jointing and terminating of the cable can be done accordingly.
- The correct tools shall be used to cut the cable.
- Repeat this procedure until all the cables have been pulled according to the design drawing.
- Ensure that all items in inspection and test plans have been fulfilled and signed off.

7.3.8 Backfilling of the Cable Trenches

- The correct backfilling soil should be use to backfilling the cable trench.
- Ensure the backfilling soil and the blanket soil are sifted, and they do not have little stones.
- Ensure the thermal resistivity of the blanket soil is not more than 1.2 K.m/W.
- Backfill with the blanket soil in accordance with the D-DT 0892 (for HV and EHV cables).
- The cable trench shall be compacted in accordance with 240-45683927.
- Ensure hand compaction tools are used.
- Ensure that all items in inspection and test plans have been fulfilled and signed off.

7.3.9 Site Tests

7.3.9.1 Insulation Resistance

- Connect the free megger test probes to the core that is required to be tested.
- Connect one probe to the red core, the other probe to the blue core, white core and sheath. The blue core, white core and sheath are connected together and earth.
- Measure the resistance.
- This must be done for each core.
- Then connect one probe to the red core and the other probe to the blue core.
- This must be done for each core respective core.
- Measure the resistance.

7.3.9.2 Conductor Resistance

The following minimum equipment is needed:

- Micro Ohmmeter

This method to be used is the four-wire or Kelvin method, see figure 1.

- Connect current lead C1 and voltage lead P1 to one end of the conductor.
- Connect current lead C21 and voltage lead P2 to one end of the conductor.
- Measure and record resistance value.

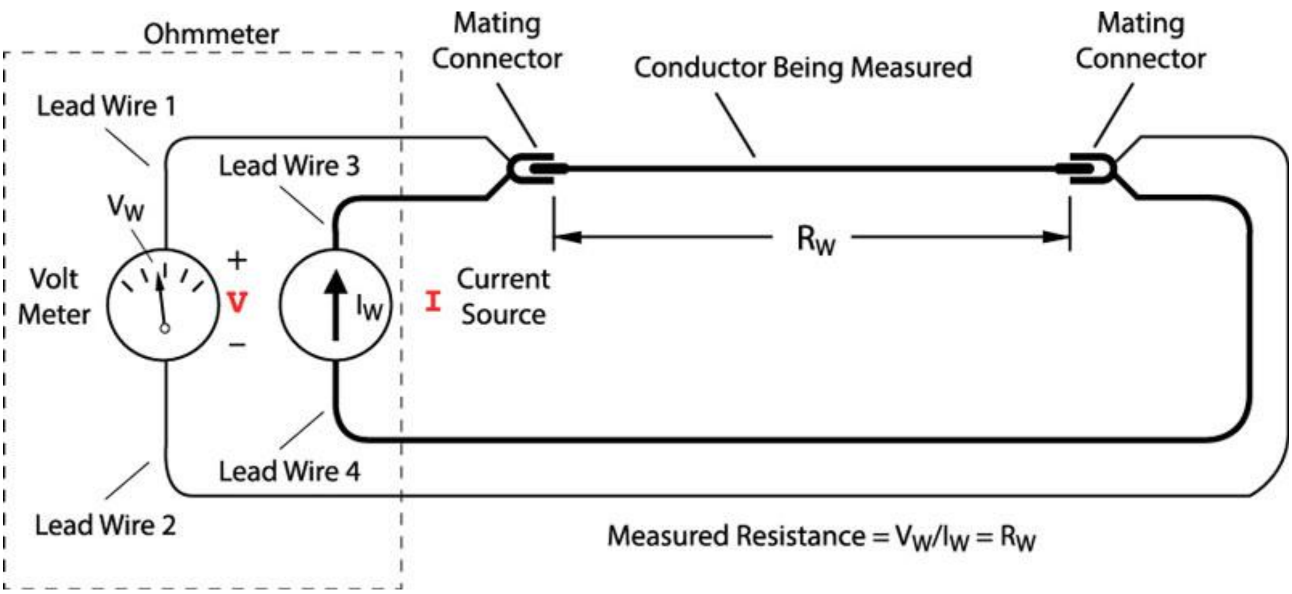

Figure 1: Four-Wire Kelvin Method

8. Earthing Method Statement

This section covers the various methods and practices to be employed in earthing the equipment.

8.1 Risks

The following is some of the risks identified for the specified activities.

8.1.1 Environmental:

- Weather conditions.
- Noise from equipment.
- Moving vehicles.
- Working in close proximity of live equipment.

8.1.2 Human Error:

- Inappropriate designs.
- Miscommunication between winch/tensioner/crane operators/site supervisors.
- Falling objects like tools, bolts and nuts etc.
- Employees not using PPE/climbing equipment correctly.
- Work position of workers and specific tasks.
- Overall supervision.

8.2 Safety Requirements

- Sufficient material to bond and connect earth leads.
- Enough personnel to perform the task safely.
- PPE required.
- Ensure adequate steps undertaken to protect exposed underground services.
- Special care must be taken to safeguard person from electrical contact in existing Sub-station yards.
- Ensure the oxy-acetylene is stored upright.

8.3 Earthing – Equipment

- Draw copper rolls and move to working area.
- Unroll and straighten copper strap.
- Measure and cut lengths required allowing for necessary joint overlaps and bends.
- Cut copper straps with guillotine or shears.
- Deburr cut ends of straps with file if required.
- Measure position of clamping and securing holes and mark strap.
- Drill required holes ensuring that the hole is correct oversize for bolt to be used.
- Fix earth strap in position using lattice bolts on legs of equipment support.
- Join earth strap to equipment and ensure that full contact over the strap and earth connection is made.
- When all earth straps are installed, check against drawings for correctness and quantities.
- Examine all joints for mechanical strength.
- All exposed surfaces mounted earth satraps must be secured to the surface using the specified clamping arrangement at the prescribed interval.
- Ensure that all items in inspection and test plans have been fulfilled and signed off.

8.4 Site Tests

8.4.1 Earthmat Resistance Measurement

This method is applicable for use on Distribution and Transmission size substations with typical maximum earth grid diagonals more than 150m, with current injection distance between the edge of the grid and C2 of three to five times the largest grid diagonal.

The following minimum equipment is needed:

- Variable frequency power source (e.g. Elgar Continuous Wave AC power source):
- Selective frequency voltmeter (e.g. HP Wave Analyzer):
- Ammeter

The process below must be followed when preparing for and taking the actual measurements, with reference to Figures 2 and 3.

- Determine the point at the edge of the earth grid where the equipment will be set up and unpack all needed equipment. This point is labelled “E”.
- Connect current lead C1 and voltage lead P1 to a structure in the substation that is properly bonded to the earth grid to ensure a proper connection to the earth electrode.
- By making use of the measuring wheel determine the positions for “P2” and “C2” based on the predetermined distance over which current will be injected. Hammer the voltage and current probes into the ground at these points.
- The linear distance “EC2” should be between three and five times the largest diagonal of the earth grid.
- The linear distance “EP2” should be 60% of the distance “EC2”.
- Roll the leads out from point “E” to points “P2” and “C2” ensuring a separation distance of at least 500mm between leads.
- Connect the voltage lead to voltage probe “P2” and the current lead to current probe “C2”.
- Connect all leads to the test equipment by making use of the connectors if necessary.
- Take the measurement and note the injection current and measured voltage ensuring that:
- The variable frequency power source is set to 60Hz.
- The selective frequency voltmeter is set to 60Hz.
- The current injected is 1A.
- Calculate the impedance and plot the result on the graph paper
- Repeat steps above for the following frequencies as well:

  · 70Hz; 80Hz; 90Hz; 110Hz; 120Hz; 130Hz; 140Hz; 160Hz; 170Hz and 180Hz.
- Move the voltage probe to 40% of the distance “EC2” and connect the voltage lead to it.
- Repeat above steps for the second test.
- The grid resistance obtained from both tests should correlate well with each other. Take the average of the two RG values as the substation grid resistance.

For further information refer to standard 240-101940513: Substation earth electrode resistance measurement.

Figure 2: Determining current injection distance

Figure 1: Determining current injection distance

Figure 3: Determining current injection distance and area

8.4.2 Continuity measurement

The continuity tests should incorporate the 4 point measuring method to determine the earth grid continuity to equipment earth tails and support steel work with respect to certain reference points selected in the substation

The following minimum equipment is needed:

- It is advisable that a robust unit should be used with an injection current of 100 Amps e.g. A Garret Digital Micro-Ohm Meter
- A standard 2.5 mm^2 flexible copper conductor, flexible PVC insulated cable is to be used
- Ideally clamping devices will be the standard chrome vanadium vice grip clamps
- Electrical Insulation Gloves

The 4 point measuring method as shown in Figure 3 shall be used, consisting out of:

- Two “current connections” for current injection, indicated as C1 and C2,
- Two “potential connections” for voltage measurement, indicated as P1 and P2.
- Important: Current injection connections are to be placed on the outside of the circuit with the voltage measurement connections on the inside of the circuit.
- The process below must be followed when preparing for and taking the actual measurements
- Carefully assess the area where the measurements will be done and do a risk assessment.
- Identify the first reference point, and mark it on the applicable drawing.
- Connect the short leads to the reference point and then the test instrument. :

- Ensure that the test instrument is properly earthed (if required).
- Ensure that the current connection (C1) is connected the outside of the measurement circuit at the equipment/structure in relation to the potential connection (P1), refer to Figure 4.
- Ensure proper connections to the reference point as well as to the test instrument.
- Connect the long leads to the equipment/structure to be measured, as well as the test instrument.
- Ensure that the current connection (C2) is on the outside of the measurement circuit at the equipment/structure in relation to the potential connection (P2), refer to Figure 4.
- Ensure proper connections to the equipment/structure as well as to the test instrument.
- Take the measurement and capture the result. Consider the magnitude of the measured value, if it is more than the required maximum:
- Check all connections to ensure proper contact is made,
- Repeat the test to verify the previous result.
- Move the current (C2) and potential (P2) leads to the next piece of equipment/structure and repeat above steps.
- When the test leads run out of reach, identify the next reference point and repeat above steps until all equipment/structures have been tested.

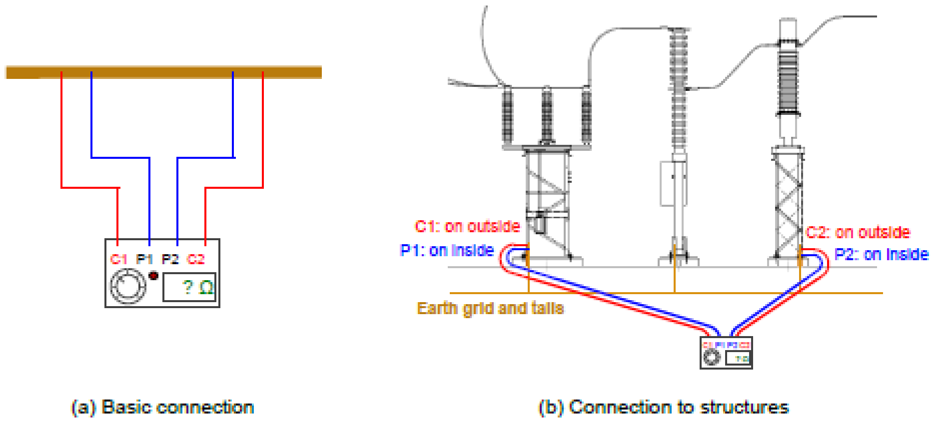

Figure 4: Four point measuring method connection

For further information refer to standard 240-101940513: Substation earth electrode resistance measurement.

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10. Revisions

Date	Rev	Compiler	Remarks
April 2019	1	R Ramnarain	First Issue

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12. Acknowledgements

Not Applicable.