Ergon Energy Corporation Limited

Specification for Erection of Line Materials

This material is made available on the basis that it may be necessary for a Registered Professional Engineer of Queensland (RPEQ) to undertake or oversee the engineering services to meet statutory obligations.

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Ergon Energy Queensland Pty Ltd ABN 11 121 177 802

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1. Purpose and Scope

This specification specifies requirements for the installation of conductor and earthwires and includes earthing of structures, running out, sagging and clamping of conductor and overhead earthwires, and installation of line hardware and insulators. The Schedule of Rates for Erection of Line Materials will cover all the works described in this Section unless specifically excluded herein.

2. References

2.1 Ergon Energy controlled documents

Nil

2.2 Other sources

IEEE Std 524-1992 – Guide to the Installation of Overhead Transmission Line Conductors
AS 1742 – Manual of Uniform Traffic Control Devices

SAI GLOBAL quick search

3. Definitions, Acronyms, and Abbreviations

3.1 Acronyms and Abbreviations

The following acronyms appear in this standard:

IEEE	The Institute of Electrical and Electronics Engineers
OPGW	Optical Ground Wire
AS	Australian Standards
ACSR	Aluminium Conductor Steel Reinforced
UTS	Ultimate Tensile Stress
OPTDR	Optical Time Domain Reflectometer

4. Security

Nil

5. Safety, Environmental and Ergonomic Considerations

As per Ergon Energy's Safety, Environmental & Ergonomic Policies.

6. General

The Contractor shall install earthing, erect insulators, conductors and overhead earthwires including all fittings in accordance with this Section. Generally all materials, except for the insulators, conductors and OPGW required to complete the works shall be provided by the Contractor, unless otherwise designated in the Main Specification.

The Contractor shall ensure that structures are not loaded above the applicable limit state design loads.

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7. Structure Earthing

7.1 Main Structure Earthing

Where required on the Drawings main structure earthing shall be installed with the structure foundations.

7.2 Supplementary Earthing

After completion of foundation installation but prior to the installation of overhead earthwires or conductors, the electrical resistance of each structure footing to earth will be measured by the Contractor. The Contractor shall use the fall-of-potential method for measuring the footing resistance of a structure (pole or tower). It is only possible to measure the footing resistance of a structure using conventional earth testers when the overhead earthwire is disconnected or insulated from the structure being tested. For this reason it is more convenient to measure the footing resistance for new structures prior to stringing of the overhead earthwire. For foundations that are cast *in situ* or rely on cement stabilised backfill, the footing resistance shall be measured at least 14 days after construction.

If the readings are greater than 5 Ω within 2km of a substation or 10 Ω elsewhere on the line, the Superintendent may direct the Contractor to install supplementary earthing. If the ground moisture is high due to good rainfall, then the target footing resistances shall be reduced to 3 Ω and 6 Ω respectively. The installation of such supplementary earthing shall be in accordance with the Drawings and shall be completed prior to the installation of overhead earthwires. The installation of earthwires and conductors shall only proceed when the Superintendent is satisfied with the earthing.

Footing resistance testing of structures with additional earthing requires that the spacing of the pins (probes) is well beyond the hemi-sphere of influence of the earthing system. This is confirmed when there is a constant resistance measurement when the distance to the voltage pin (probe) is varied over a range of 30% to 70% of the distance to the current pin (probe).

Where additional earthing is provided by means of deep drilled electrodes with dry bentonite/gypsum backfill, a reliable measurement will not be possible until the backfill hydrates to the same moisture content as the native soil. The footing resistance shall be measured at least 14 days after installation.

7.3 Earthing for Gradient Control

Earthing for gradient control shall be installed in accordance with the Drawings at structures nominated by the Superintendent.

7.4 Rock and Soil Classification

Material in which earthing is installed shall be classified as follows:

(i) Material which, in the opinion of the Superintendent, can reasonably be excavated by the use of hand tools such as picks, shovels or hand bars or rubber tyred tractor mounted backhoes, or trenching machines shall be considered to be soil.

(ii) Material that requires the use of pointed pneumatic tools or explosives for removal shall be considered to be rock.

7.5 Trench Backfill

Excavated material shall be used for trench backfill unless otherwise directed by the Superintendent. The backfill shall be placed in layers not exceeding 200 mm thick and thoroughly compacted using competent compaction equipment. Backfill shall be placed and compacted until the level is such that after any long term settlement the final level of the backfilled area is higher than the surrounding natural ground level.

8. General Requirements for Stringing of Conductors and Earthwires

8.1 General

All structures and stays shall be complete and all bolts tight before stringing commences. All concrete shall have cured for the designated time prior to loads being applied.

The Superintendent shall nominate those sections of the works where it will be mandatory for the Contractor to use tension stringing methods. Tension stringing of OPGW is mandatory. The Contractor may use 'slack stringing' or tension stringing elsewhere.

The Contractor shall supply the Principal with a detailed stringing programme for approval, supported by calculations and including conductor run out lengths, equipment locations, nominated runout tensions at winch and brake, maximum tensions over the run due to variations in terrain, line deviation and sheave losses, and anticipated sagging locations including where sagging off blocks will be performed. This programme shall be submitted at least six weeks prior to the run out of any conductor.

8.2 Care of Conductor and Earthwire

Conductors and earthwires shall be protected from damage at all stages of handling and installation. In particular scratching or other departure from the smooth surface condition of the conductor strands shall be avoided. Conductors and earthwires shall be handled using only suitable equipment and in such a manner as to prevent bird caging, overtensioning or other deformation or damage.

Conductors shall be protected from immersion in water or contamination with foreign materials. Vehicles shall not be driven over conductors or overhead earthwires on the ground.

Conductor and earthwire drums shall at all times rest with the axis parallel to the supporting surface and shall be raised on battens so that the drums are at least 50 mm above the ground. Drums shall not be dropped from trucks but shall be lifted by means of a crane using a suitable axle, slings and spreader.

8.3 Damage Repair

Conductor and earthwire that has become contaminated shall be cleaned using approved materials and methods prior to erection.

Minor damage, abrasions or protrusions which in the opinion of the Superintendent will not significantly affect the strength or endurance of the conductor, shall be removed by careful polishing with fine abrasive paper of the "wet and dry" type.

If no more than 20% of the outer layer strands are substantially damaged and no inner layer or steel core damage has occurred, repair rods of the "line guard" type may be used to repair the damage. No more than two such repair positions shall be permitted in any one conductor or earthwire of any one span.

When damage is more extensive than that described above or where the cable has been deformed, overtensioned, or had strands loosened, the affected section shall be cut out and a full tension mid span joint shall be installed, except for OPGW where a joint shall be made at an adjacent structure.

8.4 Stringing Equipment

All stringing equipment shall be suitable for its intended use and in particular it shall meet the requirements outlined below.

(i) Stringing sheaves shall be mounted on free-running ball or roller bearings to ensure the best possible transfer of tension between adjacent spans.

Stringing sheaves shall be selected so as to preclude possible damage to conductors or earthwires, and the selection shall consider the conductor, pulling tension, weight spans, deviation angles, and terrain. Internal diameters of conductor and earthwire sheaves shall not be less than 18 times the cable diameter. All sheaves shall be lined with semi-conducting neoprene or hard rubber equivalent. Sheaves with damaged linings shall not be used.

Sheaves shall be numbered to facilitate identification.

(ii) Tensioning machine bull wheel diameters shall be not less than 40 times the cable diameter, and shall be lined with neoprene or other suitable material subject to the approval of the Superintendent. The radius of the groove for the stringing sheaves and bull wheel shall be not less than 0.55 times the cable diameter. The minimum depth of groove for the sheaves and bull wheel shall be 1.25 and 0.5, respectively, times the cable diameter.

(iii) Woven wire cable hauling grips shall be used for the pulling out of conductor and earth wires. Each grip shall be attached to the pilot wire with a swivel to permit the pilot wire and conductor to rotate independently of each other at all hauling tensions.

(iv) Only non-rotating type steel pilot wires shall be used for hauling or tensioning conductors and earthwires. Nylon or other polymer pilot ropes may be used for hauling pilot wires.

(v) Hauling devices for tensioning the conductor and earthwire may be of the woven, preformed, bolted clamp or sliding jaw type. The type used shall be selected by the Contractor with due regard to the nature and size of the wire to be tensioned so that no damage or deformation of the wires occurs during tensioning operations.

After removal of the tensioning device, the wires in the vicinity of the device shall be thoroughly inspected, and any damage shall be repaired or cut out as directed by the Superintendent.

9. Safety Precautions During Stringing

Safety precautions as set out below are to be observed during the period when conductors and earthwire are being run out, tensioned and finally clamped. Precautions are necessary to avoid possible hazards to personnel caused by induction. Notwithstanding these specified precautions, the safety of personnel working on the line remains the responsibility of the Contractor.

The following precautions shall apply for all stringing carried out under this contract.

Main structure earthing shall be completed prior to the commencement of stringing. No stringing work is to be carried out during periods of thunderstorm activity.

Throughout the period during which draw wires, conductors and earthwires are being run out they shall be effectively earthed as follows:

(i) For tension stringing, a running earth shall be fitted to all wires within 50 metres of the drum site and shall be connected to a driven earth stake.

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(ii) For slack stringing, the conductors and earthwires shall be connected together and earthed at a point within 50 metres of the commencement point of the run out.
(iii) Where the transmission line crosses an existing overhead line two running earths shall be applied, one not more than 50 metres from the drum site and the second not more than 50 metres from the winch or anchor site. Immediately after run out, all conductors and overhead earthwires shall be earthed at structures on both sides of the overhead line crossing by bonding them together and connecting them to either an earth stake or the earthed structure metalwork.

All earth stakes shall be driven to a minimum depth of 500mm and all connecting leads shall have a minimum copper-equivalent cross-section of 65sq. mm. All earthing shall be installed in a manner and at locations subject to the approval of the Superintendent using fittings designed for the purpose.

During final clamping, conductor bridges at both ends of the section being clamped shall be left open.

After final clamping, conductors and earthwires shall be earthed to nominated structures within the section as directed by the Superintendent. Where the earthwires have been permanently bonded to the structure, through conducting tension or suspension clamps, earths will only be required on the phase conductors.

The Contractors shall record the position of each earth and shall ensure that all such earths have been removed before he reports to the Superintendent that the line is clear for energising. Such report shall take the form of a written clearance from the Contractor that all earths have been removed and that all its workers are clear of the line. Thereafter the Contractor shall have no access to the line without a written permit issued by the Principal.

All costs associated with the implementation of “Safety Precautions” shall be deemed to be included in the Rates for Stringing.

10. Additional Safety Precautions During Stringing

Many line construction or maintenance projects take place within close proximity to adjacent electrical circuits. Consequently, the potential hazards of electrostatic induction under normal operating conditions and electromagnetic induction under normal or fault conditions will require the Contractor to provide specific management plans.

The stringing of conductors and earthwires undertaken with parallel live circuits will require additional safety where hazards exist from:

- Induced charges by an above or neighbouring energised line
- Accidental energisation of the line
- Potential failure causing contact or flashover to an above or parallel energised line.

The means of providing personnel protection can take several forms. These include insulation or isolation of workers, provision of an equipotential zone around the workers, or provision of a low resistance path for induced charges or fault currents. The primary and most practical method of protection adopted here is the establishment of equipotential work zones to limit step and touch potential to safe levels.

Additional information is provided in the IEEE Guide to the Installation of Overhead transmission Line Conductors (IEEE Std 524-1992).

For tension stringing:

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1) A buried earth mat shall be installed around both the brake and winch mechanisms. The mat shall consist of 10 mm diameter steel rod 7/3.75 SC/GZ or 7/2.0 copper or equivalent buried to a depth of 0.5 metres and shall completely enclose the stringing equipment at each site.

2) All equipment, structures, concrete anchor blocks, draw wires, conductors and overhead earthwires within the perimeter of the earth mat shall be connected to the grid by earth stakes located within the perimeter and connected to one of the mat's radial conductors.

3) Running earths shall be applied at the brake site and at the winch site, connected to the earth mat by a driven earth stake. Immediately after run out, all conductors and overhead earthwires shall be earthed at structures at each end of the pull section.

4) During the runout of draw wire, conductor, or earthwire a running earth shall be applied at structures not more than 3 km apart. The position of each running earth shall be made known to the Superintendent's site representative. Neither semiconductively lined nor unlined sheaves shall be relied upon for attaching safety earthing.

5) For mid-span joints not made on the buried mat at the brake site, a metallic ground mat such as Gridmesh (expanded metal) shall be used. Vehicles that may be holding the conductor shall be bonded to the mat. The ends of the conductors to be joined and the mat shall be bonded to a common earth stake. A jumper shall be installed directly between the conductor ends before they are separated in preparation for joining. All splicing work shall be performed on the mat and access to the mat and the vehicle shall be via an insulated walkway.

For slack stringing:

1) Running earths shall be attached to the conductor or earthwire and bonded to the metal chassis of the run-out vehicle. The vehicle chassis shall be earthed by means of two dragging chains approved by the Superintendent.

2) Both ends of the conductor or earthwire shall be earthed at all stages of the stringing operation.

3) During the runout of conductor or earthwire running earths shall be applied progressively at structures nominated by the Superintendent.

4) Conductor or earthwire and associated stringing equipment at anchor blocks shall be bonded to a common earth stake.

Mobile equipment such as cranes operating at any structure during structure erection, stringing or during subsequent work shall be bonded electrically to the structure earthing system. An exception to this is fully insulated EWPs.

Before any work (such as clipping-in) is carried out on any draw wire, earthwire or conductor they shall be bonded electrically to the structure earthing system. The personal working earths shall be applied as close as practical to the worker involved. The bonding leads shall be connected to the earth system first. When removing bonds, the end connected to the conductor or equipment shall be removed first.

The adherence to these precautions does not absolve the responsibility of the Contractor, i.e. the Contractor remains responsible for the safety of personnel on site.

11. Run-out of Conductors and Earthwires

11.1 General

This section includes requirements for both “tension stringing” and “slack stringing” methods of run out. Where conductors are required to operate at nominal voltages in excess of 132 kV, the tension stringing method shall be employed. For overhead earthwires and conductors at other operating voltages, either method may be used, however slack stringing shall only be used where approved by the Superintendent.

Sub-conductors of a phase bundle shall be run simultaneously.

When left overnight unsagged or when the run out is stopped for more than one hour, conductor and earthwire tension shall be reduced so that it does not exceed 17% MCBL (Minimum Calculated Breaking Load), or to such a level that the reduced tension does not create hazards or impede traffic flow.

11.2 Economical Use of Conductor and Earthwire

Conductor and earthwire drums shall be positioned so as to ensure economical usage of cable. Short lengths of conductor of more than 30 m may be included in the line, providing they are used as the first length from a strain position and providing that not more than one such length is used in any one span of one conductor. Lengths of conductor of less than 30 m shall not be included in the line except as bridging conductor at strain structures.

The Contractor shall carefully plan the optimal usage of drums and the run out of OPGW so as to minimise the number of joints and the wastage of OPGW. OPGW joints at termination and strain poles will be preferred however it is likely that joints at suspension and flying angle poles will also be required.

The Principal will be entitled to charge the Contractor for OPGW if its usage exceeds 105% of the route distance.

11.3 Crossing of Obstructions

The Contractor shall construct the powerline works over or adjacent to any existing power lines, telephone lines, railway lines, main roads, navigable streams or any other obstructions. In all cases where the transmission line crosses such obstructions, the Contractor shall make all necessary arrangements and obtain the required approvals for such crossings. All costs of services provided for the crossing of these works will be met by the Contractor.

For the purpose of this contract the Principal’s charges to the Contractor for powerline crossings shall be deemed to apply at the rates in the Contract for Miscellaneous Works.

The Contractor shall give the Superintendent at least four weeks’ written notice of his intention to carry out such work adjacent to or over powerlines. The Principal will not accept responsibility, nor will extensions of time be granted, for any delays resulting from notice of less than this time having been given.

The powerlines shall generally be crossed by stringing under the existing energised line. The Contractor shall provide hold-down blocks and protective hurdles for each conductor and earthwire at the crossing. The arrangement and detail of the hold-down facilities at each crossing shall be subject to the Superintendent’s approval. It may also be necessary to leave the conductors and earthwires off a pole adjacent to a crossed line or support them in sheaves on a lower position on the structure. Following completion of the runout, an outage of the powerline shall be arranged during which the powerline conductors will be cut and passed under the construction in conjunction with the Contractor’s operations of pulling up the conductors to their correct height.

When the new conductors are pulled up to their correct location the Contractor shall make the line safe by attaching slings to each conductor and earthwire at the structures either side of the crossing until these structures are clamped in.

Alternatively, for some of the crossings there may be a strain structure on one side of the crossing. The contractor shall string to the strain structure on one side and to blocks on the other side. During an outage on the line the conductors and earthwires shall be passed over and terminated and sagged.

Operational restrictions may necessitate runouts being shorter than the optimum and run-outs may have to be made at specific times to minimise the effects on the crossed facility. The Contractor shall plan and co-ordinate his entire stringing operation so that interruption times for crossed facilities are both minimised and made at the required times nominated by the Superintendent. All costs involved e.g. stand-downs, overtime, weekend working etc., shall be borne by the Contractor.

When stringing across roads, the Contractor shall erect and maintain at his own expense road signs complying with AS 1742 - “Manual of Uniform Traffic Control Devices”.

Sugar cane and other crops may be encountered beneath sections of the transmission line. The Contractor shall carry out stringing in these areas by using existing headlands and farm tracks as far as practicable. Where clearing of cane or crops is essential to the stringing operation, the Contractor shall give the Superintendent 4 weeks’ written notice of the areas through which he requires access. The Principal will arrange for the necessary clearing, which may be confined to a clear walking track; any other clearing required by the Contractor shall be subject to the Superintendent’s approval.

During the running out and erection of conductors and earthwires, all structures, roads, obstructions (excluding power lines and electrified railways), and fences crossed shall be adequately protected by approved hurdles or other protective structures. No fence shall be cut, lowered or damaged in any way. The cost of these hurdles and other protective structures shall be included in the Schedule of Rates for Stringing.

Costs of services provided by the Principal such as clearing, de-energising, lowering, dismantling or undergrounding of power lines and electrified railways shall be borne by the Contractor. Thus all costs associated with crossing of obstructions including all of the charges from the Principal and the provision for hurdles or other protective devices shall be deemed to be included in the Schedule of Rates for Stringing.

11.4 Restrictions on the Use of Joints

A mid-span joint in a conductor or an earthwire shall be not closer than 8 m to a suspension insulator string or closer than 30 m to a tension string. Not more than one joint shall be used in any one conductor or earthwire in any one span. A mid-span joint shall not be located in spans crossing railway lines.

Where a compression fitting is to be pulled over a stringing sheave it shall be protected by an approved oversleeve. The design and use of protective oversleeves shall be subject to the approval of the Superintendent. The sleeves shall be numbered to aid in identification. Protective oversleeves shall not be pulled under tension through a structure having a resultant conductor deviation angle greater than 25 degrees.

Where compression fittings are required to pass through deviation angles greater than 25 degrees, the conductor tension at the angle shall be reduced to not greater than 15% MCBL and the joints shall be lifted through the sheave in a manner approved by the Superintendent so as to minimise bending stresses on or near the joints.

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11.5 Tension Stringing Method

Conductor shall be run out at as low a tension as possible and such that the conductor does not contact the ground, protective hurdles, or other obstructions during the run-out. The speed of the conductor run-out shall not exceed 5 km/hr, nor shall the conductor tension in any span along the run-out exceed 22% MCBL. The Contractor shall be responsible for the provision of sufficient tension measuring devices to demonstrate to the Superintendent compliance with this tension limitation, and shall provide the Principal with current calibration certificates for the tension measuring devices prior to their use on the work and if required by the Superintendent during the currency of the work.

The tension measuring devices at the winch shall be arranged such that the tension in the conductor is continuously monitored and such that hauling of the conductor is automatically stopped should the nominated runout tension be exceeded.

The Contractor shall use an approved reliable signalling and communications system between the winch, brake, and strategically placed observers during stringing and sagging of earthwire and conductors. Throughout the run-out the Contractor shall maintain continuous visual monitoring of the lead end of the conductor and earthwire as well as any compression joints fitted to either the conductor or earthwire.

The number of conductor drums which may be run out simultaneously in any one pull length shall be subject to the approval of the Superintendent. Should the Superintendent judge that in practice the Contractors' stringing programme has underestimated the tension increases due to terrain, line deviation, and sheave losses, the maximum number of drum lengths run out simultaneously shall be limited to two until such time as the Contractor's programme can be corrected.

Under no circumstances shall the conductor or earthwire be pulled through a sheave where the resultant deflection angle of the conductor or earthwire at the sheave is greater than 25 degrees; nor shall they be pulled through an accumulated line deviation angle, in any one run-out, of greater than 90 degrees without the written approval of the Superintendent.

11.6 Slack Stringing Method

Where slack stringing is approved by the Superintendent, the conductor shall be run off moving, rotating drums and laid stationary on the ground. The hauling of conductor from stationary drums shall not be permitted. The drums of conductor shall be mounted on a suitable vehicle and moved along the length of the line with the outer end of the conductor anchored at the starting point of the run. The rotation of drums shall be controlled to prevent their over-running. Conductor shall be passed through stringing sheaves at each structure as run-out proceeds, and particular care shall be taken to protect the conductor against damage on rocky surfaces, fences and other obstructions by the use of hurdles, protective matting or other approved means.

12. Sagging of Conductors and Earthwires

12.1 General

The Contractor shall sag the conductor and earthwire by employing the "Time Compensation" method. The same method shall be employed for all run-out sections between strain structures unless otherwise approved by the Superintendent.

All sagging and the making off of all conductors and earthwires shall be carried out in the presence of the Superintendent. Responsibility for ensuring correct sag shall nevertheless rest with the Contractor. The Contractor shall ensure that stays are adjusted prior to final sag measurement and that structures remain within applicable tolerances for verticality and deflection.

The Contractor may be called upon to provide assistance to the Superintendent in his verification of the Contractors measured sags.

Where directed by the Superintendent, the Contractor shall employ offset clamping methods during sagging.

Within 4 weeks of receipt of the Contractor's detailed stringing programme, the Principal will provide the Contractor with sag and tension data to be used for both the conductor and earthwire. This data will show sags both in sheaves and in clamps. Presag data and temperature corrections will also be supplied for use with Time Compensation sagging.

In addition the Principal's data will show offsets for clamping. This data is supplied as information only. The responsibility for ensuring correct sag in clamps and vertical insulator alignment remains with the Contractor.

Should the Contractor alter his stringing programme subsequent to the provision of this data by the Principal, the costs of any necessary recalculation of the sagging data shall be borne by the Contractor.

The temperature of seven wire conductors and earthwires shall be deemed to be their surface temperature. The temperature of other conductors and earthwires shall be deemed to be their core temperature. Conductor and earthwire temperatures shall be measured at their installed average elevation above ground level while exposed to sun and wind.

Neither the conductor nor the earthwire shall be sagged when the wind is gusting at velocities in excess of 5 m/s (10 knots), or while it is raining.

12.2 Initial Condition Method

The Initial Condition Method shall be used to sag conductors and earthwires where the tension after run out and before sagging has been maintained at 17% MCBL or less.

Using this method the Contractor shall sag the conductors and earthwires within 10 days of completion of run out using the initial sag/tension data supplied by the Principal.

12.3 Time Compensation Method

The Time Compensation Method shall be used to sag conductors and earthwires .

Using this method the Contractor shall pre-sag the conductor or earthwires to the nominated sagging tension within 24 hours of the completion of run-out. Pre-sags shall be measured in one span near the midpoint of the run out. After 12 hours, but within 72 hours of completing pre-sagging, the Contractor shall final sag the conductors or earthwires to the time/creep compensated sag and tension data supplied by the Principal.

12.4 Measurement of Sag

Regardless of the method selected, no more than two nominal drum lengths or twenty spans, whichever is the lesser, shall be final sagged at any one time. Sags shall be measured by the Contractor in the following locations in spans approved by the Superintendent:

(i) one location per drum length;

(ii) a span adjacent to a line deviation angle exceeding 15°;

(iii) all spans greater than the ruling span by 150 m or more.

When sight boards and sighting telescopes are used for sagging, they shall be accurately located with respect to the conductor or earthwire and shall be firmly attached to the structures.

Should the conductors or earthwires be overtensioned by more than 10 percent during sagging, the Contractor shall reduce the applicable conductor or earthwire tensions to approximately 15% MCBL and sagging shall be repeated.

After final sagging, the conductors and earthwires shall be transferred from sheaves to suspension assemblies as soon as possible and within 72 hours.

When the "Time Compensation" method is being used, the pre-sagging tolerance for conductors shall be plus or minus 4%.

The final conductor position in the sheaves shall be:

(i) No higher than 0.5% of design sag or one cable diameter, whichever is greater, above design position, or

(ii) No lower than 1% of design sag or three cable diameters, whichever is greater, below design position, and

(iii) Where there is more than one subconductor per phase, the greatest difference in subconductor spacing for a vertical bundle, with respect to the design bundle spacing, or the greatest difference in subconductor sag for a horizontal bundle, shall not exceed one conductor diameter.

Additionally, fourteen days or more after having been clamped-in, the maximum difference in sag between any two phases in any given span shall not exceed 2% of the actual sag or 150 mm, whichever is the greater. Where there is more than one subconductor per phase, the difference in subconductor sag in any given phase shall not exceed two conductor diameters.

The final earthwire position in the clamps shall be no higher than 1% of design sag above design position nor lower than 2% of the design sag below design position.

13. Installation of Insulators and Line Fittings

13.1 Insulators

Insulators shall be installed as shown on the Drawings. Immediately prior to installation all insulators shall be cleaned in a manner approved by the Superintendent.

When installing ceramic type insulators the Contractor shall take care that they are not chipped or otherwise damaged. Damaged insulators shall not be erected. Strings of disc insulators shall be hauled so as to minimise loading stresses on the insulator pins and security clips.

Non-ceramic composite insulators shall not be removed from their protective packing, if so supplied, until immediately prior to installation. When directed by the Superintendent, covers shall be installed over the insulator sheds to prevent damage from birds. The covers shall be removed just prior to energisation of the line. If this occurs sometime after practical completion of the line then Ergon will remove the covers that will become Ergon's property. The design of the covers shall allow easy removal.

At the completion of conductor clamping, all insulator assemblies on in-line suspension structures and all jumper assemblies on strain structures shall hang vertically. Insulator assemblies on angle suspension structures shall be on the bisector of the horizontal conductor angle.

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Deviation from correct alignment at the end of the insulator assembly shall not exceed 100 mm.

13.2 Compression Fittings

Conductor joints and termination fittings will be of the compression type unless otherwise specified.

All compression fittings shall be made in accordance with the manufacturer's recommendations and their requirements.

The inside of all compression fittings, the outer conductor and the exposed steel core (for ACSR) shall be thoroughly cleaned of all grease with a suitable solvent and dried before compression. In preparing ACSR cable for jointing particular care shall be taken to ensure that the steel strand of the core is not cut or nicked by the cutting tool. The innermost aluminium layer shall be only partially cut and then broken off. The lay of all the conductor strands and core shall be maintained during preparation and compression of the joint.

The outer strands of the conductor shall be thoroughly scratch brushed until shiny, wiped clean, and immediately liberally coated with an approved jointing compound, before compression of the outer sleeve. The joint as a whole and the line of compressions along the outer sleeve shall be straight after compression.

Prior to commencement of stringing, the Contractor shall make up a test sample for each size and type of cable requiring compression fittings. Each sample shall consist of a length of cable, one centrally located mid span joint and two termination fittings. The overall length of the assembled sample shall be between 5.5 and 6.0 metres.

Test samples shall be produced in the presence of the Superintendent, using dies and presses that will be in use on the job. The samples will be subjected to tensile and other tests by the Superintendent at the Principal's cost to verify the adequacy of the Contractor's equipment and installation techniques. If the Superintendent is not satisfied with the test results, which can be attributed to the Contractors process or equipment, the Superintendent may direct further tests to be undertaken at the Contractors cost. Field joints shall be made by the Contractor in the same manner as the test joints unless directed otherwise by the Superintendent.

13.3 Preformed Fittings

All preformed fittings shall be installed in accordance with the manufacturer's recommendations.

The outer surface of the cable shall be thoroughly cleaned of all grease with a suitable solvent and dried before application of the preformed fitting.

Preformed fittings for use in tension positions shall not be re-applied. Such a fitting shall be destroyed after its first removal.

13.4 Tension and Suspension Assemblies

Tension and suspension assemblies shall be assembled and erected as shown on the Drawings. Armour grip suspension units shall be installed such that the ends of preformed rods do not differ in alignment by more than 15 mm.

Safety goggles shall be worn by workers handling, tensioning, or clamping in glass insulators (in case of spontaneous shattering of the glass).

13.5 Bridging Assemblies

The Contractor shall install bridging conductor such that the electrical clearances are maintained. Where a bridging insulator string is employed, the conductor length shall be such that it exerts a

positive weight downwards on the bridging insulator string or post insulator. The bridging conductors shall hang neatly without twists and kinks.

Where directed by the Superintendent, all metallic contact surfaces between adjacent ceramic insulator discs shall be treated with an approved conducting grease applied in a manner approved by the Superintendent. The cost of the grease and its application shall be included in the appropriate schedule rate.

The contact surfaces of bolted conductor palms shall be thoroughly scratch brushed until shiny, wiped clean, and immediately lightly coated with an approved jointing compound, before bolting of the palms.

13.6 Vibration Dampers

The Contractor shall install vibration dampers on conductors and earthwires in accordance with the Drawings and the manufacturer's instructions. Vibration dampers shall be installed at the same time that the conductor is clamped in.

The Superintendent may require the Contractor to install additional dampers at specified locations. The installation of all dampers will be paid for at the appropriate schedule rates.

13.7 Spacers

On bundled conductors, spacers shall be installed at the locations nominated in the Schedules. The spacers shall be installed in accordance with the manufacturer's instructions.

13.8 Other Fittings

Where required on the Drawings, other fittings such as aircraft warning spheres, parallel groove clamps and counterweights shall be installed in accordance with the Drawings and the manufacturer's instructions. Installation of these items shall be included in the rates in the "Erection of Line Materials" schedule.

13.9 Transpositions

Where required, phase transpositions will be effected by rolling the phases over two spans with the orientation of crossarms reversed on the middle structure or the transpositions may occur when changing from vertical to horizontal configuration. The Contractor shall allow for such costs of two transpositions in the tender rates for stringing and structure erection.

14. Requirements for OPGW

Where the requirements for handling, installation ect. of OPGW given below are inconsistent with that provided on the manufacturers data sheets, the most onerous condition shall apply. If any doubt exists as to which document applies this shall be determined by the Superintendent.

14.1 Cable Delivery

14.1.1 Reels (Drums)

The optical ground wire (OPGW) will be shipped on reels having sufficient strength to carry the required length of cable and to allow the cables to be de-reeled under controlled conditions. The reels will be constructed of wood or steel and will be returnable or non-returnable as agreed with Ergon Energy Corporation Limited. The cable will be protected by the use of lagging and the inner end of the OPGW will be readily accessible for test purposes. Both ends of the OPGW aluminium tube will be capped to prevent water entry into the optical core.

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14.1.2 Transport and Handling

Reels are so constructed that they must be supported either on an axle through the arbor hole or by the reel flange. At all times, during transportation and storage, the reels shall have their flanges in a vertical plane. The reels shall never be stored or transported horizontally on their flanges.

Proper equipment shall be available to lift the reels from the delivery vehicle. The hoist shall have sufficient capacity for the weight involved. When the reels are lifted by an axle, a spreader bar shall be employed to prevent damage to the OPGW and the reel caused by inward pressure on the reel flange. The reels shall not be rolled off the delivery vehicle.

14.1.3 Inspection

The reels are to be inspected prior to pickup from Ergon Energy and any damages reported to the Superintendent's Representative. Drum numbers should be recorded as part of the Contractor's Quality Assurance.

14.1.4 Test Data

A copy of the Certified Test Report from the manufacturer will be made available for each drum upon request. This indicates the condition of the optical fibres prior to shipping the OPGW.

14.2 Pre-Installation Testing

14.2.1 Procedure

The attenuation of all optical fibres shall be checked by the Contractor at Ergon's Store. This will eliminate any possible concerns or disputes, which may occur when the cable is tested after installation. Attenuation data will be compared with that included on the Certified Test Reports supplied from the manufacturer.

After completion of this test, the Contractor shall seal the cable against water entry. This practice will be observed after each subsequent test, prior to splicing. Plastic caps shall be fitted using adhesive plastic tape to seal the ends.

14.3 Installation Guidelines

14.3.1 General

Factors that can cause possible fibre damage, if they are excessive, are as follows:

a) Tension
b) Twisting
c) Bending
d) Crushing
e) Vibration

14.3.2 Recommendations

Refer to the summary of key parameters above which are reviewed in more detail below.

a) Excessive tension can cause fibre breakage due to cable elongation. The OPGW is designed to withstand the anticipated environmental conditions without excessive elongation. However, for installation and stringing purposes, the OPGW is limited to a maximum allowable tension of 20% of UTS. This value must not be exceeded unless written authorisation is granted by the Superintendent's Representative or otherwise specified in the project specific portion of the specification. It is recommended that tension monitoring and automatic cut-off devices be employed to prevent such an occurrence. It is also important that the tension be applied smoothly and uniformly.

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b) Excessive twisting will cause fibre breakage. Since OPGW (particularly single layer designs) has a tendency to twist during installation, it is important that measures be adopted to prevent this from occurring. The recommended solution is to use an “anti-twist” device.

c) Bending will cause damage if the bending diameter of the OPGW during installation is less than 800 mm for single layer designs and less than 1,000 mm for double layer designs. Equally, damage will result if the diameter is less than 1,000mm in the fixed static position after installation. An OPGW that has been subjected to smaller diameter bends during or after installation is likely to experience deformation of the optical tube assembly or distortion of the wires which may reduce the life expectancy of the cable. During installation of the OPGW, all stringing sheaves must have a minimum diameter of 400mm.

d) Crushing will damage the inner aluminium tube that houses the optical fibres. Care must be taken in selecting sheaves to ensure that their profile is suitable for the particular size of OPGW being installed. It is also important that all tools and hardware to be used in conjunction with OPGW be suitable for the specified OPGW. This applies to dead-end fittings, suspension fittings, downlead clamps, come-alongs, etc.

e) Excessive vibration will cause long term damage to the metallic components of OPGW. This is controlled by the use of dampers. It is also important that vibration, and other movement be controlled immediately after installation. For this reason the OPGW shall be permanently clamped within 48 hours of being run out. Otherwise wind could induce vibration or reciprocating longitudinal movement, which could have harmful effects on the aluminium tube, which is an important part of the fibre protection.

14.4 Installation Equipment

14.4.1 General

The installation equipment required for OPGW is generally the same as that used for regular ground wire.

14.4.2 Reel Pay Off Stand

A reel pay off stand capable of handling reels up to 2,750 mm diameter, 2,160 mm overall width and 13,600 kg in weight is recommended. This is the maximum reel size that may be supplied. Specific smaller reel sizes may be used on particular projects. The equipment should be capable of handling reel shafts of diameter in the range 76 - 83 mm or 127 - 134 mm. The unit shall be capable of applying sufficient back tension to prevent overrun. This typically being in the range 70 - 200kg.

14.4.3 Bullwheel or Tensioner

The bullwheel diameter shall not be less than 800 mm for OPGW designs with single wire layer and not less than 1,000 mm for designs with 2 wire layers. The bullwheel groove shall be U shaped and large enough to accommodate the OPGW without the OPGW protruding above the surface of the bullwheel. This unit shall be capable of applying a uniform back tension on the OPGW that must be controllable up to at least 2,000kg.

OPGW is typically left-hand lay, and the bullwheel must be reeved from the right to left in this instance. Refer to figure II in IEEE Std 524.

14.4.4 Sheaves (Travellers or Pulley Blocks)

Sheaves are to be used at each structure to allow the OPGW to be pulled along the route. The maximum number of sheaves to be used in any single pull shall be limited to 25. All sheaves must be a minimum of 400 mm in diameter and must be lined with polyurethane or other similar material that is sufficiently hard to prevent the OPGW from climbing up the side of the groove. The sheave

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diameter is important in order to prevent damage or deformation to the tube containing the fibre optic units.

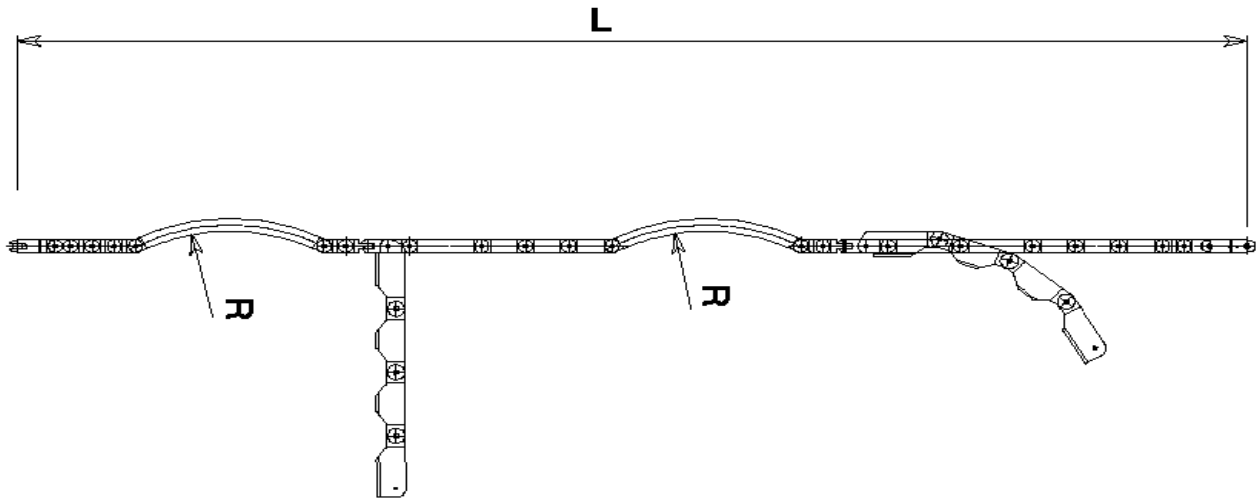
The minimum diameter at the base of the groove is recommended to be 1.10 times the diameter of the OPGW. The depth of the groove shall be a minimum of 25% greater than the diameter of the OPGW. The sides of the groove should flare between 12° and 20° from the vertical to facilitate the passage of swivels, grips, etc., and to contain the OPGW within the groove, particularly at line angles. The bearings should preferably be ball or roller type with adequate provisions for lubrication and shielding against contamination.

At structures where the transmission line horizontal deviation is less than 20° and/or the contact angle around the sheave is less than 45°, only one sheave is necessary. Where the transmission line horizontal deviation is between 20° and 60° and/or the contact angle around the sheave is greater than 45°, a double or multiple sheave arrangement must be used. Pulling through transmission line horizontal deviations greater than 60° is not recommended.

14.4.5 Anti-twist Devices

During the installation of any single layer OPGW there is a strong tendency for the cable to twist and it is important to prevent this by the use of an anti-twist device. The anti-twist device must be rigidly fixed to the leading end of the OPGW so that relative twisting between it and the OPGW is prevented. A swivel is required to connect the draw wire (rope) to the anti-twist device.

There must be at least 2 drawback counterweights to avoid cable twisting as one counterweight passes through the sheave. The counterweights should be flexible in the longitudinal direction (to allow folding when passing through the sheaves), and rigid in the lateral direction (to cause an increasing restoring torque if the unit starts to twist). The lengths of the counterweights should typically be 1.0 - 1.5 m and they're spacing slightly more, approximately 2 m. A minimum restraining torque of 5 kg/m per counterweight is recommended.



14.5 Pulling

14.5.1 OPGW Tensions

It is every important that the pulling tensions be uniform and that the maximum tension shall not exceed 20% of the rated tensile strength of the OPGW. The pulling device shall be capable of being pre-set at a chosen maximum tension value and have an automatic cut-off if that value is exceeded.

The tension between the pay-off reel and the bullwheel shall be less than 70 kg for single wire layer designs and less than 200 kg for double wire layer designs. The pulling speed should be less than 3 km/hr with a constantly applied tension.

14.5.2 Angles

The back tensioning unit (brake) and the pulling unit (winch) should be positioned at a sufficient distance from the end structures such that the angle between the line to the structure sheave and the horizontal shall not exceed 30°. For angles greater than 30° a calculation similar to that given in Appendix A of *IEEE Guide to the Installation of Overhead Transmission Line Conductors* (IEEE Std 524 – 1992) must be performed to ensure safe loading on the crossarm, insulator string and sheave. In addition the bearing pressure between the OPGW and the sheave lining must be less than 3.0 MPa as calculated from Appendix C of IEEE Std 524.

As mentioned in section 14.4.3, if the transmission line horizontal deviation at tower structures is less than 20°, a single lined sheave may be used (minimum diameter 400 mm). For angles between 20° and 45°, lined double sheaves are required and above 45°, 3 more banked sheaves shall be used. Pulling through transmission line horizontal deviations greater than 60° is not recommended.

14.5.3 Bending Diameters

After installation, the OPGW should not be subjected to permanent bends of less than 1,000mm diameter.

14.5.4 Pulling Grip (Stocking, Sock of Woven Wire Grip)

The pulling grip used to connect the anti-twist device to the cable may be any device that will grip the cable securely without allowing any twisting to occur. If a stocking type grip is used, care must be taken that the OPGW is inserted fully into this type of grip.

14.6 Temporary Clamping

14.6.1 Background

After running out the OPGW it will be suspended in the sheaves and it will be relatively free to move longitudinally. If there is a significant time (for instance overnight) before the clamping is completed, wind forces may cause vibration and longitudinal movement, which could cause damage to the OPGW.

14.6.2 Procedure

Under the circumstances described above, the OPGW shall be clamped-in and vibration dampers fitted at every fifth structure to restrict longitudinal movement and vibration. The final clamping process shall be completed within 48 hours of stringing.

14.7 Sagging

14.7.1 General

Normal sagging procedures are used in conjunction with the line hardware items specified elsewhere. Sag and tension data will be supplied by Ergon Energy Corporation Limited.

14.7.2 Come-Alongs

The Principal recommends use of dead ends to hold OPGW tensions. Care shall be taken to ensure that tools used as come-alongs (if used) do not exert excessive compressive force on the OPGW.

14.7.3 Angle Structures

The OPGW may not necessarily be spliced at every angle structure and a loop is required to alleviate mechanical pressure from the cable. To achieve this requires the removal of slack from an adjacent span. To avoid over tensioning the OPGW, careful planning is required prior to stringing and sagging.

14.7.4 Splicing

There is one primary difference between OPGW and normal overhead ground-wires. Normal overhead ground-wires are typically spliced midspan with a compression type connector. OPGW, on the other hand, is typically spliced at a pole. A long tail is therefore required to make up the connection. The length of the tail is typically equal to the height of the structure plus another 10m. Depending on the particular splice box arrangement being used the tail is coiled up with a diameter not less than 1000 mm and mounted with the slice box part way up the structure. Sometimes the splice box is placed inside a pit at the base of the structure. For this situation the length of the tail remains the same and the OPGW is enclosed in conduit in the ground and partway up the structure. In this situation the conduit may need to be installed with the construction of the foundation. The location of splice boxes shall be nominated on the drawings or in the Main Specification.

14.8 Summary of Key Parameters for Installation

The following is a summary of key parameters to be met during OPGW installation:

Stringing Tension	20% of UTS (max)
Bullwheel Diameter of Tensioner/Brake Single layer OPGW Double layer OPGW	 800 mm (min) 1000 mm (min)
Bending Diameter – After Installation (Static) Single layer OPGW Double layer OPGW	 1000 mm (min) 1000 mm (min)
Sheaves Diameter Number per pull	 400 mm (min) 20 (max)
Horizontal Line Deviation Angle Less than 20° Between 20° - 45°	 Single sheave Double sheaves
Total Contact Angle Over the Sheave Less than 45° Greater than 45°	 Single sheave Double or multiple sheaves
Anti-Twist Device Counterweight length Restraining torque per counterweight Spacing between counterweights	 1.0 to 1.5 m 5 kg.m (min) 2 m
Installation speed	3 km/hr (max)
Pay-off tension from reel Single layer OPGW Double layer OPGW	 70 kg (max) 200 kg (max)

14.9 Splicing and Termination of OPGW

The Contractor shall carry out the fibre terminations by fusion splicing methods such that the signal attenuation at each joint is less than 0.3 dB at 1310 nm and at 1550 nm. The average loss for all joints in any one fibre from substation to substation shall not exceed 0.12 dB. The fibre shall be arranged in the termination boxes with loops contained within trays in an orderly and consistent identifiable pattern with sufficient slack to allow re-jointing without resorting to extra OPGW cable.

The Contractor shall be responsible for sealing the termination boxes such that they are watertight. The boxes and coiled OPGW shall structurally secured in a neat and tidy manner. Materials used for securing the OPGW and the terminal boxes shall be durable to give the required maintenance free design life of 50 years.

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14.10 Post Installation Testing

The attenuation of all fibres shall be checked with an OPTDR by the Contractor after installation of the OPGW and splicing of the fibres. The Contractor shall be responsible for all work and materials required to remedy any fibre defects that occurred during installation or for the remaking of joints that do not meet specification requirements.

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