Eskom	Standard	Technology

Title: **OPGW HARDWARE AND INSTALLATION REQUIREMENTS FOR OVERHEAD LINES**

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1. Introduction

This document contains technical information for OPGW hardware and installation aspects.

2. Supporting Clauses

2.1 Scope

This document covers the OPGW hardware requirements for installation. At each end of the OPGW cable, the necessary duct cables to the equipment rooms and patch panels will need to be installed as defined in the secondary plant document (240-106030205).

This document also identifies the essential methods for stringing, tensioning, earthing, joining and terminating metallic armoured, overhead ground wire with optical fibre (OPGW) for the main transmission system.

2.1.1 Purpose

This document specifies the technical requirements for the OPGW assemblies and individual components that will be used for the installation of OPGW on overhead lines.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.2 Normative/Informative References

Parties using this document shall apply the most recent edition of the documents listed below.

2.2.1 Normative

The line specification prepared for the specific line project must take precedence if there is any conflict between it and the following documents:

[1] IEC 60120, Dimensions of ball and socket couplings of string insulator units.

[2] IEC 60372, Locking devices for ball and socket couplings of string insulator units.

[3] IEC 60383, Insulators for overhead lines with nominal voltage above 1000V.

[4] IEC 60471, Dimensions of clevis and tongue couplings of string insulator units.

[5] IEC 60815, Guide for the selection of insulators in polluted conditions

[6] IEC 60826, Loading and strength of overhead transmission lines.

[7] IEC 61089, Round wire concentric lay overhead electrical stranded conductors

[8] IEC 61109, Composite insulators for AC overhead with nominal voltage greater than 1000V

[9] IEC 61284, Overhead lines – Requirements and tests for fittings.

[10] SANS 1556-1, ISO Metric screw threads part 1

[11] SANS 1700, ISO Metric screw threads part 2

[12] SANS 121, Hot-dip galvanized coatings on fabricated iron and steel articles specification.

[13] SANS 935, Hot-dip zinc coatings on steel wire specification.

[14] ISO 9001 ; 2000, Quality management systems – Requirements

[15] NRS 061-1:2012, Specification for Overhead Ground Wire with Optical Fibre – Part 1: Product Specification

[16] NRS 061-2:2015, Specification for Overhead Ground Wire with Optical Fibre – Part 2: Installation Guidelines

[17] NWS 1612 Rev 0, Specification for composite insulators.

[18] SANS 10280, Code of practice for overhead power lines for conditions prevailing in South Africa.

[19] 240-70732888, Fibre Optic Cable System Acceptance Testing Procedure

[20] 32-245, Waste Management Procedure

[21] TPC41-701, Approval and registration of drawings submitted by Contractors

[22] NRS 088, Duct and Direct Buried underground Fibre Optic Cable

[23] 240-70733995, Optical Distribution Frames

[24] TSP41-591, Transmission line towers and line construction.

[25] 240-60777474, Specification for suspension and strain assemblies and for hardware for transmission lines.

[26] TST41-168, Quality requirements for the procurement of assets, goods and services.

[27] 240-130615862, Earthing of Transmission Line Towers

[28] 240-75880946, Earthing Standard (Sub-Transmission)

The drawings provided in Appendix A are for reference only and are simply indicative of the Employer's requirement.

Note: The editions of the normative references that are current at the date of issue of the enquiry shall apply.

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

None

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
ADLash®	All-Dielectric Lashed
ADSS	All-Dielectric Self Supporting
HDPE	High-density polyethylene
ODF	Optical distribution frame (patch panel)
OPGW	Optical ground wire
OTDR	Optical Time-Domain Reflectometer
UTS	Ultimate tensile strength

2.5 Roles and Responsibilities

It is the responsibility of the Technology Division to maintain and update this document when applicable. The Fibre Optics SCOT members who reside within transmission and distribution are responsible for implementation within their respective divisions.

2.6 Process for monitoring

Not applicable.

2.7 Related/Supporting Documents

Not applicable.

3. OPGW and Hardware Requirements for Installation and stringing

3.1 General Requirements

This document outlines the technical requirements for the OPGW assemblies and related components to enable a complete system to be installed on an overhead line. Measures to protect the optical fibres against environmentally degrading factors such as Aeolian vibration, moisture and large temperature variations as well as electrically induced effects are also recommended.

3.2 OPGW Requirements

The OPGW cable offered must comply with all specifications in NRS 061-1, unless improved upon in this document. The OPGW must be tested before and after stringing according to the test specifications in NRS061-1 as well as those stated in this document.

Note that the optical requirements of the OPGW and Duct cables are the same.

3.3 OPGW Hardware Requirements

3.3.1 General

All hardware shall be accepted by the OPGW supplier and Eskom. Hardware assemblies, including down-lead clamps, for the OPGW shall be compatible with the cable to ensure that the system so formed will survive the operating environment for the design life. All items of hardware shall conform to specified requirements. The hardware component supplier shall be fully responsible for his designs and their satisfactory performance in service. Acceptance by Eskom does not relieve the supplier of responsibility for the adequacy of the design, dimensions and details.

Suspension and strain assemblies shall be designed so that line contact between coupled components occurs. Point contact between components shall be avoided. Recommendations as per the Eskom hardware specification 240-60777474, shall apply for the design, manufacture and testing of OPGW assemblies and components.

3.3.2 Specifications

All work must be carried out in accordance with the Standards, Specifications and Drawings listed in this document.

3.3.3 Technical Details

The contractor is encouraged to optimise (in terms of improved solutions and quantities) all insulation and hardware assemblies, but must nevertheless maintain overall connecting lengths of hardware assemblies, mechanical strengths, and electrical parameters. When selecting hardware for OPGW, great care must be taken not to apply excessive stresses on the conductor under any circumstances.

The assemblies offered must be such that they can be coupled directly to the standard tower shackle provided with the tower.

Drawings of assemblies offered shall be supplied indicating for each component: the material type, the material grade (and heat treatment where applicable), the strength rating, tolerances (where applicable) and dimensions.

Additional items may be required in the assemblies to suit the Contractor's designs. All conceptual drawings provided give critical dimensions only, and must not be considered as the final solution.

Dimensions of all items of hardware shall be subject to the tolerances specified in the referenced standards. Where no standard or tolerance is referenced, the fit tolerance shall be ±2 % of the dimension. All tolerances shall be subject to Eskom's acceptance. Items of hardware found to be out of tolerance will be rejected.

Test certificates for all vibration damping devices to be used must be submitted to the Employer by the Contractor before delivery commences, indicating the damper performance test(s) that have been conducted on the damping devices.

The strength requirement as indicated by the drawings refers to hardware material strength. In the case of suspension and earth wire strain assemblies, it does not refer to the slipping strength between the conductors and clamp for example.

With reference to specification NRS061-2, "Specification for Overhead Ground Wire with Optical Fibre – Part 2: Installation Guidelines", particular attention must be paid to the hardware arrangements at splicing towers. Furthermore, all the requirements in terms of grounding connectors, down-lead clamps, support insulators, earth tails with crimped on lugs, bending radius, grounding cable connection to towers, cleaning of OPGW and towers, must be observed and adhered to.

3.3.4 Suspension Assemblies

(See Drawings LES – GEN – OPGW5 and LES – GEN – OPGW6).

Conceptual assemblies are shown on the drawing for both standard and insulated OPGW suspension assemblies.

a) Only AGS (Armour Grip Suspension) type assemblies with a neoprene insert, or similar approved, will be accepted (see drawings LES – GEN – OPGW5 and LES – GEN – OPGW6 in Annex A).

b) Suspension assemblies shall withstand the fault current design parameters.

c) Non-insulated suspension assemblies shall be fitted with a ground cable (earthbond) to ensure proper grounding between the OPGW and the tower steelwork. The ground cable shall be fitted to the OPGW according to one of the three options stipulated in the applicable drawing for this assembly. Preference will be given to a connection to the OPGW cable that does not damage the outer layer of the OPGW. All grounding connections must be rated equal to or higher than the fault current rating of the OPGW.

3.3.5 Tension Assemblies

a) Tension assemblies shall be the preformed dead-end type (see drawings LES – GEN – OPGW – 1, GEN – LES – OPGW – 4, GEN – LES – OPGW – 2 and GEN – LES – OPGW - 3 in Annex A).

b) Tension assemblies shall withstand the fault current design parameters.

c) Where the OPGW must be joined at a splicing tower, a ground cable shall be installed between the two spans to ensure electrical continuity between the two. This shall be assured by using a preformed type wrap earth tail or cable having a rating equal to or higher than the OPGW cable.

In the case of an insulated strain assembly (see drawing LES – GEN – OPGW - 1 in Annex A) the ground cable should be insulated from the tower. Depending on the geometry of the tower, using a support or stand-off insulator will prevent contact between OPGW and tower steelwork under all environmental operating conditions.

The creepage distance of the insulation material shall be equal to or more than 50 mm.

At the terminal tower, the OPGW shall be earthed or not, in accordance with TST41-321.

For OPGW Non-Insulated Strain Assembly at Joint Tower (See drawing GEN – LES – OPGW – 4), a continuous earth connection with adequate rating between the spans and to the tower steelwork must be established. Non-insulated OPGW down-lead clamps must be used to support the OPGW to the splicing box. These down-lead clamps must be spaced no more than 2 metres apart and be installed at every tower member intersection and crossing with the OPGW conductor. During the planning stage of any project, installer to confirm location and quantity of downlead clamps required.

3.3.6 Down-Lead Clamps

The design of these clamps shall be such that no excessive stresses that will affect the performance of the OPGW under any circumstances, will be induced. Two options exist, namely insulated down-lead clamps and non-insulated down-lead clamps. The type to use will depend on whether the hardware assemblies, connecting the OPGW to the tower, are insulated or non-insulated.

Design of downlead clamps must be such that they are interchangeable to be used on any tower steel member orientation / size. Preference will be given to non-bolted type connection to the OPGW cable. The downlead clamps shall not have any joints and no damage to galvanising will be accepted.

3.3.6.1 Non-Insulated Down-Lead Clamps

This type of down-lead clamp shall ensure proper electrical connection between the OPGW conductor and the tower steelwork. When attaching the clamp to the tower steelwork care shall be taken, to ensure an electrical connection is established and that mechanical damage, which in turn could lead to corrosion damage, will not be imposed on the tower steelwork. Materials used for the down-lead clamp shall be such that galvanic corrosion will not be induced between the down-lead clamp and the tower steelwork.

An adequate number of down-lead clamps shall be used to ensure sufficient support of the OPGW along the tower. This support shall be in such a manner that the OPGW will not clash with any part of the tower steelwork as a result of wind or due to its own mass if strung or laid in a horizontal configuration.

3.3.6.2 Insulated Down-Lead Clamps

The requirements for the insulated down lead clamps are exactly the same as those for the non-insulated down-lead clamps in 3.1.3.3.4 above, except that no electrical contact between the OPGW and tower steelwork shall occur. In all cases a minimum distance of 50 mm shall exist anywhere between the OPGW and tower steelwork. The creepage distance of the insulation material shall be equal to or more than 50 mm.

3.3.7 Typical Installation at a Non-Insulated Splicing Tower

Detailed arrangements depending on the type of tower must be supplied on how the splicing boxes must be installed above the anti-climbing devices or at a distance above ground not accessible by unauthorised persons. This distance above ground must be accepted by Eskom before implementation.

The minimum bending radius as recommended by the cable manufacturer must be adhered to at all times.

To allow sufficient slack for the joint to be brought to ground level for splicing, the OPGW downlead length at a joint tower must be equal to a minimum of the tower height (connection of OPGW assemblies to earthpeak to ground) plus 5m.

Should a duct cable be present at such a joint tower, then a minimum length above the anti-climb device should be allowed for, in order for future maintenance and jointing to be done at that tower on ground level.

All slack to be taken up in a proper manner. Use of brackets to contain excessive OPGW material will not be allowed for Transmission projects.

Note that the tower clamps (down-lead & joint box) must be fitted with pinch bolts with "swivel seats" to avoid damaging the galvanising of the tower.

Details of installation procedures of hardware assemblies and down-lead clamps shall be supplied both with a tender offer and with each batch delivered where requested. The basic requirements for hardware at splicing towers and standard towers as well as assemblies for insulated and non-insulated requirements are depicted as LES-GEN-OPGW1-6 in annex A. If splicing is required at strain towers and/or suspension towers, the tension assemblies as shown in LES-GEN-OPGW1 & 4 shall be used, depending whether insulated assemblies are required or not. Relevant project Bill of Quantities (BOQ) from Eskom will depict insulated and non-insulated towers. Installer to confirm any changes to this BOQ as required.

3.3.8 Termination of OPGW at Substation Gantries

The termination of OPGW into substations shall be by means of a standard, non-insulated strain assembly.

The OPGW shall be attached to the gantry (on the outside of the structure and not threaded through), using a dedicated earth tail to ensure a proper electrical connection, which is wrapped to the OPGW and fitted with a crimped lug that enables it to be bolted to the steelwork to guarantee a proper current path. Dedicated earthing is required on all non-insulated assemblies. To ensure a proper electrical connection between the earth tail and OPGW, the OPGW shall be clean and free of dirt, grass or any other contaminant. The OPGW shall be brushed with the appropriate conductor cleaning brush at the point where the earth tail is attached to the OPGW.

Metallic, non-insulated clamps shall be used to attach the down-leads to steelwork.

The OPGW shall be clamped at every intersection with steelwork using approved hardware.

A general layout can be seen in figure 8 in annex A.

3.3.9 Vibration Dampers for OPGW Conductor

The offer must include a schedule of required spacing for all span lengths on the line. This includes short span lengths below 100 m and exceptionally long spans which exceed 1000 m. The hardware manufacturer should be consulted where necessary.

The OPGW cable will typically be strung to the specified C-value, or to a value matching the sag of existing earth wires when applicable.

Where:

C = H/W (see OPGW Schedule A/B)

H = final horizontal tension (N)

W = vertical weight of conductor (N/m)

The requirements for damping Aeolian vibration for the OPGW conductor strung at the specified C-value or any other C-value as agreed to with the manufacturer, are that the maximum allowable stress in the OPGW outer layers must not exceed the safe bending limit set by the manufacturer. For the calculation of placement of Stockbridge type Aeolian vibration dampers a wind speed of 7m/s perpendicular to the OPGW cable can be used. **Only multi-frequency type Stockbridge dampers must be used.***

Contractors must supply the results of a detailed vibration analysis on the positioning of Stockbridge-type dampers, based on the everyday tension provided and the characteristics of the cable offered, for the project manager's acceptance prior to commencement of stringing.

Vibration damper clamping mechanisms used to clamp the damper to the OPGW cable must be of non-bolted type and have material characteristics that will not cause galvanic corrosion. In most cases for preformed type attachments, the clamp of the damper is lined with a material that prevents direct contact between the clamp and cable.

*For conductor sizes less than 15 mm, the option of using spiral vibration dampers (SVD's) can be considered, but must be accepted by the Eskom design engineer on a per project basis. This decision will be based on previous experience with this product and the line parameters (OPGW specification, tension, span lengths and terrain).

3.3.10 Materials

OPGW:

The material and construction of the OPGW will be specified as per the offer.

FITTINGS (tension and suspension assemblies):

Only preformed type suspension and strain assemblies must be used. The choice of material for tension and suspension assemblies, as well as the earth bond mechanism, must be specified by the OPGW manufacturer to match the material of the OPGW and will take precedence over this specification. In order not to initiate galvanic type couplings using dissimilar materials and thereby enhancing corrosion of the materials, the following must be observed. If the OPGW outer layer is of steel, the fitting material will be of steel material. When the OPGW outer layer is of aluminium or aluminium clad steel material, the fitting material will be of either an aluminium alloy or aluminium clad steel material. In all cases the correct lay direction of the fittings in relation to the OPGW must be observed. Normally the lay direction of the fitting wire is opposite to the outer OPGW layer direction.

3.3.11 Grounding Cable or Earth Bonds

See drawing LES-GEN-OPGW-7

- The OPGW must be correctly bonded to earth at the terminal station gantries and at all non-insulated towers. Type Test Certificates for proposed earth bonds must be available on request.
- The type of material and size will be adequate to safely handle the required short circuit rating and requirements of the OPGW as specified. The choice of material must also consider compatibility with the OPGW so as not to initiate galvanic corrosion.
- All earth bonds must be of the flexible type and be corrosion resistant. Earth bonds must be of sufficient length to connect the OPGW to the tower steel work. It is expected that earth bonds will be 1 m to 1.8 m long.

Note: Contractors must physically measure the length required from the connection point on the suspension clamp/ armour rod to the connection point on the tower. This must be done in such a way that an allowance is left so that when the earthwire swings out for an angle of about 45 degrees, there is enough slack to cater for the swing.

- The length must be agreed with the Project Manager.
- One end of the earth bond must be fitted with a crimped lug enabling connection to the tower steel work by means of an M16 bolt or M12 bolt. The contractor must confirm the required bolt size prior to the commencement of any work. Before connecting the crimped lug or fitting to the tower members, the tower steelwork must be cleaned to remove paint, grease or any other impurities to ensure proper electrical connection. After connection the exposed area(s) must be re-painted or cold galvanized to prevent corrosion of the tower steel members. The other end of the earth bond must be fitted with a suitable clamp arrangement for connection to the OPGW.
- The preformed type “pig tail” earth bond is not acceptable. However connection of the earth bond to the OPGW or OPGW armour rods by means of preformed helical attachment or a parallel groove type (PG clamp) connection, will be acceptable on condition that results of electrical testing be submitted. The electrical testing must be performed not on the earth bond in isolation but on the complete connected assembly including the OPGW simulating a typical fault current in field conditions. The type of material and size must be adequate to safely handle the required short circuit rating requirements of the OPGW as specified. The choice of material must also consider compatibility with the OPGW not to initiate galvanic corrosion. When using parallel groove type clamps, the design must be such that no excessive stresses, that will affect the performance of the OPGW under any circumstances, will be induced.
- The companion earthwire must be continuous from gantry to gantry. In cases where lines have structures with both single and dual earthpeaks, the companion earthwire should be continuous along the sections of line which have dual earthpeaks. It may be necessary to install additional jumper straps on this earthwire. The Contractor must allow for this eventuality, and perform the necessary work.

3.3.12 Joint Boxes

All the joint boxes for the OPGW must be in accordance with 240-72274816 (Fibre Optic Cable Joint Enclosure for Aerial Cables) and shall be subject to Eskom's acceptance.

Joint boxes must have 4 re-sealable ports, which remain sealed until required. The joint boxes must be capable of multiple re-entries without damaging the sealing mechanism.

All joint boxes must be mounted as high in the tower as practical, to avoid theft. It must be ensured that the joint box is mounted above the anti-climb device while still maintaining the safe working clearance to the phase conductors above.

All construction details and ingress protection (IP) ratings of the proposed units shall be provided. The splicing enclosures shall be supplied with tower earth bonding fixtures: they shall facilitate fibre organization and splicing requirements and shall be vandal resistant if specified.

As far as possible, the use of insulated splice box installations shall be avoided during project planning. However, if this is unavoidable the splicing box shall be insulated from the tower steelwork ensuring a gap distance of 50 mm or more from the tower steelwork. The creepage distance of the insulation material shall be equal to or more than 50 mm.

All accepted joint boxes must be installed in accordance to the manufacturer's requirements.

3.4 Stringing Requirements

The stringing of overhead ground wire with optical fibre (OPGW) is analogous to the stringing of the standard ground wire but the presence of the optical fibre core implies the adherence to special protection measures to prevent damage to the fibres due to mechanical elongation, bending, twisting and crushing forces.

3.4.1 Preparatory Work for Stringing

To ensure the integrity of the fibre optic core during stringing, additional preparatory work is necessary:

a) OPGW drums shall be carefully selected for the length of the sections to be strung to minimise the number of insulated joint positions. Allowance shall be made for sag and winch tensioner take-up.

b) Drums are often manufactured to pre-calculated lengths to fit specific sections of line and are not interchangeable. The contractor should verify that the correct drum length is being used for a line section before commencing with stringing.

c) The drums shall be transported to the designated material holding area in a vertical position with the cable ends fixed and sealed so that no moisture can affect the cable. Drums shall remain in the vertical position during unloading so that the drum is not damaged. Under no circumstances shall the drums be placed on their sides. The drums shall be stored far from any activity that could damage the cable and so that handling and loading are facilitated. To minimize the risk of fire, the storage area shall be free of grass and other vegetation.

d) After selection of suitable locations for the tensioner and puller, OPGW drums, fittings and accessories shall be transported to site and kept in a proper place until their final use.

e) The contractor is to make sure that before stringing commences, all drums are checked for any protruding nails, damaged flanges, staples etc that can damage the OPGW when it is rolled out from the drums.

3.4.2 Special Tooling and Precautions Needed For OPGW Stringing

Figure 1 in annex A shows the recommended equipment necessary for OPGW stringing:

a) Hydraulic pullers equipped with dynamometers. The puller shall have a pulling capacity equivalent to twice the stringing tension. The puller shall be properly anchored to resist any lifting forces during stringing;

b) A tensioner equipped with dynamometers having a bull wheel 1.2 m or more in diameter. The tensioner shall be anchored to prevent any uplift force;

c) Drum jacks of suitable capacity shall be used on both sides of the drum so that the drum can rotate freely without touching the ground. Drum jacks shall have braking arrangements to ensure that rotation stops smoothly.

d) Anti-twisting counterweights consisting of a series of weights linked by hinges. The weights for the anti-twisting devices shall be used as follows:

1) 12 kg for span lengths up to 300 m;

2) 15 kg for span lengths from 300 to 700 m; and

3) 20 kg for span lengths of more than 700 m.

e) Swivels

f) Neoprene or similar material lined pulley guides (sheaves) 600 mm or more in diameter. A single wheeled pulley block shall be used if the line angle and the OPGW angle are less than 60°. If the angle is greater than 60° a twin wheeled pulley (wheels placed in tandem) block will be necessary (see figure 2 in annex A).

g) Preformed pulling grips. Sock-meshed grips shall not be used on aluminium alloy cladded steel armouring.

h) Pre-stretched polyester and steel ropes.

i) Guy grips for hauling cable at strain points. Come-along clamps shall not be used.

j) Contractor to adhere to earthing practices as explained in The Standard for The Construction of Overhead Powerlines (TRMSCAAC5.2 – 240-47172520) Annex D.

k) When strung OPGW is left overnight in running blocks, the section must be secured by using proper clamps (come-along or preformed strain dead-ends) to prevent the OPGW from falling to ground which may then result in damage to the cable or property. It is preferred that at the joint towers (end of sections), proper dead-end assemblies are used. Where the line crosses over other obstacles like roads and other power lines, the towers on either side of the obstacle must also be secured.

l) There should also be proper earths installed along the strung section so that any circulating currents that do exist on the strung conductor are dissipated.

4. Installation of Duct Cable

4.1 Installation Arrangements

a) The underground fibre installation is to be executed utilising G.652D metal-free duct fibre optic cable. The number of cores shall match the line cables being interconnected.

b) The contractor is responsible for supplying a single length of duct fibre optic cable. The contractor is responsible for measuring and confirming the cable length required prior to implementation of the works.

c) The fibre optic cable shall comply with the Eskom specification for Fibre Optic Duct cable NRS 088-1 but shall be unarmoured.

d) Installations on non-insulated towers must be done in accordance with Figure 3 in Annex A.

e) Installations on insulated towers must be done in accordance with Figure 4 in Annex A. Note the creepage extension sheds to maintain insulations levels. Three cold shrinkable rain sheds (for creepage increase) must be installed on the duct cable, just prior to entry into the splicing box. Any duct cable slack loop must remain at ground potential. See also Photo 1 below.

Figure 1: Creepage extension sheds

4.2 Installation Requirements

a) The duct fibre optic cable must be installed in directly buried 40mmϕ/33mmϕ Outside/Inside diameter ducting, a Class 6 HDPE equivalent. The ducting must be buried at a minimum depth of 1500mm on farmland and 500 – 1000mm elsewhere. The depth of the installation is to be approved by the Eskom Telecommunications representative or design engineer for each project. A single length of ducting shall be utilised; no joints will be tolerated and shall go up the tower to above the anti-climb device.

b) Where the duct fibre optic cable is buried in a trench, cable warning tape must be buried 500mm directly above the duct cable to act as a warning of the presence of a buried cable should the ground be dug up some time after installation. The plastic warning tape should be non-adhesive, a minimum of 150mm wide, and be brightly coloured for ease of recognition.

c) When the trenching is complete, the environment must be restored to its original condition with the necessary precautions taken to prevent future soil erosion. The Grid Environmental Advisor (GEA) is to monitor the rehabilitation area.

d) Note: All of-cuts to be disposed in an environmentally sound manner in accordance with EPC 32-245

e) Where the ducting is brought to the surface at the tower leg, a minimum bend radius of 400mm must be maintained.

f) At the surface the ducting must be brought into a 50mmϕ x 2mm galvanised steel pipe (minimum inside diameter 40mm to accommodate the duct). This arrangement must be encased in a 1000mm x 1000mm x 100mm concrete slab to prevent vegetation growth. The steel/HDPE pipe shall penetrate through the slab into the ground.

g) The steel/HDPE pipe shall extend from the concrete casing to just above the anti-climbing guard on the tower leg. The steel/HDPE pipe must be attached to the tower leg with a minimum of 4 stainless steel straps.

h) The duct must extend through the steel pipe by a minimum of 50mm to protect the fibre optic cable running through it. This arrangement must be sealed at the top with UV resistant silicon sealer or heat shrink tubing.

i) The overhead fibre optic cable on the tower must be brought down the tower leg to be terminated correctly in a joint box in accordance with the appropriate specifications. The appropriate standard downlead arrangement for the particular installation, being AD-Lash®, OPGW or ADSS fibre cable, must be applied.

j) The joint box must be mounted above the anti-climbing guard of the tower leg at each end of the connection. Where a joint box does not already exist the contractor shall supply one unless Eskom states otherwise. The joint box supplied must comply with the relevant installation specification and must match the existing installation unless prior agreement is obtained in writing from Eskom.

k) The minimum bend radius of the cable as specified by the manufacturer is to be maintained at all times.

l) On completion of the work, the total installation / fibre splices must be tested in accordance with the Eskom Fibre Acceptance Test Procedure 240-70732888.

m) There may be some minor variations required to the basic design described above depending on tower type. In the event that a slightly different approach is required, any variation proposed must be discussed with, and approved by, the design engineer before any work commences.

5. Tests

5.1 Optic Fibre Site Tests Before Installation

a) The integrity and attenuation of individual fibres shall be tested before stringing, in accordance with the Fibre Optic Cable System Acceptance testing procedure 240-70732888.

b) The test shall be performed for each fibre in the OPGW with an OTDR at wavelength 1550 nm from one direction only;

c) The cores shall be tested sequentially as per standard colour coding.

d) The results of the tests shall be OTDR outputs format and in accordance with the examples in annex B. The table heading shall contain the drum number and the length of the OPGW;

e) The table shall record the attenuation for each fibre. Results shall be produced in a digital format;

f) If the drum test was successful, the drum shall be handed over to the main contractor. In the case of failure the drum shall be returned to the supplier, and all costs associated with the replacement of the defective material shall be for the suppliers account.

g) Unless otherwise specified in the project requirements, the main contractor shall be held responsible for the proper protection and safekeeping of the OPGW drums until the completed transmission line is taken over by Eskom, and any surplus material has been returned to Eskom. The contractor shall be held responsible for any loss or damage to material required for or surplus to, the contract works. All material received shall be neatly stored in proper defined storage areas to facilitate checking of quantities and quality. Receipt slips shall be forwarded to Eskom within two days of delivery, and a record shall be kept on site of the total quantities of material received and used.

5.2 Tensile Type Test

A tensile type test must be performed on the OPGW, together with the line hardware to be used on the actual system, to prove that the combination will achieve a tensile performance of a minimum of 95% of the stated UTS of the OPGW cable. (Note: UTS= ultimate tensile strength). A type test report, witnessed by the Employer or its appointed representatives, must be submitted after tender award and prior to installation.

Note: The Contractor should ensure that when the relevant strain hardware and OPGW cable are tested and eventually installed, the relative movement between inner and outer layers (in the case of a multi-layer construction) should be the minimum possible. This may either be achieved by selecting the appropriate cable construction for the intended hardware to be used or selecting appropriate hardware for the suggested cable construction.

The OPGW cable plus hardware may be considered to be a system. The Contractor must therefore supply the hardware correctly matched to the OPGW cable to minimise installation and operational problems during the life of the cable, under all conditions.

5.3 Joint Testing and Testing after Completion

The system must be tested in accordance with the latest revision of Eskom Fibre Acceptance Test Procedure 240-70732888.

6. Stringing of OPGW

6.1 Stringing Operation

To protect the integrity of the optical fibres and the armature during stringing, the following restraints shall be carried out:

a) The minimum diameters of the tensioner reels (on which the OPGW will be coiled during installation) shall be at least 80 times the diameter of the OPGW being installed;

b) The distance from the winch to the first pulley on the tower shall be at least four times the height of the pulley attachment point;

c) The diameter of the pulleys shall never be less than 600 mm. However at the first and last tower in the section and at towers with an angle of deviation between 15° and 60°, the pulley diameter shall be at least 800 mm. If the angle is greater than 60° a twin pulley block (wheels placed in tandem) shall be used (see figure 2 in annex A);

d) The stringing shall be carried out using winches with settable pulling force limitations and automatic shut-down facility. The pulling force shall be monitored: the maximum pulling tension shall not exceed 50 % of the installed OPGW tension in the section. The winch shall be checked for correctness of pulling force before the start of stringing;

e) The stringing speed shall not exceed 30 m/min but depending on the stringing conditions this could change. The winch shall be started slowly at the minimum speed and the speed increased gradually to the maximum speed. When the anti-twisting device is approaching the pulley, the stringing speed shall be decreased to 5 m/min.

f) For new lines, the OPGW stringing operation will be governed by other construction activities such as erection of the towers and stringing of phase conductors. For existing lines, where the earth conductor is substituted by the OPGW, the earth conductor can be used as a pilot cable wire if it is in good condition and if the specific pulling force does not exceed the weight of the conductor. In both cases the stringing shall be carried out using the standard method. For lines without earth wire, the pulling rope shall be installed first and then the OPGW installed using the standard method shown in figure 1 in annex A.

6.2 Special Conditions during Stringing

a) Counterweights shall be used to protect the optical fibres against excessive twisting action during the stringing operations. A counterweight shall be installed at the front end of the OPGW. If more than one counterweight must be used then the counterweights shall be located as shown in Figure 1 in annex A. Counterweights and pulleys shall be compatible. The counter-weights shall pass through the pulley at reduced speed.

b) Care shall be taken to ensure that the cable is not damaged by dragging it along the ground or over any objects.

c) In order to prevent the OPGW from being damaged, the maximum period allowed between stringing, regulating and clamping shall not exceed 72 hours. The installer shall be responsible for any damage caused to the cable if this time frame is not maintained, unless external factors beyond the control of the installer are completely responsible for the time frame not being obeyed.

d) OPGW shall be strung and tensioned with minimum mechanical impact. The minimum bend radius shall never be less than that specified by the OPGW supplier.

e) A protective sleeve shall be inserted around the conductor for a length of 5 m, where the anti-twisting devices are positioned on the conductor. Subsequently, the conductor portion where the anti-twisting device was attached shall be removed.

f) Post-installation tests shall be performed after the installation of each length of cable to ensure that the integrity of the fibres meets the standard.

6.3 Regulating, Clamping-in, Joining and Splicing the OPGW

On completion of the stringing of the OPGW, it must be regulated and clamped as per section 8.2.7 in TRMSCAAC 5.2 (240-47172520)

Upon completion of section stringing, when optical fibre cables are hand fed through the tower structure, the minimum-bending radius specified by the manufacturer, shall not be compromised.

a) Upon completion of stringing, sufficient spare cable shall be pulled down to permit joining to take place. The length of the OPGW for connection purposes shall be determined by measuring from the strain clamp to the base of the splicing box plus sufficient allowance to permit splicing at ground level and to preserve the manufacturer's recommended bending radius (see figure 5 in annex A). A further minimum allowance of 5 m shall be provided into each box to make fibre optic connections.

b) The correct number of correctly dimensioned down-lead clamps shall be used at each downlead cable to ensure that the OPGW is securely anchored to the tower in such a way as to eliminate vibrations and cable clashing against the tower. A down-lead clamp shall be installed at each tower member intersection. The distance between clamps shall be as specified in 3.1.3.3.3. Clamp bolts shall be tightened using torque wrenches. The torque that will prevent damaging stress concentrations due to clamping shall be determined.

   On insulated strain or suspension towers (see LES-GEN-OPGW-1 in annex A) the down-lead shall be insulated from the tower using insulated clamps. The minimum distance between the insulated cable and any tower member shall be greater than or equal to 50 mm. This distance of 50 mm shall be maintained between the two OPGW cables themselves, at the places where they run parallel to one another in the down-lead clamps.

   On non-insulated strain or suspension towers (see LES-GEN-OPGW-4 in annex A) the down-lead shall be electrically connected to the tower by means of non-insulated clamps.

c) If OPGW sagging and jointing cannot be done in a continuous operation, the ends of the OPGW shall be sealed using a compressed pulling eye that shall remain in place until jointing work starts. Spare lengths of OPGW at jointing tower shall be coiled in coils greater than 1, 5 m in diameter. The coils shall be securely attached, above the anti-climbing devices, to the tower in order to prevent OPGW damage under windy conditions as well as to prevent theft.

d) Well-trained technicians shall carry out splicing of optical fibres. Adequate splicing machines, tools and measuring equipment shall be provided and used for each splice. Splicing shall be done at ground level after which the splice enclosure shall be fixed on the tower above the anti-climbing device.

The operation of splicing shall follow the following sequence:

a) Fix an adapter for the splice enclosure on the tower;

b) Remove the outer strands and expose the optical fibre unit;

c) Clamp the OPGW using internal clamps inside the splicing box;

d) Splice the optical fibres by fusion;

e) Reinforce the splicing point with heat shrinkable tube;

f) Secure and lay the optical fibres inside the box on completion of a permanent splice; and

g) Close and seal the splicing box.

7. Marking, labelling and packaging

For OPGW cable requirements, see section 5 of 240-75521456 (Phase Conductor for Eskom Overhead Lines).

For hardware requirements see section 4.17 of 240-60777474 (Specification for Suspension and Strain Assemblies and for Hardware for Transmission Lines).

8. Quality Control

The latest revisions of all Eskom quality control documents should be used by the client, manufacturer and installer during the production, testing and installation of all fibre optic cables.

Installer must provide project specific Inspection and test plans to be accepted by Eskom before installation of the OPGW system.

9. Spares

Adequate spares for all components should be catered for in the BOQs of all projects. Any spare hardware or cable lengths not used during projects shall remain the property of Eskom.

10. Authorisation

This document has been seen and accepted by:

Name and surname	Designation
R Vajeth	Senior Manager Line Engineering Services
B Haridass	Senior Consultant Line Engineering Services

11. Revisions

Date	Rev	Compiler	Remarks
Nov 2018	2	H Khan	Added Section 3.1.5 – Installation of Duct cable
July 2016	1	H Khan	Document reviewed and circulated for final acceptance Document number changed
Nov 2012	0	V Naidu	Draft Document for review created from 32-1290

12. Development team

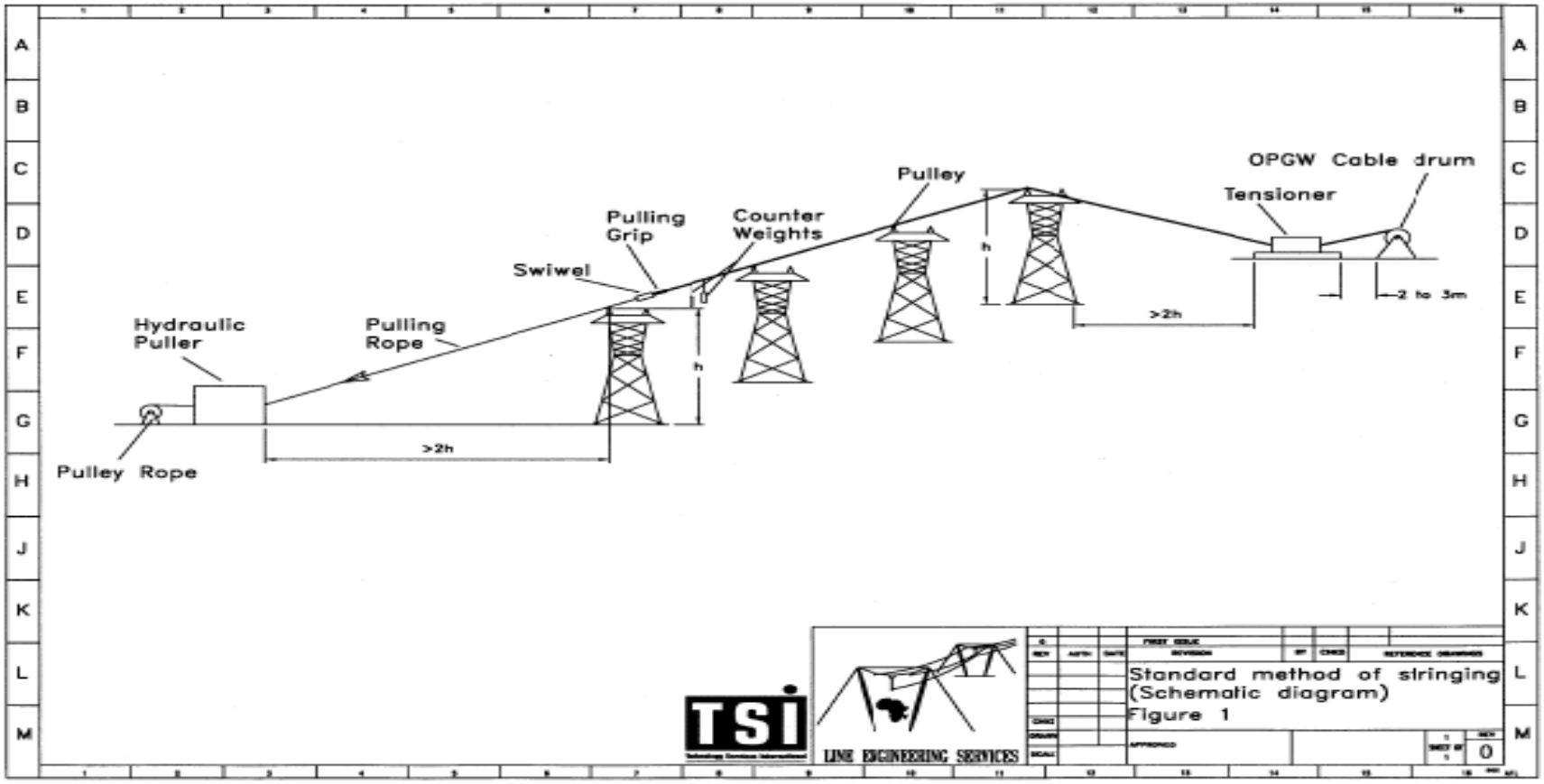
The following people were involved in the development of this document:

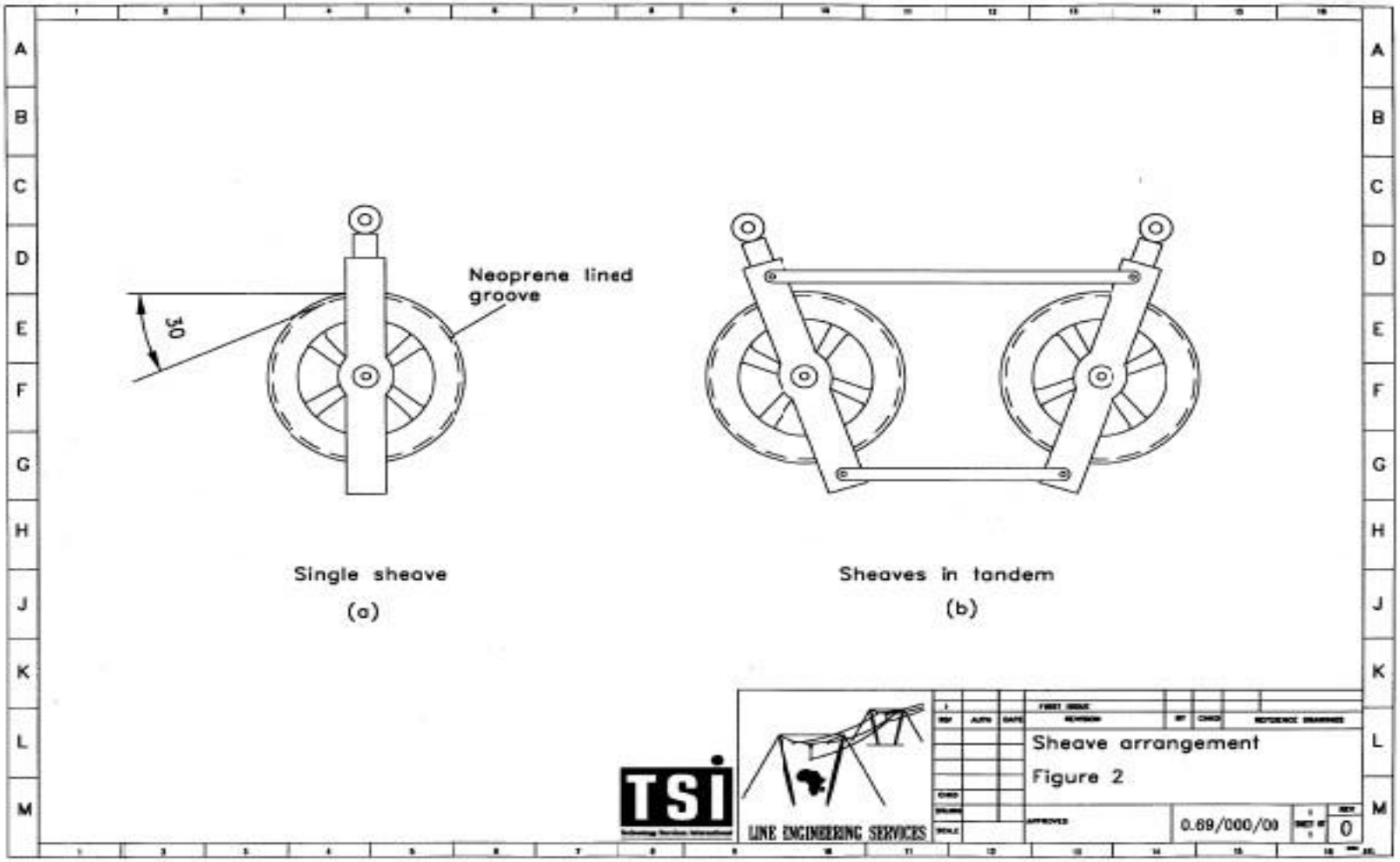
- Hussain Khan
- Vanessa Naidu
- Bharat Haridass

13. Acknowledgements

Not applicable.

Annex A – Drawings





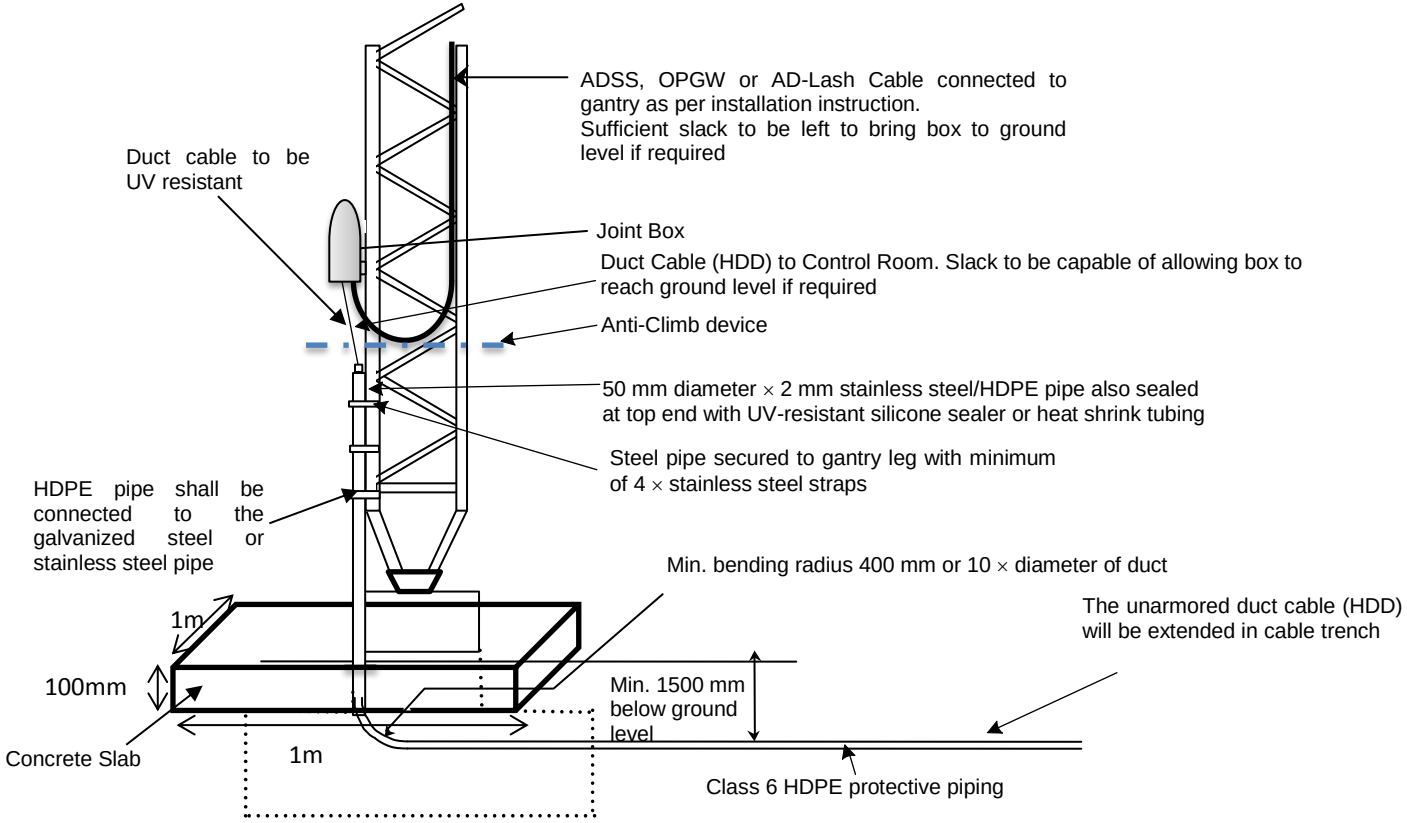


Figure 3: Duct cable installation at a non-insulated tower.

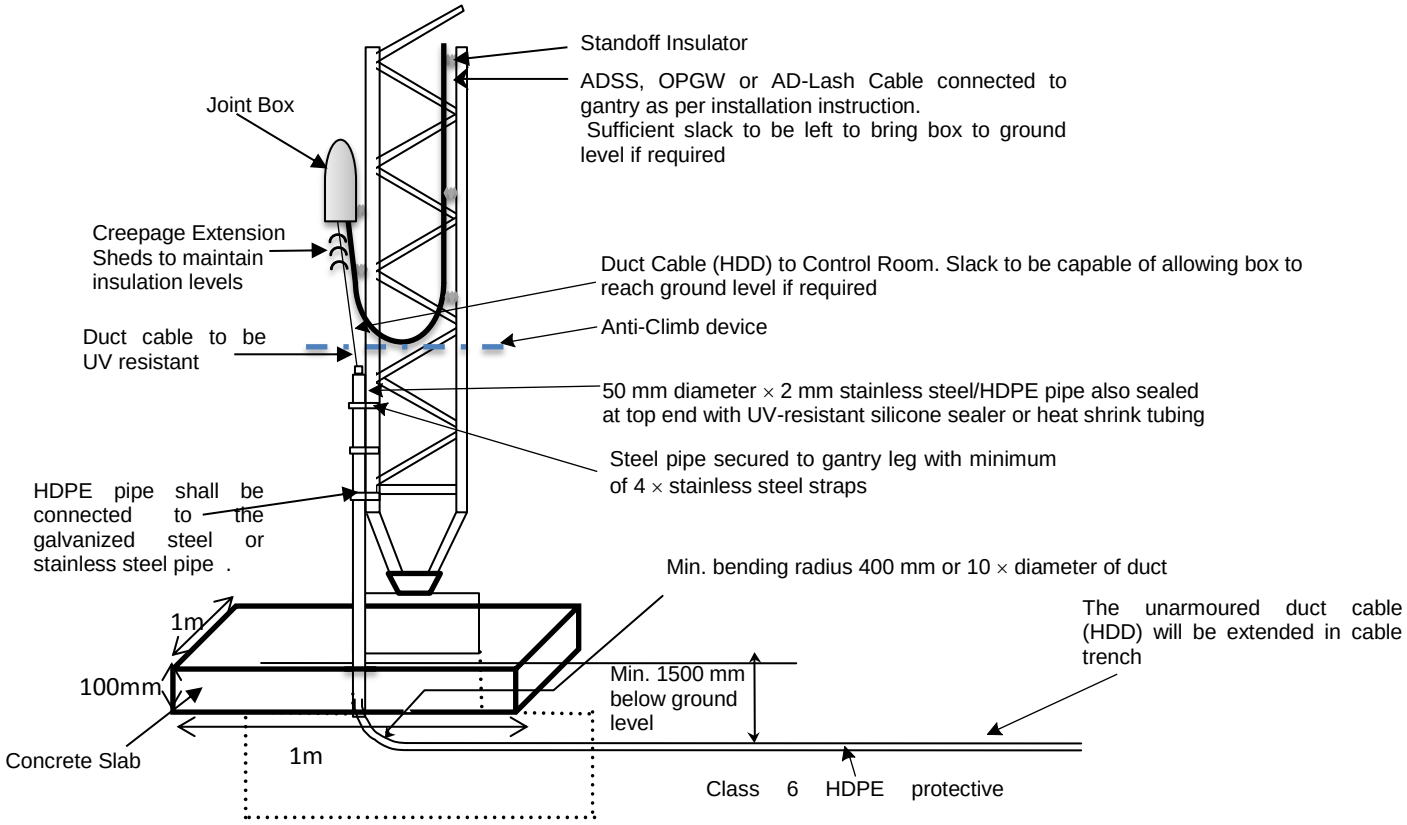
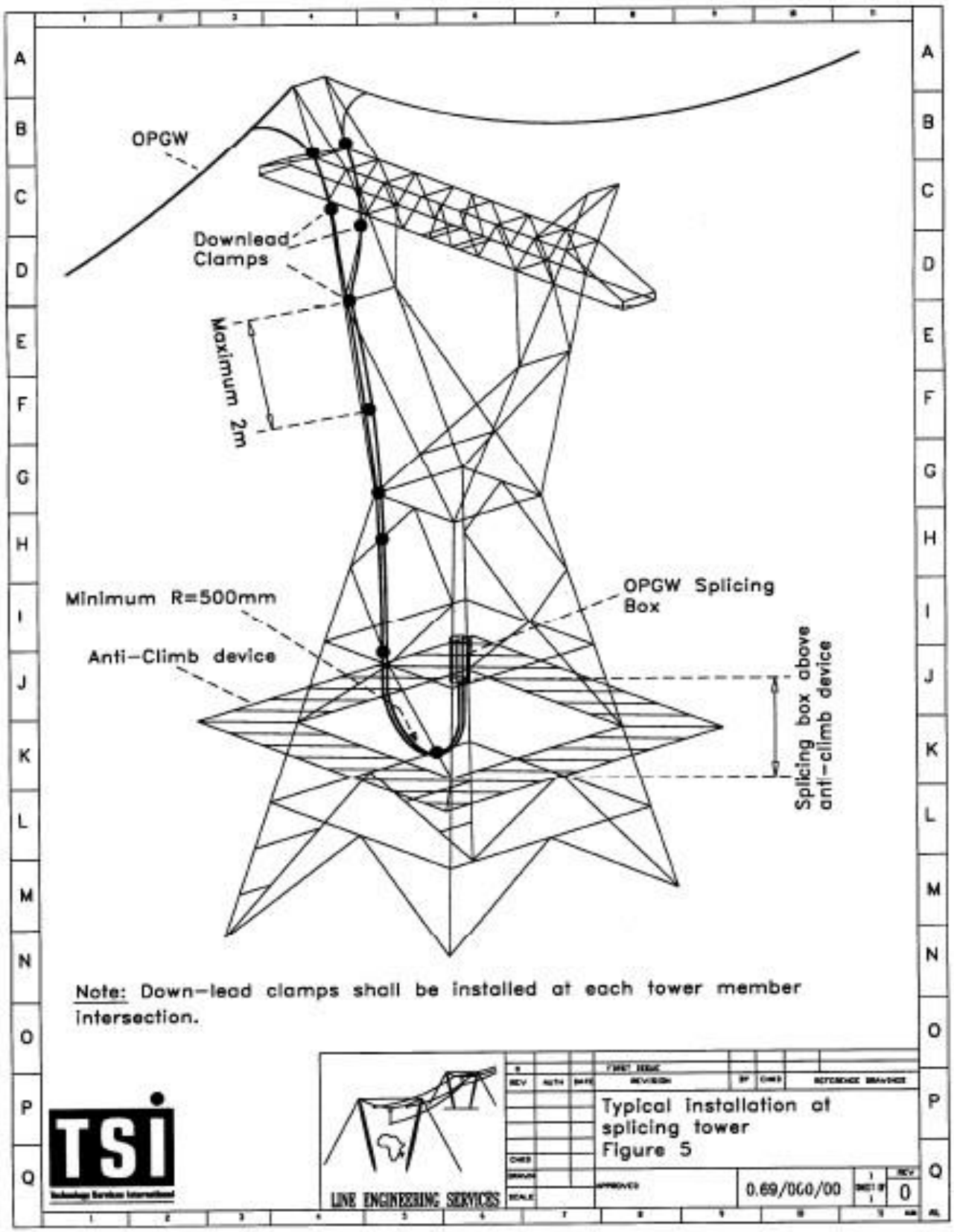
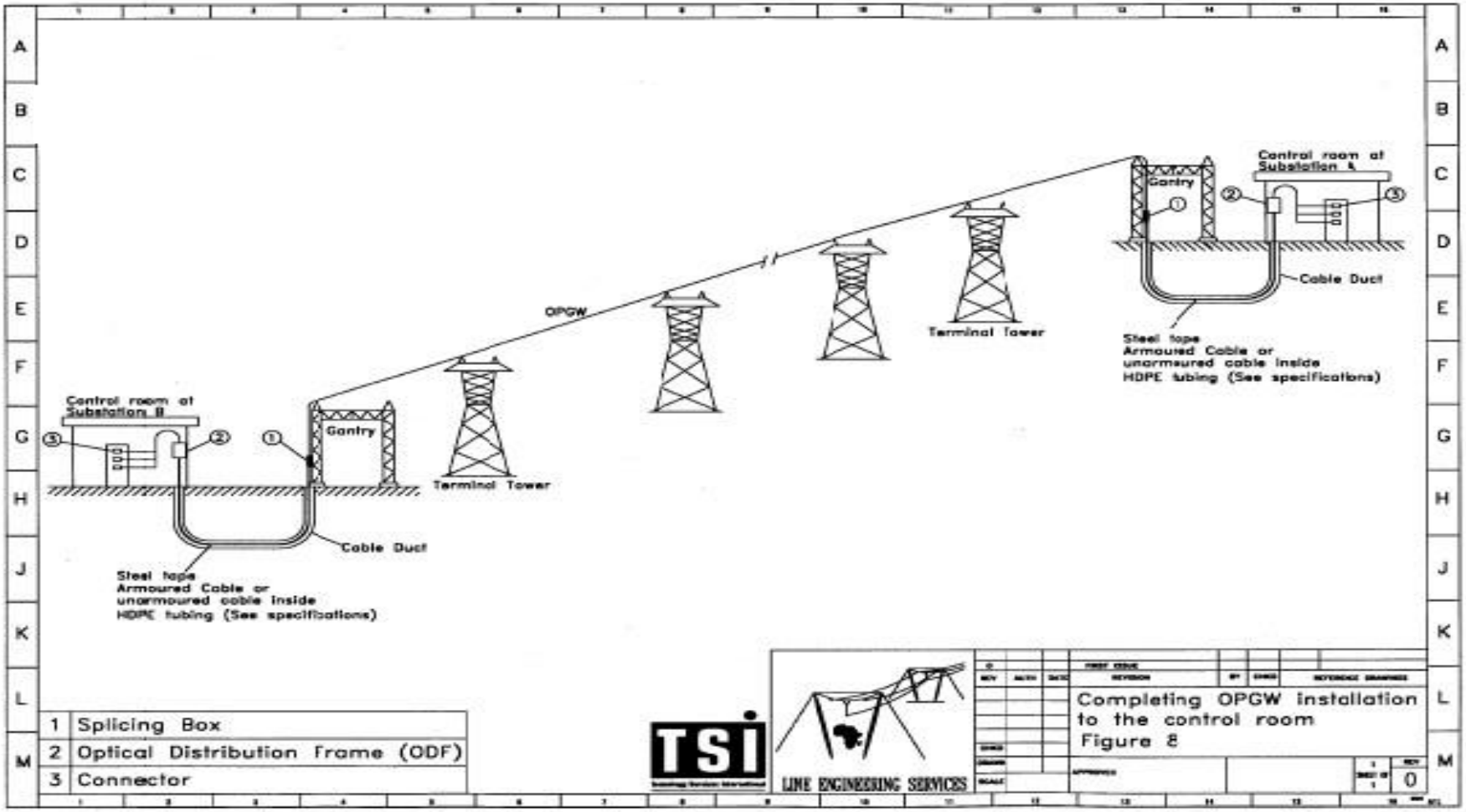
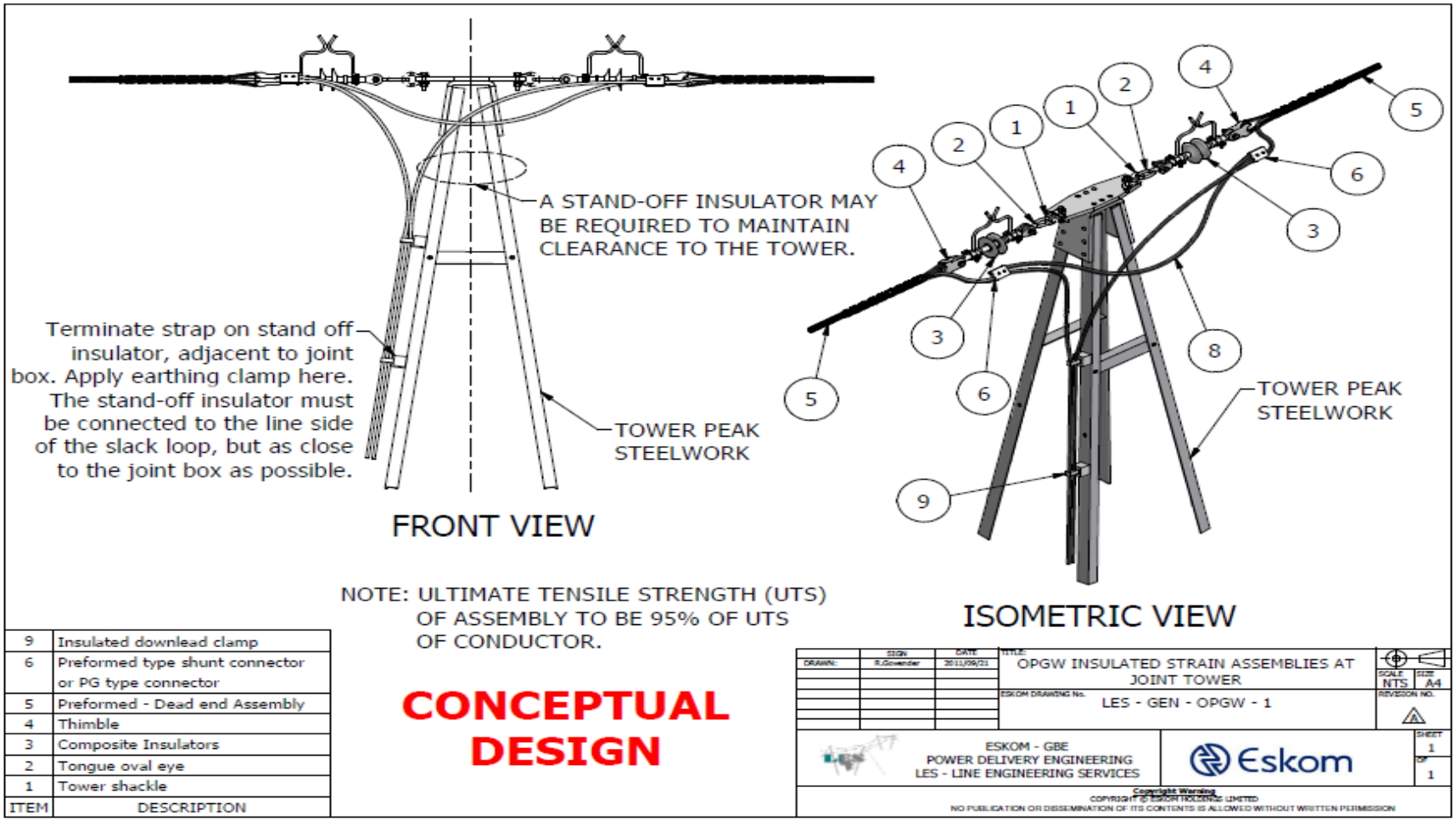


Figure 4: Duct cable installation at an insulated tower.







NOTE: ULTIMATE TENSILE STRENGTH (UTS) OF ASSEMBLY TO BE 95% OF UTS OF CONDUCTOR.

ITEM	DESCRIPTION
9	Insulated downlead clamp
6	Preformed type shunt connector or PG type connector
5	Preformed - Dead end Assembly
4	Thimble
3	Composite Insulators
2	Tongue oval eye
1	Tower shackle

CONCEPTUAL DESIGN

DRAWN:	R.Govender	2011/09/21

TITLE: OPGW INSULATED STRAIN ASSEMBLIES AT JOINT TOWER

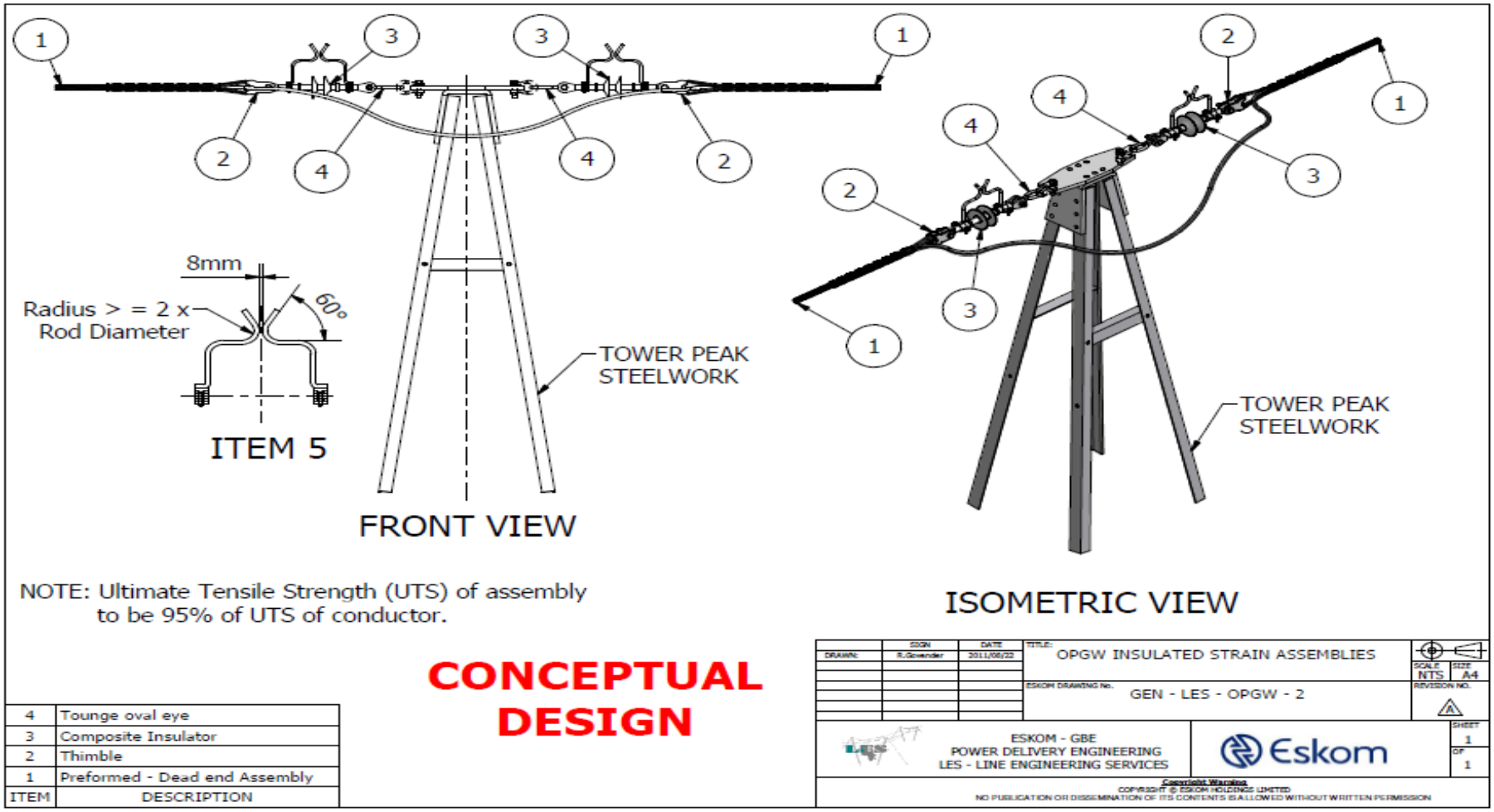
ESKOM DRAWING No.: LES - GEN - OPGW - 1

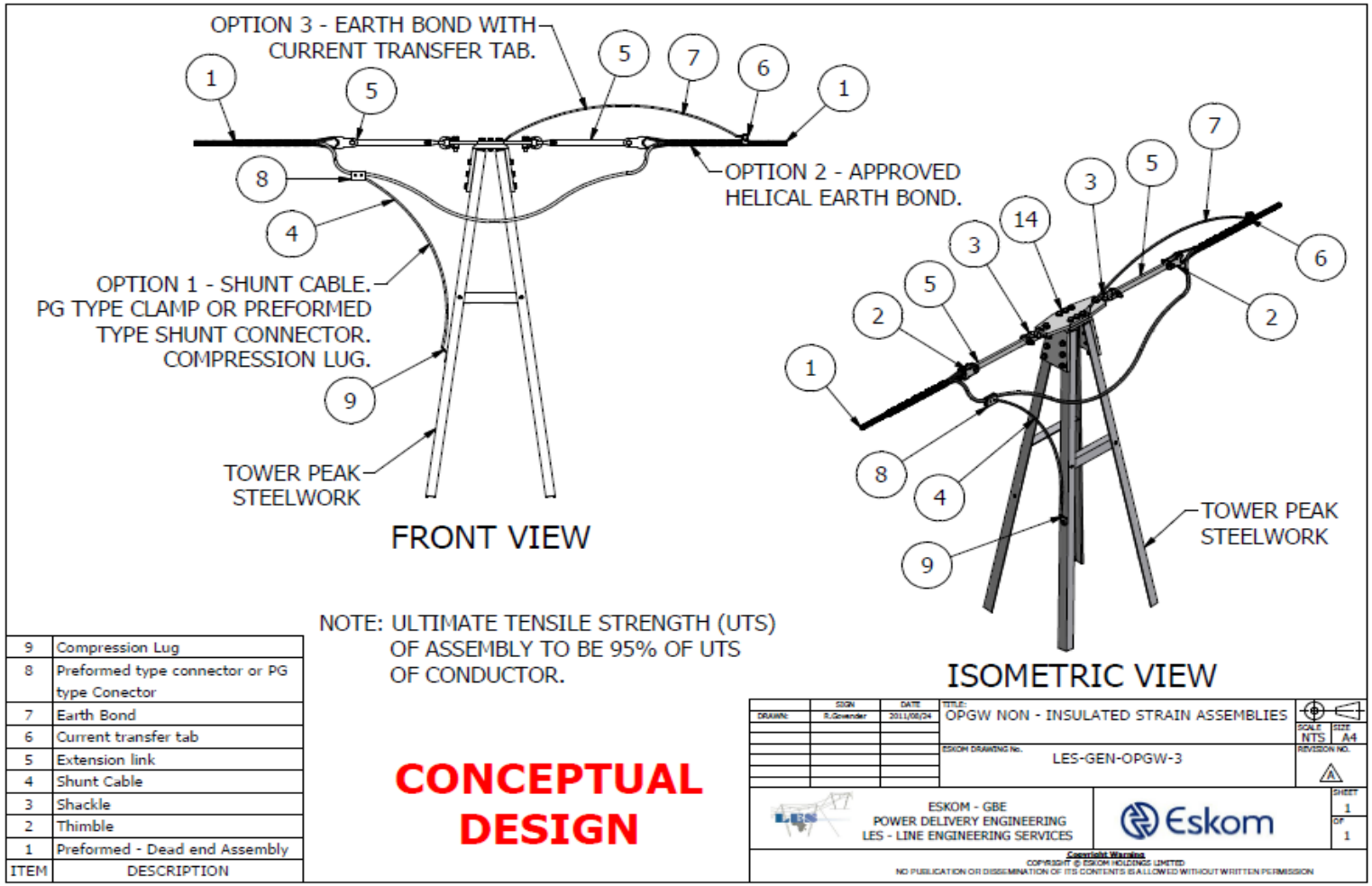
SCALE: NTS | SIZE: A4 | REVISION NO.: A

ESKOM - GBE
POWER DELIVERY ENGINEERING
LES - LINE ENGINEERING SERVICES

Eskom

SHEET 1 of 1





ITEM	DESCRIPTION
9	Compression Lug
8	Preformed type connector or PG type Conector
7	Earth Bond
6	Current transfer tab
5	Extension link
4	Shunt Cable
3	Shackle
2	Thimble
1	Preformed - Dead end Assembly

NOTE: ULTIMATE TENSILE STRENGTH (UTS) OF ASSEMBLY TO BE 95% OF UTS OF CONDUCTOR.

CONCEPTUAL DESIGN

DRAWN:	SIGN: R.Govender	DATE: 2011/06/24

TITLE: OPGW NON - INSULATED STRAIN ASSEMBLIES

SCALE: NTS | SIZE: A4

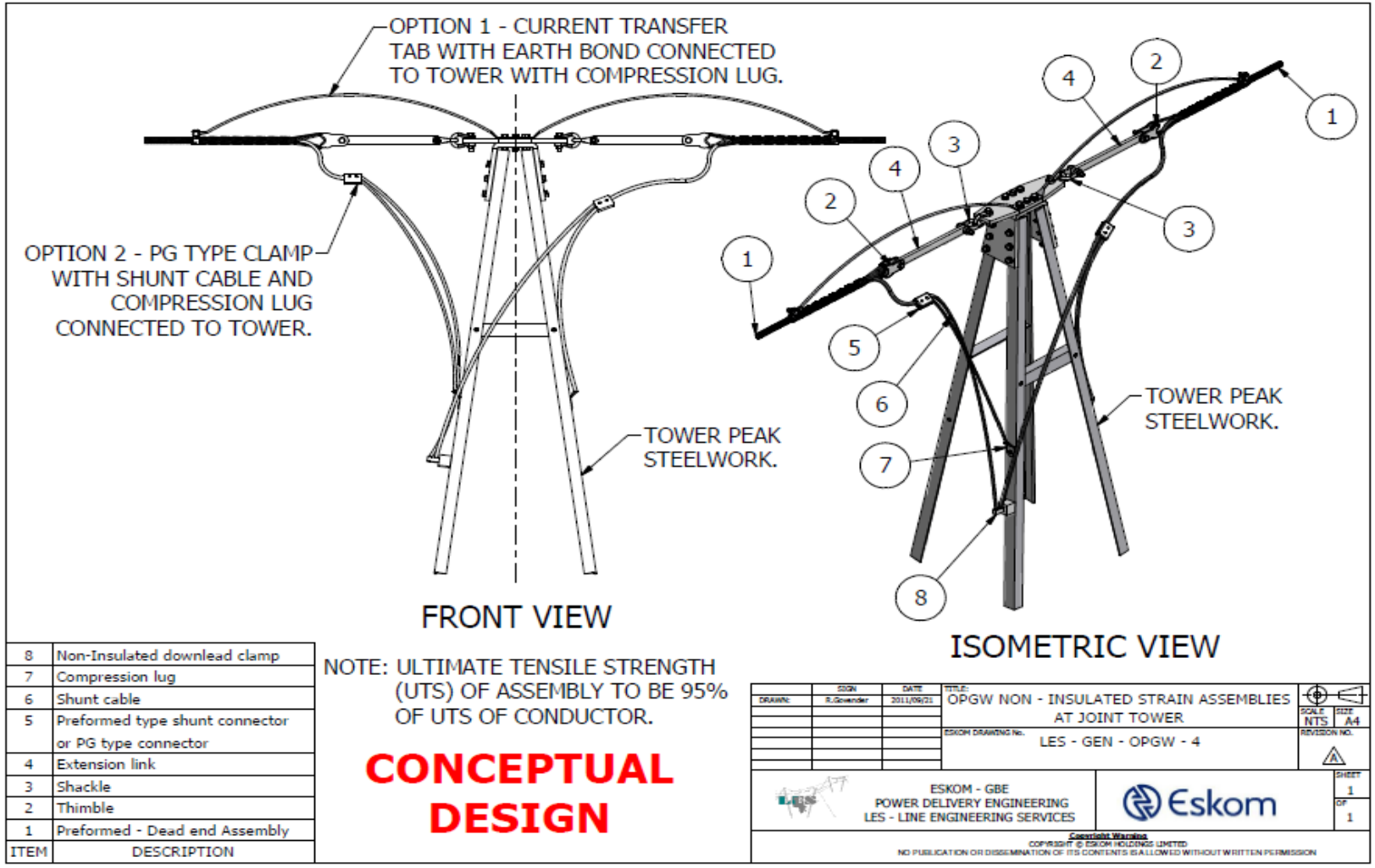
ESKOM DRAWING No.: LES-GEN-OPGW-3

REVISION NO.: A

ESKOM - GBE
POWER DELIVERY ENGINEERING
LES - LINE ENGINEERING SERVICES

Eskom

SHEET 1 OF 1



ITEM	DESCRIPTION
8	Non-Insulated downlead clamp
7	Compression lug
6	Shunt cable
5	Preformed type shunt connector or PG type connector
4	Extension link
3	Shackle
2	Thimble
1	Preformed - Dead end Assembly

NOTE: ULTIMATE TENSILE STRENGTH (UTS) OF ASSEMBLY TO BE 95% OF UTS OF CONDUCTOR.

CONCEPTUAL DESIGN

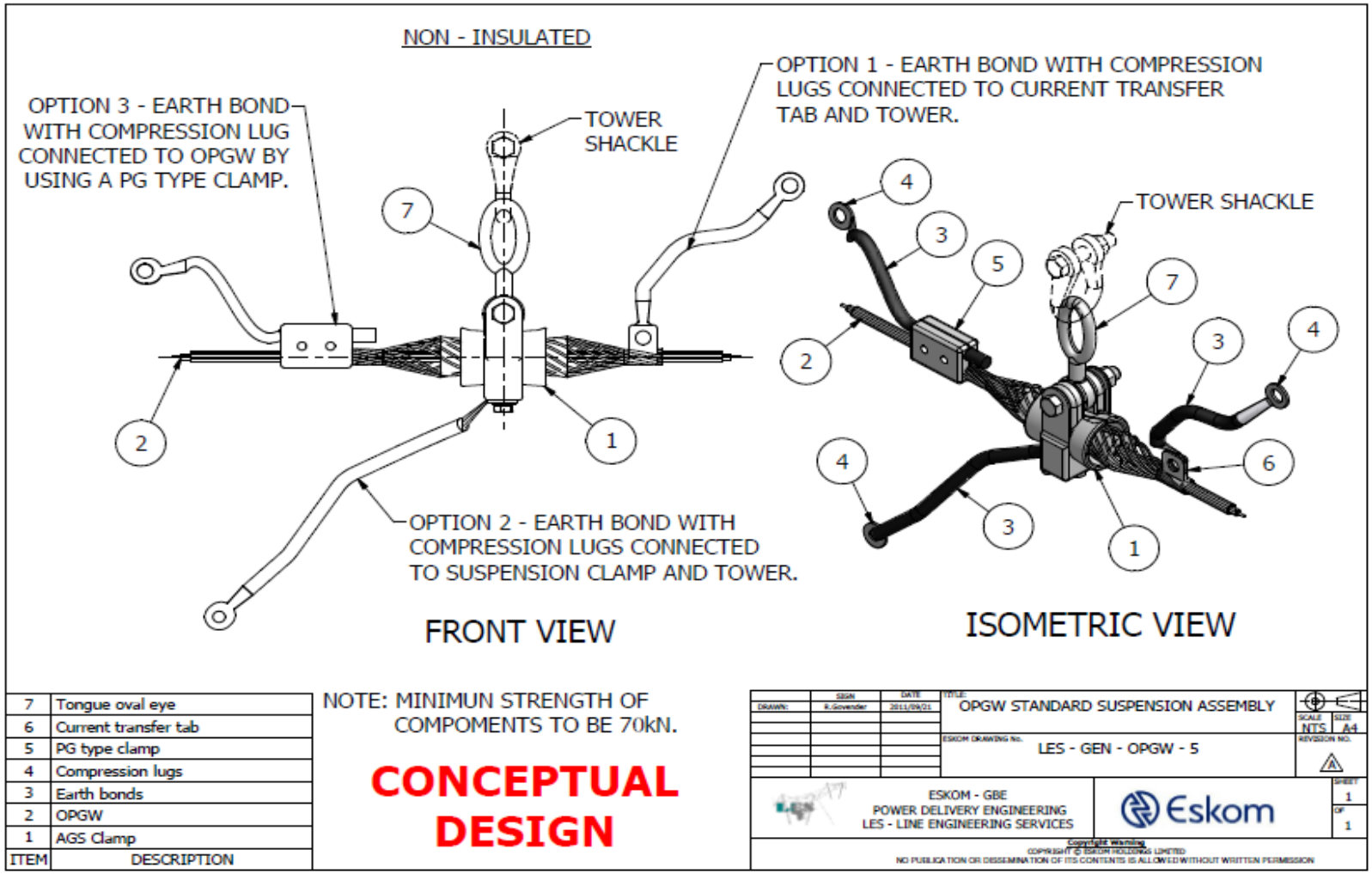
	SIGN	DATE
DRAWN:	R.Govender	2011/09/21

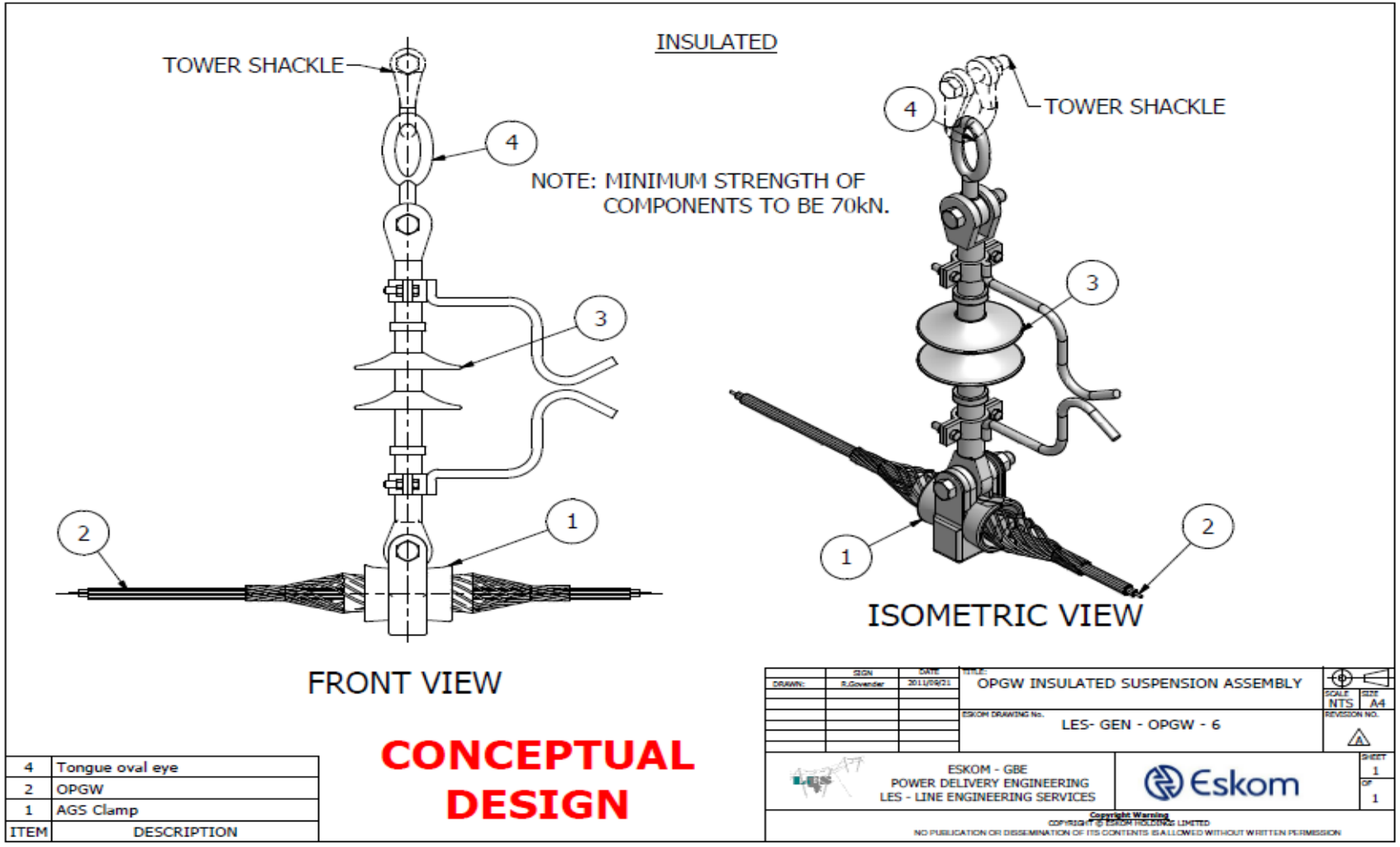
TITLE: OPGW NON - INSULATED STRAIN ASSEMBLIES AT JOINT TOWER

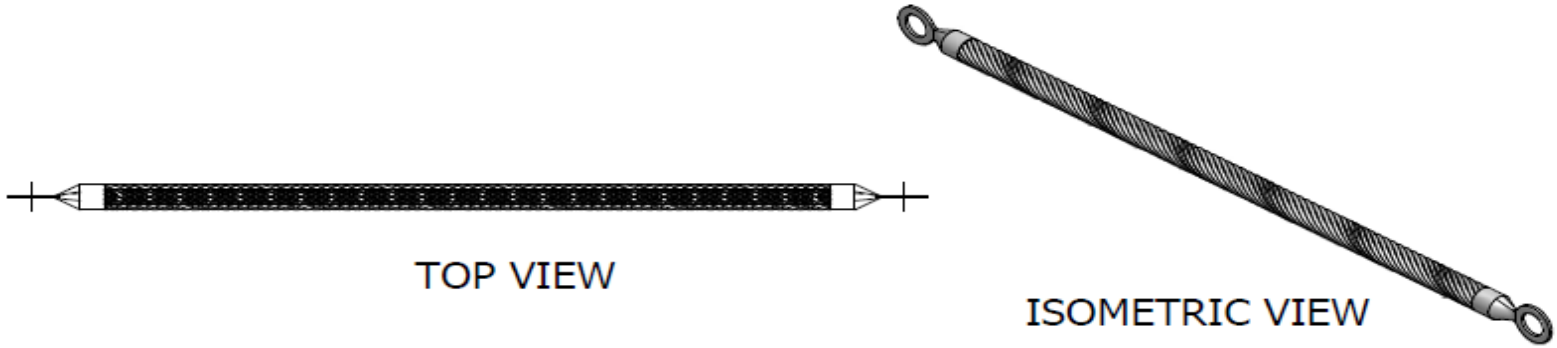
ESKOM DRAWING No.: LES - GEN - OPGW - 4

SCALE: NTS | SIZE: A4 | REVISION NO.: A | SHEET 1 OF 1

ESKOM - GBE
POWER DELIVERY ENGINEERING
LES - LINE ENGINEERING SERVICES







TOP VIEW

ISOMETRIC VIEW

FRONT VIEW

CONCEPTUAL DESIGN

NOTE: The earth bond should be having the following specifications:

1. Suitable to match OPGW diameter - 9 to 16mm.
2. Lengths - 1m, 1.5m, and 1.8m.
3. Lugs should have a 16mm diameter hole for attachement to tower bolt.
4. Be of flexible type.(AAAC Conductor to be used)

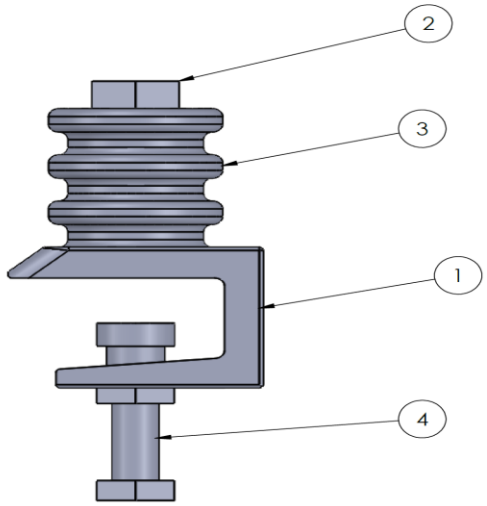
	SIGN	DATE	TITLE:	
DRAWN:	R. GOVENDER	2011/09/06	OPGW - Earth Bond	SCALE: NTS / SIZE: A4
			ESKOM DRAWING No.: LES - GEN - OPGW - 7	REVISION NO.: A

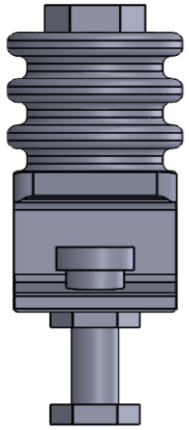
ESKOM - GBE
POWER DELIVERY ENGINEERING
LES - LINE ENGINEERING SERVICES

Eskom

SHEET 1 OF 1

No.	Description
1	Cast AL clamp bracket
2	M12 Bolt and nut for attachment of parallel bracket
3	Ceramic insulator
4	M10 Set screw with washer

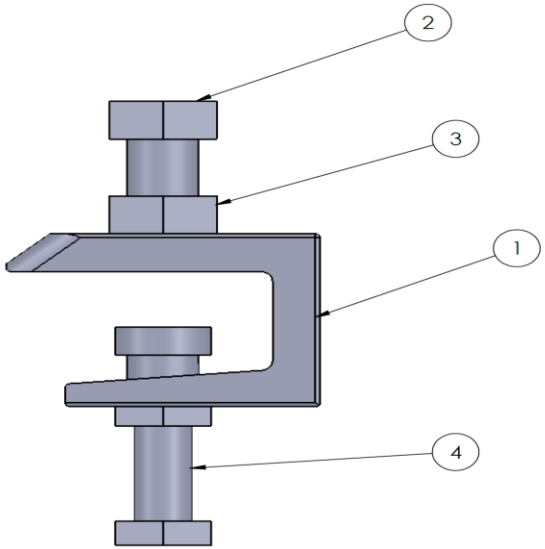


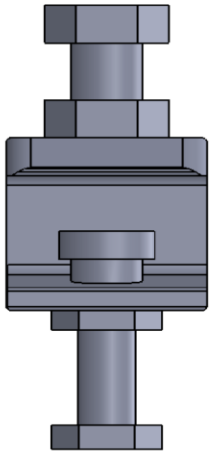


Please Note this is a **CONCEPTUAL DRAWING.**

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:		FINISH:		DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING / REVISION
	NAME	SIGNATURE	DATE		TITLE: Insulated downlead clamp for lattice tower
DRAWN	Gino Pillay				
CHK'D	Hussain Khan				
APPV'D	Hussain Khan				
MFG					
Q.A				MATERIAL:	DWG NO. DC-LT-INS / A3
				WEIGHT:	SCALE:1:2.5 / SHEET 1 OF 1

No.	Description
1	Cast AL clamp bracket
2	M12 Bolt and nut for attachment of parallel bracket
3	M12 Nut
4	M10 Set screw with washer





Please Note this is a **CONCEPTUAL DRAWING.**

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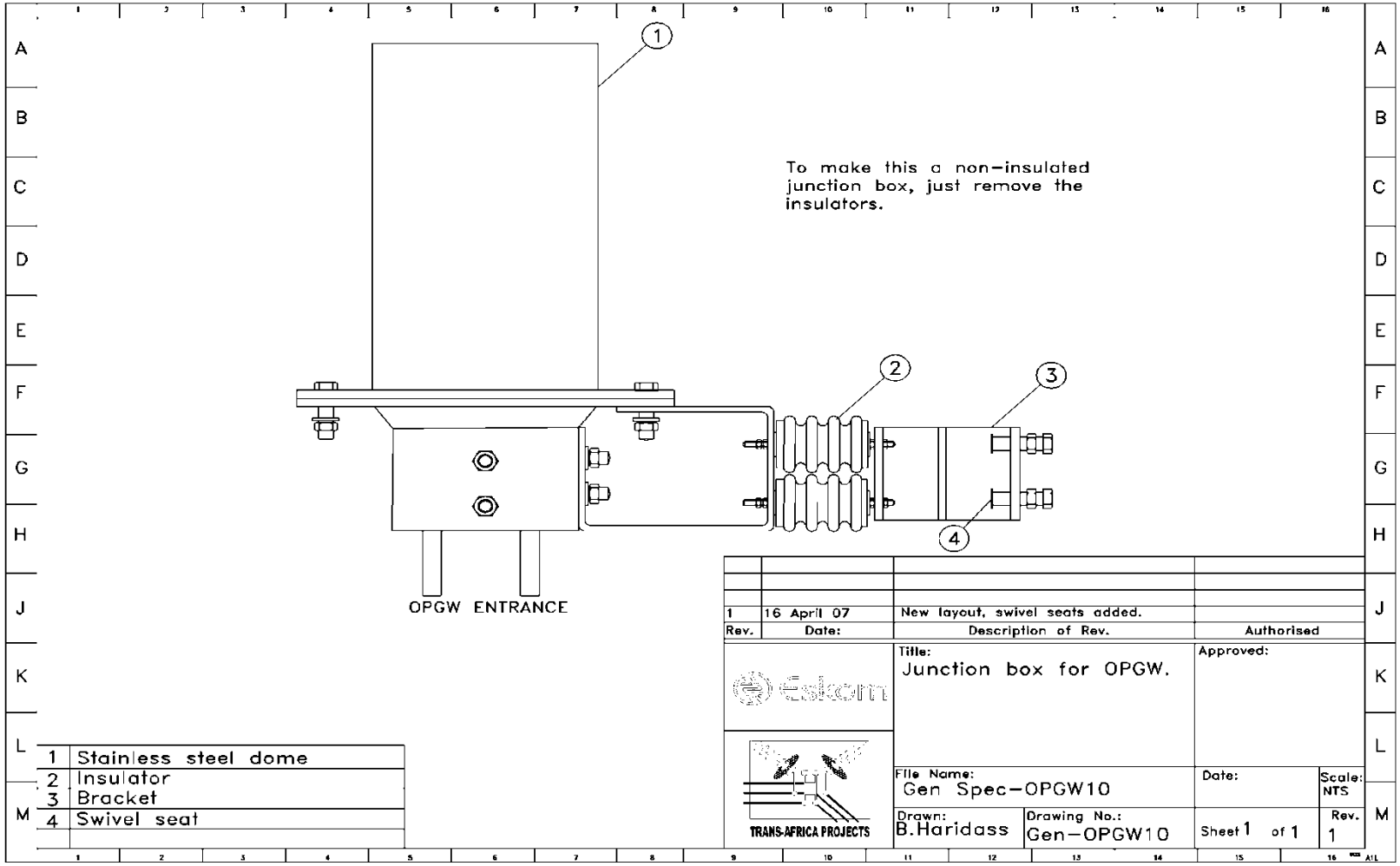
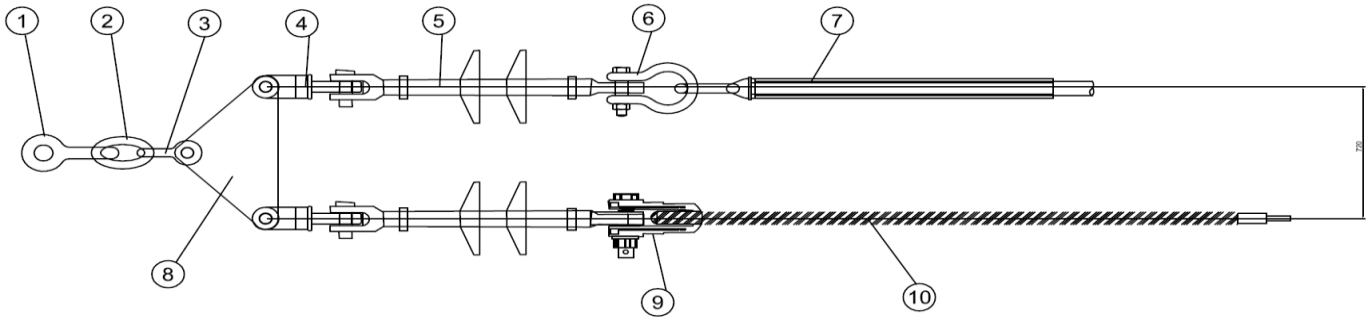
	NAME	SIGNATURE	DATE	TITLE: Non-insulated downlead clamp for lattice tower	
DRAWN	Gino Pillay				
CHK'D	Hussain Khan				
APPV'D	Hussain Khan				
MFG					
Q.A					
MATERIAL:				DWG NO. DC-LT-NON-INS	A3
WEIGHT:				SCALE:1:2	SHEET 1 OF 1





1	Tower shackle	210kN
2	Chain link	210kN
3	Shackle	210kN
4	Twisted clevis tongue	120kN
5	Composite insultor	120kN
6	shackle	120kN
7	Compression deadend for ACSR earthwire	210kN
8	Traingular yoke plate	210kN
9	OPGW Thimble	120kN
10	OPGW preformed deadend	120kN

REVISED BY | DATE | CHANGES MADE | REV NR.

	NAME	SIGNATURE	DATE	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS
DRAWN	B.Haridass		2015/11/24	DESCRIPTION: OPGW and ACSR earthwire joint for strain towers
				ESKOM DWG NO. OPGW+Earthwire

REVISION: 1.0

ESKOM - GROUP TECHNOLOGY
LES - LINE ENGINEERING SERVICES

A4

N.T.S.

SHEET 1 OF 1

STATEMENT OF COMPLIANCE

The material and equipment supplied on this contract complies in all respects with the requirements of the specification and Schedule A/B, and the installation practice will be in accordance with this document

For each paragraph mark Noted, Comply, Partially Comply, Don't Comply:

Paragraph	Noted, Comply, Partially Comply, Don't Comply
3.1	
3.2	
3.3.1	
3.3.2	
3.3.3	
3.3.4	
3.3.5	
3.3.6	
3.3.7	
3.3.8	
3.3.9	
3.3.10	
3.3.11	
3.3.12	
3.4.1	
3.4.2	
4.1	
4.2	
5.1	
5.2	
5.3	
6.1	

Paragraph	Noted, Comply, Partially Comply, Don't Comply
6.2	
6.3	
7	
8	
9	
Figure 1	
Figure 2	
Figure 3	
Figure 4	
Figure 5	
Figure 8	
LES-GEN-OPGW-1	
GEN-LES-OPGW-2	
LES-GEN-OPGW-3	
LES-GEN-OPGW-4	
LES-GEN-OPGW-5	
LES-GEN-OPGW-6	
LES-GEN-OPGW-7	
DC-LT-INS	
DC-LT-NON-INS	
GEN-OPGW10	
OPGW + Earthwire	

Annex B – OPGW Pre-Installation And Final Tests

1) OPGW Pre-installation Test

Testing before installation shall be done in accordance with 240-70732888:

a) The test shall be performed on each fibre in the OPGW at wavelength 1550 nm;

b) The fibres shall be marked for numbers and colour;

c) Results shall be produced in table and graph format in accordance with the example below;

d) The table shall contain the drum number and the length of the OPGW as a heading; and

e) The table shall record the attenuation for each fibre.

Results shall be produced in digital format. The table below is an example for test recordings.

Project:			Drum number:	
			Loss db/km	
Tube	Fibre	Colour	1550 nm	Length
1	1			
	2			
	3			
	……			
	10			
	11			
	12			
2	1			
	2			
	3			
	……			
	10			
	11			
	12			

2) Final tests

An end-to-end test shall be performed to satisfy Eskom that the fibre optic installation is acceptable.

The final test shall be performed in accordance with Fibre Optic Cable System Testing Procedure 240-70732888. Only a calibrated Optical Time Domain Reflectometer instrument (OTDR) will be acceptable.