NSP/004/125 – Code of Practice for the Installation of (ADSS) Fibre Optic on Overhead Lines

1. Purpose

The purpose of this document is to provide guidance on the installation of ADSS (All Dielectric Self Supporting) Fibre Optic Cable on overhead lines located on the Northern Powergrid distribution system.

This document supersedes the following documents, all copies of which should be destroyed.

Reference	Version	Date	Title
n/a			

2. Scope

This code of practice applies to the installation of ADSS fibre optic conductor onto existing 11-132kV Overhead Line supports for use on the distribution system of Northern Powergrid.

2.1. Table of Contents

3. Technical Specification

3.1. Introduction - ADSL Benefits

ADSS cable differs from other OHL optical fibre cable technologies as it is physically separate from the OHL conductors of the electricity transmission or distribution network; this is one of the main advantages of ADSS cable. This segregation has the advantage that the operation and maintenance of ADSS cables and components will cause minimum disruption to the electricity network and vice-versa. This advantage applies even more so on 132 kV systems, where clearances are greater.

Being all dielectric, the cable is non-conductive and simple procedures, such as using running earths, can ensure safety from the system during ‘live line’ installation. Fittings can be easily bolted to the wood pole, where modification to the pole will not be required unless it is already near its load limit.

On tower routes there is usually sufficient clearance to install ADSS cable although some modification might be required to tower steelwork at the attachment location. ADSS cable can support much higher fibre counts than other optical cable technologies. With current designs, counts of up to 432 fibres can be accommodated if required. Depending on the design and construction of the line, the costs for installing ADSS cable lies somewhere in the range of costs between that for fibre wrapped and OPGW cable

3.2. General Considerations

The decision whether to install ADSS cable in favour of OPGW or fibre wrapped cable is not a simple one. Considerations of cost, outages required, time to install, maintainability and reliability all play important parts in the decision process when evaluating ADSS technology. Some of the considerations and skills required are like those encountered when installing new conductor on an OHL, where others will be old.

Considerations particular to installing ADSS cable on an existing OHL are explored in this guidance document.

A line survey should be conducted to determine the suitability of a route for ADSS cable.

The key issues (many explored in more detail below) to be addressed include the following:

- Are the support structures, poles or towers, in good condition?
- Is there sufficient strength in the structure to withstand the additional loads?
- Can the ADSS cable be suitably positioned on the structure?
- Is there shotgun activity that takes place along the route?
- Is strength co-ordination a necessary concern?
- Are suitable installation and maintenance procedures available?

Installing an additional cable will have little visual impact on a dual circuit route but might be more noticeable on a single circuit route, especially on a pole route where the ADSS cable will be mounted below the conductors. This could be of significance in sensitive environmental areas.

3.3. Condition and Strength of Support Structures

3.3.1. General

Installing ADSS cable on an OHL is essentially the same as installing an extra conductor. The tension in the ADSS cable will add to loads at terminal and angle structures, while the extra vertical and lateral loads resulting from weight and wind resistance respectively will impact all structures. Whilst the weight and tensile loads, including those under wind and ice conditions, associated with ADSS cable are often relatively small compared to conductors, they are not negligible and increased wind loadings can be very significant.

As a result, it is important that existing structures intended for the installation of ADSS cable are assessed to ensure they have sufficient strength, and that strength is not compromised by being in poor condition. In general terms, a project to install an ADSS cable should be treated in much the same way as an OHL refurbishment, where “decayed” and “suspect” poles should be changed, and badly corroded tower steelwork should be replaced if it will experience increased loadings.

It is recognised that a full design analysis can be quite involved and, often, an initial rough approximation is desirable in order to establish the feasibility of an ADSS cable installation. The paragraphs below provide this rough guidance.

It is important that structural loads under design wind and ice loading conditions applicable to the OHL are always fully assessed to ensure that design standards are not infringed.

Very generally, lines comprising lattice steel tower structures will accept the addition of an ADSS cable with very little, if any, modifications required to provide additional tower strength. Towers are designed in such a way to accept certain maximum span lengths and angles of deviation which, due to restrictions on where they can be placed, are rarely fully exploited. However, at the ideal landing place for an ADSS cable there could be no tower metal work to provide an attachment for cable fittings or the existing metalwork might need reinforcing.

As a rough guide, providing angle towers are not being used to within, say, 5° of their design maximum deviation angles, and that no structures are carrying more than around 80% of their design maximum sum-of-adjacent span lengths, then ADSS cable installation is unlikely to cause any design loading issues.

ADSS cable installations on wood poles, however, are likely to be less straightforward. Wood pole structures are less standardised than steel towers and they are often built closer to their design limits.

Typically, however, pole structures with stay wires fitted, i.e. sections and pin angles, present a low risk of being overloaded by the addition of ADSS cable. The additional strut loads on poles are relatively low and, where stays become overloaded, these can easily be upgraded.

Structures presenting the highest risk of overload are intermediate wood pole structures, where no stays are fitted. While the impact of the ADSS cable tension is zero, and the additional weight is negligible, the impact on wind loading is very significant.

3.3.2. Wind Loading of Intermediate wood Poles

While ADSS cable is very light and is installed at significantly lower tensions than phase conductors, its outer diameter will contribute to wind loading in exactly the same manner as phase conductors. Put simplistically, installing an ADSS cable of the same diameter as existing phase conductors on a standard three-phase 11 kV OHL will result in an approximate increase in the wind loading on the poles of 33%. Few existing unstayed poles will have this level of reserve capacity.

With wood pole OHL design standards, wind loading capacity of intermediate poles is typically expressed as an allowable wind loading span length, which is dependent on the conductor type, pole length, pole grade, pole planting depth, and how many, if any, foundation baulks are installed. Where such design information is available, the impact of the addition of ADSS cable can be easily assessed by a prorate comparison of the windage created by the ADSS compared to the equivalent windage created by the existing conductors compared to the maximum allowed windspan available at the support.

This approximation will be slightly conservative given ADSS cable is installed lower down the pole than the phase conductors. Even if the ADSS cable contributes the same lateral force as a phase conductor, the effect on pole bending moment will be reduced.

Wood pole intermediate structures can be reinforced by the addition of wind stays, where stays are fitted each side of the pole to resist the lateral forces resulting from wind loading. While this is an easy retrofit, it does require a significant footprint. A more compact solution is to change single pole structures to H pole or Rutter pole structures. Where structural modification cannot be achieved, span lengths will need to be shortened by the imposition of additional poles.

3.3.3. ADSS Cable Positioning

3.3.3.1. General

There are several factors that need to have been taken into account when determining the position of ADSS cables on a tower or pole system.

a) Space potential.

b) ADSS cable clashing.

c) Strength of structure at attachment position.

d) Clearances to ground, obstacles, and conductors.

Different routes will have different constraints. What is a limiting factor on one route might not be the limiting factor on another? The factors (see a) to d) above) are the main considerations that should be taken into account, where all factors should be considered; there is no particular order that is recommended. Adjustments to location of the ADSS cable should be made if any one factor becomes a limiting factor.

An overriding consideration is the requirement for an attachment location on the structure to be available that does not interfere with any existing structure-mounted plant or equipment, such as pole mounted transformers and switches. Where such equipment exists on structures selected for ADSS cable installation, the ADSS cable should not restrict access to or maintenance of that equipment. This is not generally an issue at 132 kV but will be a major consideration at 11 kV.

3.3.3.2. Space Potential

A phenomenon known as dry-band arcing can take place if the space potential where the ADSS cable is installed is too high. Dry-band arcing has the ability to destroy the cable very quickly, i.e. in a matter of hours, once it starts. Under normal operating conditions the space potential is determined by the following factors.

- System voltage.
- Phasing arrangement (both electrical and physical position).
- Clearance between the ADSS cable and live conductors.

On dual circuit lines the space potential with only one circuit live should also be considered, as this will significantly change the space potential around the ADSS cable.

On some dual circuit routes, power flows are in opposite directions in each circuit. Power flows have no consequence on the calculation of space potential and calculations can therefore be performed without knowledge of the power flow direction or magnitude. Recommendations on optimal phasing to reduce EMFs change with the direction of power flow in each circuit. Dual circuit lines with power flows in the same direction are recommended to have alternate phasing side-to-side, whilst lines with opposing power flows are recommended to have the same phasing on each side. The phasing arrangement will significantly affect the space potential around the conductors and consequently the optimum position for the ADSS cable. A significant change to the space potential will also occur if there is a single circuit outage on a dual circuit line. It is recommended that, where it is likely that the phasing arrangement could change on a route, parallel phasing, as well as a single circuit outage are considered to determine the worst case when calculating the space potential.

Experience has shown that at a space potential of 10-12 kV, dry-band arcing can start although this will depend to an extent on the sheath material of the ADSS cable. The space potential level at which damage occurs to the ADSS cable, is further affected by the level of pollution. Salt pollution in coastal areas can be particularly problematic. An assessment of these factors is necessary before installing ADSS cable.

Given the required information, the cable manufacturer is usually best placed to advise on the siting of the ADSS cable, taking into account the space potential, the level of pollution, and the characteristics of the sheath material.

3.3.3.3. Pole Routes

The recommended position should be such that there will be no contact between the ADSS cable and the phase conductors or static wires, either at the pole or mid-span, during installation or under maximum environmental load conditions. The space potential plots for various phase-to-phase system voltages are illustrated below.

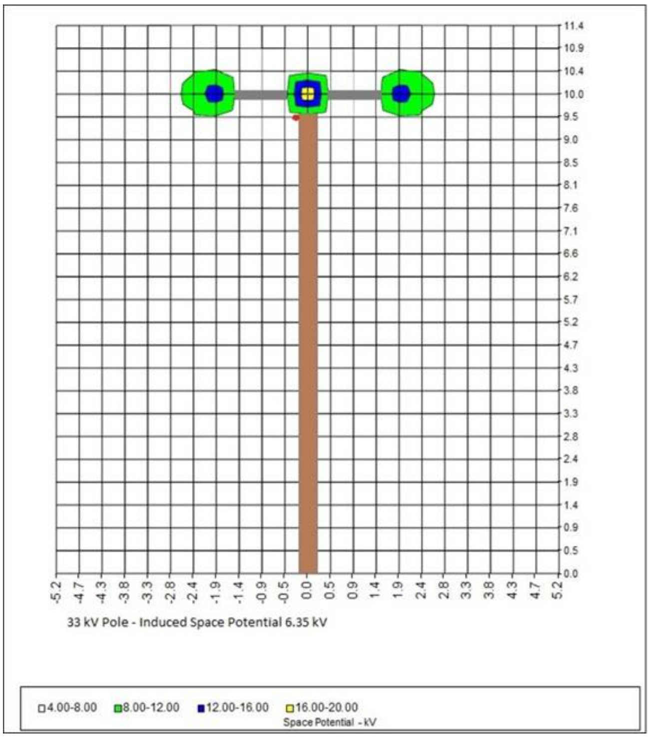


Figure 1 — Space potential plot for 33 kV

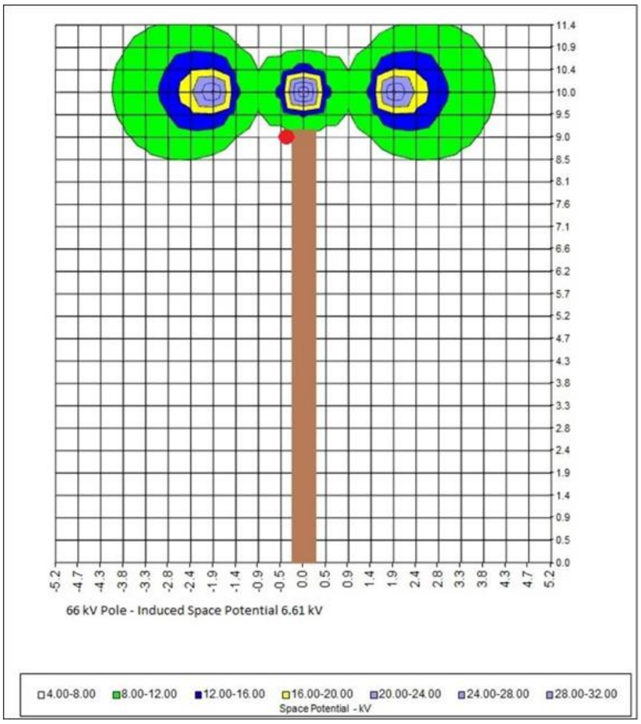


Figure 2 — Space potential plot for 66 kV

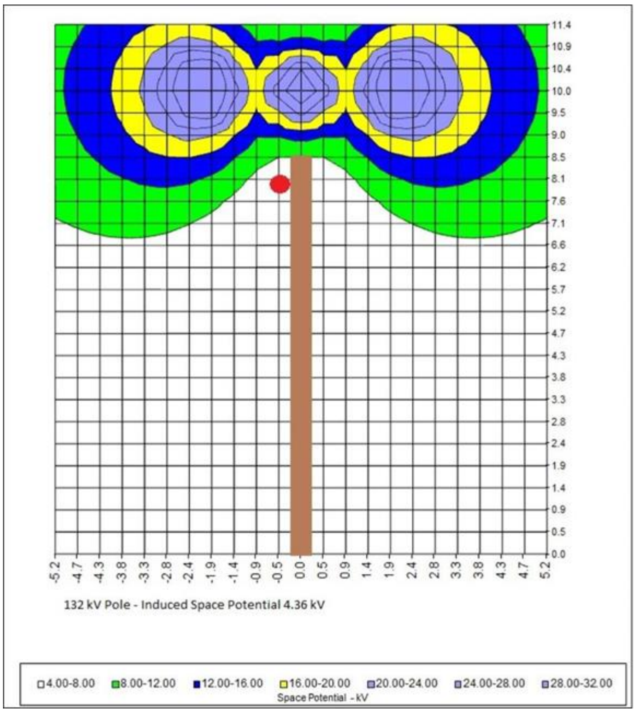


Figure 3 — Space potential plot for 132 kV

Distance from the phase conductors increases with the system voltage to ensure the ADSS cable is installed in a space potential of less than 10 kV. At a system voltage of 132 kV the distance is around 2 m.

3.3.3.4. Tower Routes

The majority of the Northern Powergrid OHL tower routes operate at 66 or 132 kV, where they are configured as a central support structure with the three phases connected or suspended from three crossarms on one or, more usually, both sides. An earth wire is centrally mounted at the earth peak above the phases to provide the necessary shade angle of protection from lightning.

ADSS cable is known to be susceptible to electrical degradation above a stated space potential. ADSS cable is thus located at a point on the tower where the space potential is within acceptable limits for the cable design and where it does not affect clearances to the ground or any underlying obstacles. On dual circuit routes with alternate phasing this will be in the diagonal centre of the bottom two phases. On single circuit routes the ADSS cable will have to be spaced at a sufficient distance from the phases to be in a low space potential window.

On dual circuit routes with alternate phasing, consideration should be given to the space potential levels if one circuit is de-energised or switched out as this will change the space potential and will likely increase it where the ADSS cable is mounted.

Using data available from the space potential plots the best location for the ADSS cable can be determined. Suitable brackets or modifications might be required on both angle and suspension towers so that the ADSS cable can be mounted in the ideal location.

3.3.3.5. ADSS Clashing

ADSS cable conductors have very different dynamic properties to metallic conductors. The ADSS cable properties that affect its behaviour include lighter weight, lower or negative thermal expansion coefficient, lower modulus of elasticity and less inherent damping.

As ADSS cable is lighter, if sagged with the same catenary as a metallic conductor, it would be subject to very large movements, especially under windy conditions. The blowout angle can be as large as 80°. in order to limit the movement of the ADSS cable and reduce the sag under ice loading, it is initially sagged with a much smaller catenary than a metallic conductor.

The behaviour of the metallic conductors and ADSS cable should be calculated to determine their relative positions under various wind loading, ice loading and temperature conditions.

An allowance should be made for the different dynamic behaviours of each cable. The in- plane x and y positions of the metallic conductor and ADSS cable should be calculated at various wind speeds and ice loading. As the sag of the metallic conductors is greater than the ADSS cable the clearance between them will differ along the length of the span. Calculations should therefore be performed at several points along the span including at least quarter span and mid-span. The results can then be plotted to ensure that the metallic conductors and ADSS cable do not clash. Steady state lateral wind conditions are easily calculated; however, gusting winds are more difficult to allow for because the lighter ADSS cable has little self-damping and will blow out much quicker than a metallic conductor.

If the ADSS cable and conductors clash there will be a risk of mechanical damage to the ADSS cable and, in extreme cases, the ADSS cable could wrap itself around the conductor. Also, when the ADSS cable is polluted and wet, there will be a small surface current due to the capacitive coupling between the adjacent conductor and the ADSS cable. The minimum allowable distance between a conductor and ADSS cable will depend on voltage to prevent the possibility of arcing.

The coefficient of expansion of the conductors will be much greater than that of the ADSS cable. The relative sag of the ADSS cable and the conductors will therefore change with temperature. This should be taken into account when determining if the ADSS cable and conductors will come into contact or clash with each other.

Several companies produce software to aid in the calculation of clearances between the conductors and ADSS cable. When assessing the suitability of these software tools the following should be considered.

a) Are static and dynamic wind conditions considered?

b) Can calculations be performed at various wind directions?

c) Does the software consider ice loading and temperature?

d) Are results given for various distances along the span?

e) Can it predict the galloping amplitude and the galloping ellipse?

f) What cable and conductor information is required to enable the calculations to be performed?

3.3.3.6. Structural Strength at Attachment Position

The assessment of structural capacity described in Clause 6 above is primarily concerned with the performance of the structure as a whole, e.g., the potential for a pole suffering a bending failure in high wind conditions. Equally important, however, especially on tower lines, is the strength of the structure at the proposed attachment point of the ADSS cable.

On wood poles, the strength of the structure is rarely an issue. Space potential issues at typical voltages associated with wood pole OHLs do not generally impose too many restrictions on ADSS cable placement. Provided that an appropriate fitting is selected and installed into good wood, localised structure failure can be easily avoided.

On tower routes, the typically higher voltages, i.e. 132 kV and above, impose more onerous constraints on ADSS cable placement due to space potential issues. This often results in attachment positions being away from the larger, stronger tower members such as the legs. In general, the centre of the tower has not been designed to support the load of an additional cable.

Where the attachment point is in the centre of the tower any supplementary fixing point might need to be attached back to the legs of the tower structure or, where only slender cross bracings are available, localised strengthening of the tower might be required to provide a suitable attachment point.

3.3.3.7. Clearances to Ground, Obstacles, and Live Conductors

There is currently no standard or specification that provides the required electrical clearance specifically to an ADSS cable supported on an overhead power line, other than Regulation 17(4) of the ESQCRs [N1] that requires “any wire or cable” attached to an OHL to have at least 5.8 m clearance to a road.

It is, however, recommended that ADSS cable should be installed so as to maintain the same minimum statutory clearance to ground of an insulated low voltage conductor, i.e. 5.2 m, to maintain consistency.

Regarding clearances between the ADSS cable and the phase conductors on the same structure, the consideration will be one of practicality. For example: at the attachment position, the working and access clearance should be maintained to allow work to be carried out under a Limitation of Access rather than a Permit to Work.

When there is a requirement for ADSS cable to over sail another OHL, it is recommended that the safety distance applicable to the voltage of the line is maintained.

In addition to the clearance recommendations in this clause, it is important to note that because ADSS cable has a much lower elastic modulus than a typical metallic conductor it will sag much further under ice loads, typically 3 to 4 times further. Consideration should therefore be given to ground and other clearances when the ADSS cable is iced including potential clashing with cables mounted lower on the structure or with cables and other objects that over sailed, especially at mid span.

3.3.3.8. Sag and Tension

So that clearance assessments can be made, it is necessary to perform a sag and tension analysis of the ADSS cable in a similar way to that for conductors. The cable manufacturer should be able to supply a sag tension chart for the ADSS cable supplied and this can be used to assess the sag and/or tension in the cable for a given span length and temperature.

For real installations that comprise a series of spans connected by suspension structures, a stringing chart based on a ruling span should be prepared for the ADSS cable. This work will require the individual span lengths along the intend route.

The installed tension of the ADSS cable will be at or below the MIT as defined by the manufacturer.

3.3.3.9. Shotgun Risk

Damage to the outer sheath of the ADSS cable might occur if shotgun pellets impact with the sheath. The level of damage inflicted is much higher the closer the shotgun is to the ADSS cable when fired.

This is due to the higher energy of the pellets at shorter range and the higher density of the pellet cloud. Tests have shown that ADSS cable is vulnerable to damage at a range of around 30 m or less; this of course depends on the individual cable design.

If the outer sheath is penetrated by a pellet this can lead to water ingress, which might cause electrical activity, and subsequent cable degradation. It might also expose the aramid yarn strength member to ultra-violet (UV) radiation and cause structural degradation. Both mechanisms will eventually lead to cable failure. The degradation might take some time to become apparent and it is unlikely that the shotgun damage will affect the optical performance of the cable until it structurally fails.

Line routes should be surveyed to ensure that there is no shooting activity near the line, in particular from organised shoots. If there is a risk of shotgun damage in a particular area it is recommended that the spans at risk do not carry ADSS cable. OHL cable resistance to shotgun damage can be determined by testing to IEC 60794-1-2/E13.

3.3.3.10. Strength Co-ordination

On pole routes the ADSS cable can be installed up to 3 m below the phase conductors, to avoid the need for a Permit to Work. Although the ADSS cable is installed with less sag than the phase conductors this will usually result in the ADSS cable being closer to the ground. ADSS cable is very strong and if it is snagged by vehicles or farm equipment passing beneath then there is a possibility that the ADSS cable could pull down the adjacent poles. To prevent this, ADSS cable can be installed with weak link fittings that are made to break at a pre-determined load. Tests have shown that if a short section of aramid yarn strength member is removed then the cable can be made to break at a load that will not pull down the adjacent poles.

A weak link has to be designed to take account of the following.

- Pole strength for typical poles used on the OHL network.
- Pole foundation strength.
- Normal ADSS cable installation tension.
- Tension imposed on ADSS cable due to extreme weather conditions.
- Adequate factor of safety.

The spans at risk should have spare cable at each end to allow cable to feed into the snagged section.

The use of weak links will only be necessary on spans that are considered to be at risk. This system of weak links is under development and is currently in the trial phase.

3.3.4. Installation and Maintenance Procedures

All routes should be the subject of a line survey to check the condition of the structures and metalwork and also to determine location risks such as shooting activity and pollution. Detailed installation procedures, risk assessments etc. will usually be written by the construction contractor or utility company. The utility company should have safety procedures, documentation and authorisations in place before installation work commences.

After completing any strengthening works and installing the landing points, the installation of the cable will normally be performed using continuous tension stringing methods particularly when working in close proximity of live energised circuits.

Apart from all the standard requirements for phase conductor stringing, when in the proximity of energised circuits, the following specific criteria should be observed during the ADSS cable installation process.

- All installation ropes should be a water blocked and sheathed construction. They should be kept clean and free from contamination.
- Where practicable on tower routes the ADSS cable should be square rigged through the body of the tower to minimise induction issues.
- Proprietary pullers and tensioners should be utilised to maintain control of the installation tensions, which are much lower than for OHL conductors.
- Running earths should be attached to all ropes and the ADSS cable adjacent to the pulling and tensioning machines.
- Running block diameters and tensioner bull-wheels should provide adequate support to the ADSS cable without damaging or affecting the performance of the optical fibre core or compromising the minimum bend radius of the ADSS cable.
- Supplementary support steelwork for tension and suspension locations might be required.
- ADSS cables should not be left in sheave wheels longer than necessary to avoid mechanical or electrical damage to the cable.
- Optical sections often do not match conductor sections on a route, i.e. tension dead ends for the optical section might not be on a tension tower for the conductor section.
- On permanent installations only new ADSS cable should be used.

3.3.5. Precautions

Care must be taken to avoid damaging the ADSS during handling and stringing operations. Avoid sharp bends to the conductor and take precautions to prevent crushing the ADSS during placement. The transmission quality of the optical fibres can potentially be degraded if the ADSS is subjected to excessive pulling tensions or excessively small bend diameters hence it is important to observe the recommended values for Maximum Stringing Tensions and Minimum Bend Radius.

Although ADSS is an all-dielectric cable, some conductivity can result from moisture on the cable and in the surrounding air. As a precaution in high voltage environments, it is recommended that the installed cable and metallic attachment hardware are grounded prior to touching.

Leakage current can be induced onto ADSS and attachment hardware even when the cable is a relatively long distance from the phase conductors. The ADSS manufactures can calculate the leakage current based upon the cable position relative to the phase conductors and to the ground, the transmission voltage and the surface resistivity of the cable jacket. The cable surface resistivity is dependent on the moisture and contaminants on the cable. A clean, dry cable has a surface resistance of 312Ω/m and a dirty, wet cable has a surface resistance of 32 Ω/m, therefore, ***ADSS shall not be installed onto Tower lines where the circuits are live during wet environmental conditions.***

When the cable is too close to the phase conductors, scintillation can occur through the air from phase conductors to the cable. This scintillation from a phase conductor to ADSS cable can occur only when the resistance of the cable sheath to the grounding location is low enough to lower the induced voltage. In the worst-case condition, the cable resistance is zero, at which time it will be like a grounded metal rod. A grounded rod configured in air has a flashover voltage of 15kV/in. for large gaps. Hence, the safe approach distance to keep the phase conductors away from the ADSS cable can be calculated by:

$$SD = E/15$$

where, SD = distance (inches), and E is the phase-to-ground voltage (kV).

When splicing ADSS cable during wet/rainy conditions near active high voltage phase conductors, it is advised to ground the cable between the work area and the spans (such as at the attachment hardware). This will prevent dangerous leakage currents and transients from flowing through personnel. In dry weather there is little induced charge on the cable; however, as a personnel safety practice, the cable should be grounded between the work area and the spans.

During Routine Maintenance:

a. Dry Weather Conditions

When the cable is suspended by insulators or on wooden poles, a voltage potential maybe induced in the metal suspension grips and support hardware. To avoid dangerous electrical shock, GROUND THE METAL GRIPS BEFORE TOUCHING. The cable can be touched anywhere when it is dry, because there is little charge induced on the small area that is touched.

b. Wet Weather Conditions

When the cable is wet, the resistance to ground is low near the tower or grounded structure, so there is little voltage potential on the metal grips or cable at these points. However, at distances of 10 to 15 feet or further from the metal grips, a voltage potential may exist. To avoid dangerous electrical hazards, GROUND THE CABLE WITHIN 3 TO 5 FEET ON BOTH SIDES OF THE AREA TO BE TOUCHED.

Adequate electrical protection must be established at all work sites. The method required, and the equipment used, will be determined by the degree of exposure to electrical hazards and the soil conditions at the site. All metallic equipment, hardware, anchors and structures within such work sites must be common bonded together, and then grounded to assure worker safety.

3.3.6. Earthing

ADSS cable, when new, is non-conductive and any surface currents will be very low. In spite of this during installation on live circuits, it is usual to have a running earth on the ADSS cable adjacent to the tensioner, puller and earth mat.

As the ADSS cable ages and weathers, surface pollution will build up on its surface and there will be leakage current from capacitive coupling with the adjacent conductors. To avoid micro-shocks, splice enclosures should be earthed to the tower structure. Current levels will be relatively small and, therefore, a 10 mm2 cable will provide adequate protection whilst having the necessary mechanical integrity.

3.4. ADSS Construction Details.

For details on the fibre count and construction requirements of ADSS, reference shall be made to NPS/004/024 “Technical Specification for Fibre Optic Cables, Wrap, OPGW and ADSS”.

3.5. Route Design Considerations

3.5.1. Wayleaves

Installing ADSS requires access to every support for personnel and equipment (although the majority of supports will only require climbing access). Providing the fibre optic cable is only being used for internal communications or protection purposes it is not normally necessary to re-negotiate new wayleave agreements.

3.6. ADSS Installation

Drum Preparation Prior to Beginning a Pull

3.6.1. Cable Preparation

Upon receipt of the cable reels, remove all reel lagging and packing material from the reel and inspect the lagging, reel, and outer coils of cable carefully for any shipping damage. Check the inside edges of the reel for any sharp edges of the reel for any sharp edges or obstructions that may have occurred during shipment and could potentially damage the cable sheath or interfere with turning the reel and the cable deployment.

Prior to starting construction, use an optical time domain reflectometer (OTDR) to verify that the cable has not been damaged during shipment. Readings obtained may be useful later for comparison with test acceptance data and as part of a records package that will assist in emergency restoration.

ADSS fibre optic cable is very strong and robust. However, care must be taken to assure the cable is not mishandled or installed improperly causing subsequent damage. Ensure that the cable is not kinked or that the minimum bend radius (typically 20 times the cable diameter plus 2 inches for dynamic (installation) conditions, and 10 times the cable diameter for static situations, (such as cable stored in a vault) is not exceeded. Take all precautions that the cable is never crushed or twisted. Any such damage will alter the transmission characteristics of the fibre and may require replacement of that cable section.

Prior to starting construction, survey the proposed cable route to assure that the right-of way is clear of obstructions that may interfere with the installation. During installation, be sure that the cable jacket is not damaged due to abrasion. Do not drag the cable over obstructions in the span or on the ground. It is recommended that if obstructions are observed, they should be removed, or a series of hold-down blocks be used to prevent contact with the obstruction. Before installing the cable, be sure all installation personnel understand the cable parameters such as handling requirements, cable bending limits, and maximum pull tensions.

Do not over-tension the cable. Sag and tension charts are available for all AFL-ADSS fibre optic cables. These charts list the Maximum Rated Cable Load (MRCL) under the appropriate weather loading situation. If the cable is over-tensioned beyond the MRCL, fibre damage may occur that will alter the transmission characteristics of the fibre and/or require replacement of the cable.

Do not allow the cable to twist as it is pulled through travellers or sheaves. If continuous twist in a constant direction is observed, stop the installation immediately, ease off the tension, and readjust to traveller. Due to the light weight of ADSS in relation to most sheaves, and the relative low stringing tensions used during installations, the traveller will require support at the base to help prevent the cable from riding out of the groove of the traveller or excessive twisting during installation. Proper feed of the cable through travellers or sheaves as showed Figure 1.

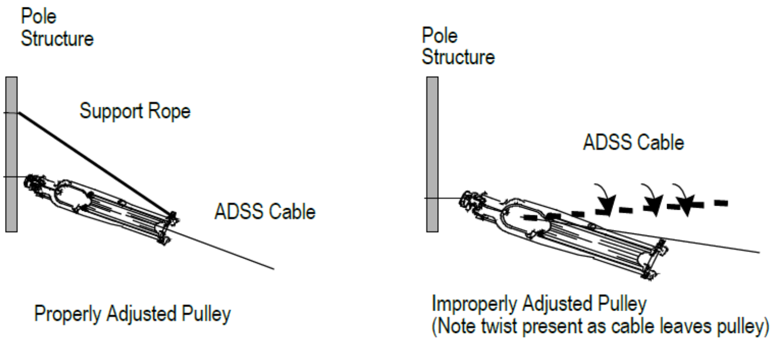


Figure 1 Proper Pulley Adjustment

Twist should be monitored using either a cloth “tail” wrapped around the cable, by spray painting a broad and visible stripe on the cable, or by watching the cable markings. A cable with a cloth “tail” is shown in Figure 2.

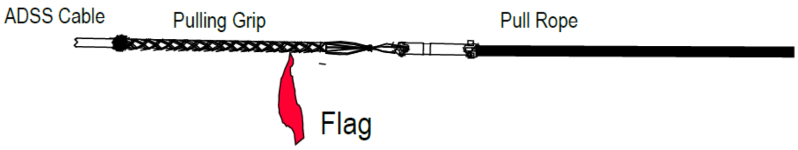


Figure 2 Flag to monitor Cable Twist

Control the rotation of the payoff reel to prevent over running. Apply only a minimal amount of braking. Braking should be applied to the reel through the support shaft, and not by methods such as wedging a 2 x 4 under the reel flange. As the reel empties, the tension will have to be periodically adjusted. More information about tensioners and pullers is included in clause 3.7 of this document.

Do not sag/tension the cable around heavy angles. Tensioning the cable around heavy angles will cause a large crushing force to be placed on the cable at the angle sheave. This crushing force can damage the fibres. Always sag/tension the cable from dead end segment to dead end trying to avoid sagging or tensioning around angles greater than 30 degrees.

DO NOT CUT THE CABLE under any circumstances without prior approval of the engineer responsible for the transmission of the project. Changes to the total number of splice points can potentially degrade quality of transmission of the system. The number and location of splices are usually determined in the initial system design.

Do not allow vehicles to pass over the cable. At road crossings, the cable should be suspended above roads, driveways, etc. during installation. Placing travellers or sheaves on a temporary slack span of rope, or steel strand, is a way to suspend the cable above such road crossings.

When placing ADSS on active structures, or structures involving power crossings, observe the safety precautions outlined in your company’s applicable procedures. When pulling up and tensioning self-supporting cable, observe the same precautions used when pulling up and tensioning metallic phase conductors or any other aerial cables. When aerial lift equipment is used for placing self-supporting cable, all precautions outlined for placing phase conductors, as well as the instructions covering the equipment must be observed.

3.7. Installation Equipment

ADSS fibre optic cable is normally supplied on non-returnable wooden reels. The cable is covered with protective covering and the cable reels are lagged with wooden lagging to provide additional protection during transportation. If the cable is not to be installed for a period of over four months from the delivery date, it is recommended that the cable be provided on a steel reel

Reel Handling

The type and construction of the reel stand determines the method and tools for handling. Reels are constructed so that they must be supported either on an axle, supported from above, or by the reel flange. When the reels are lifted by an axle supported from above, a spreader bar must be employed to maintain smooth payoff and to prevent damage to the cable or reel, or both, by inward pressure on the reel flange. Proper equipment rated for the maximum load must be available to lift the reel. If the reel stand is not self-loading, a crane, forklift or other suitable equipment should be used to load the cable reel into the stand.

Reel Stands

Reel stands are designed to be used with tensioners to supply the necessary hold-back tension to the cable. The stand(s) should be selected to accommodate the cable reel dimensions and gross weight. Standard reels are not designed to withstand the forces developed by braking during high tension stringing operations. Direct tension stringing from the reel at cable installation stringing tensions should not be attempted. The cable maybe pulled directly from the reel stand only when employing slack stringing methods that allow minimal tension to be applied directly to the reel of cable.

Pulling Machines

Both bull wheel and reel type pulling machines may be used to install ADSS fibre optic cable. Availability and previous experience with a particular type of pulling machine should be a factor when determining the type of pulling machine to be utilized.

Bull wheel Characteristics

The depth and flare of grooves in the bull wheels are not critical; however, there are some recommended guidelines. Semi-circular grooves with depths of 50% or more than the cable diameter, and with a flare angle of 50 to 150 from the vertical centre line reference, generally have been found to be satisfactory. The minimum diameter of the bull wheel (measuring at the bottom of the groove) should be at least 70 times the diameter of the cable. Tandem bull wheels should be aligned with the offset approximately one-half the groove spacing. The material and finish of the grooves should not mar the surface of the cable. Elastomer lined grooves are recommended. At least three wraps of cable around the bull wheel are recommended to minimize slippage.

Puller and Tensioner Operating Characteristics

The pulling and braking system should be operated smoothly to prevent any sudden jerking or bouncing of the cable during deployment. Each system should be readily controllable and capable of maintaining a constant and even tension and pulling velocity. Pullers and tensioners should be equipped with tension indicating and limiting devices. Selection of the puller and tensioner shall be dependent on the stringing tension and the actual cable weight and length to be installed. Tensioner bull wheels should be retarded so that the cable maintains a constant hold-back tension at various pulling speeds. Positive braking systems are required for pullers and tensioners to maintain cable tension when pulling is stopped. Fail safe type braking systems are recommended.

Travelers / Sheaves

Note: The terms traveller, sheave, pulley, and block are used interchangeably in this document to reflect different industry terms for the same piece of installation hardware.

Sheave Diameter

The diameter of the sheave should not be less than 300mm at mid-span suspension points, See Figure 4. Where the cable line makes either a vertical or horizontal angle of 250 or greater, and at the first position after the pay-off reel and the final position before the take-up reel (these are generally the parameters for dead end structures), the minimum diameter of the sheave should not be less than 500mm, or 40 times the cable diameter, whichever is larger. Sheave diameters that are larger than those specified are acceptable and offer some advantages by reducing the radial (crushing) load applied to the cable.

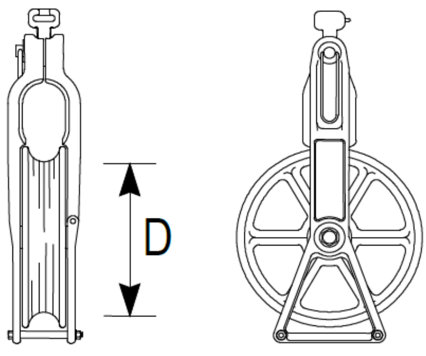


Figure 4 Sheave Diameter

Sheave Groove Configuration

The minimum radius of the sheave groove (Rg) is recommended to be 55% of the diameter of the cable. The minimum depth of the groove should be 25% greater than the diameter of the cable. The sides of the groove should flare between 150 to 200 from the vertical, to facilitate passage of grips, swivels, etc. and to contain the cable within the groove, see Figure 5.

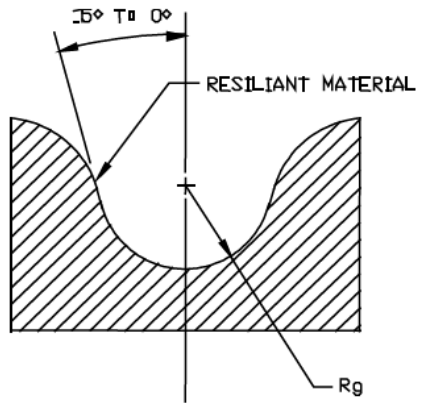


Figure 5 Sheave Groove

Traveller Construction and Material

Travelers may be made of any suitable material, such as heat-treated aluminium, with consideration for the weight. It is recommended that the safe working load and a suitable margin be matched with the maximum installation load of the fibre cable. The traveller should be in good working order and properly lubricated. The cable release should work smoothly with minimal pressure. It is recommended that the traveller be lined with an elastomeric liner that will provide cushioning and minimize any abrasion to the cable jacket. Linings of neoprene or urethane are acceptable. The liner should not be torn or loose.

Traveller Grounds

Grounding attachments are recommended when stringing fibre optic cable under active phase conductors. As a minimum, the first and last traveller of a pull should be equipped with a traveller ground attached to the structure grounding system.

Uplift and Hold Down Blocks

At positions where uplift may occur, it is recommended that uplift rollers or hold down blocks be used. This will minimize any potential for scintillation during installation on active systems and protect the cable jacket from abrasion on non-active systems. A series of travellers 300 – 350mm in diameter will maintain minimum bend radius. These devices should have a cable breakaway feature to easily remove the blocks.

Running Grounds

When installing ADSS fibre optic cable under active power systems a running ground should be used to protect personnel from electrical hazards. The running ground shall provide constant contact with the moving cable without excessive tension. It should be located prior to first support structure. The spring tension on the running ground should be adjustable, and the rollers should be sized for the diameter of cable.

Chain Hoist or Similar Tools

Chain hoists are used to tension and sag each dead-end cable span. The hoist should be rated for the maximum installation load of the ADSS cable, plus a desired safety factor. The hoist shall be in good working order and properly maintained. Assure the chain is not deformed, twisted, or corroded. Inspect release levers and cam action for proper operation. Any suspect unit should not be used. See Figure 6 for a diagram of a typical chain hoist

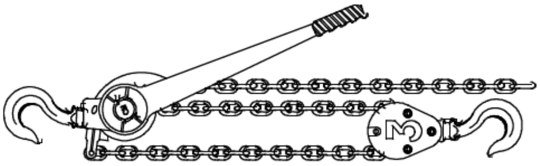


Figure 6 Chain Hoist

Dynamometers

Dynamometers are used to measure the tension at each deadend-deadend segment (See Figure 7). The dynamometer should be rated above the maximum installation load of the ADSS cable. Typically, the accuracy of the dynamometer is 0.5% of the full-scale rating. If the full-scale rating is too high above the installation load the degree of accuracy is questionable. To assure a high degree of accuracy, two comparable dynamometers can be attached in tandem, and the two readings averaged. Dynamometers should be used in conjunction with sight sagging to ensure proper tensioning of the cable.

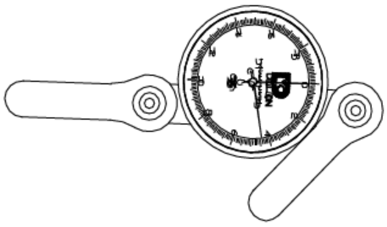


Figure 7 Dynamometer

Pulling (only) Grips

Wire mesh grips are utilized to pull the fibre optic cable through the travellers. The grip should be a double or triple weave design and be rated to match the cable diameter. The load rating shall match the maximum anticipated load on the cable during cable pull-in. This is typically well under the sagging tension, but is dependent on cable design. The grip should have a swivel link that will minimize cable twisting that may be induced by the pull rope, See Figure 8. Grips should be applied per the manufacturer's instructions. DO NOT USE THE WIRE MESH GRIP TO TENSION OR TO HOLD CABLE UNDER TENSION, ONLY FOR PULLING.

Figure 8 Wire Mesh Pulling Grip and Swivel

Tensioning Grips

A separate tensioning grip must be used to temporarily grip the cable during the sagging and tensioning process. This grip can either be a preformed helical dead-end specified for the cable, or a purpose designed "Temporary Tensioning Grip (shown below in Figure 9). If preformed helical dead-ends are used, follow the re-use instructions in the package. Typically, pre-formed wire grips may be re-used no more than three times.

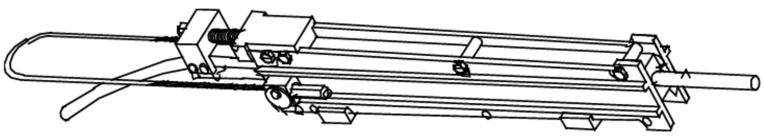


Figure 9 Temporary Tensioning Grip

Preformed Wire Installation Tools (FIT) (See Figure 10)

The use of a preformed Installation Tool is highly recommended to reduce the probability of installation damage to the cable that may occur when installing formed wire installation hardware. NOTE: THE USE OF SCREWDRIVERS IS PROHIBITED FOR THE INSTALLATION OF PREFORMED DEADENDS OR SUSPENSIONS DUE TO THE POTENTIAL FOR CABLE JACKET DAMAGE.

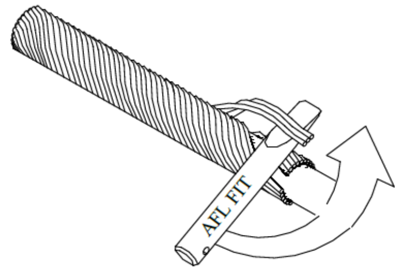


Figure 10 Preformed Wire Installation Tool

3.8. Installation Method

Methods used for placement of aerial, All-Dielectric, Self-Supporting, ADSS fibre optic cable are essentially the same as those utilized to place power utility phase conductors or other aerial cables. However, there are handling and bend radius requirements that are more restrictive for ADSS fibre optic cable. The two basic methods for the placement of ADSS fibre optic cable are; the stationary reel, sometimes called the "Back-pull Method", and the moving reel, sometime called the "Drive-off Method". The drive-off method is acceptable but is generally used only when the cable is the lowest on the structure.

Drive-off Method. As stated in previous paragraphs, this method is not utilized very frequently. Its primary application is in construction of new lines with clear right-of-way and no obstacles. A brief schematic of the method is shown in Figure 11.

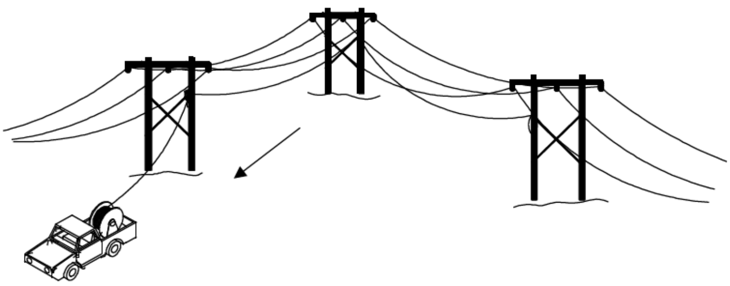


Figure 11 The drive-off (Moving Reel) Installation Method

Place cable reel in a reel trailer or line truck equipped with reel carrier, supported by the arbour holes. The cable should pay off the top of reel from the back for reel trailers and off the bottom of the reel to the front quadrant for the line trucks. A braking device, set on minimum, is utilized to slow the reel rotation by friction on the arbour shaft. This is used to prevent overrun of the reel when stopping at the support structures.

Holes are drilled and machine bolts, or comparable hardware, are placed on the structures at the appropriate mounting height. At dead-end and tensioning locations, down-guys of an appropriate loading factor are placed.

Travelers are placed above or below the desired framing location of each support structure and the cable is dead-ended at the starting location.

With minimal tension applied to the reel brake, the reel of cable is transported along the construction route and the cable is played out. As the reel empties, the back tension will have to be periodically adjusted to account for the difference in reel mass.

As the moving reel passes a support structure, the pulling is stopped, and the cable is placed into the traveller attached to the structure at the desired framing height.

The reel proceeds on to the next support structure where the process is continued until the cable is completely deployed.

With the cable deployed, starting at an end location, each dead-end segment can be sagged and tensioned and support hardware applied according to the installation requirements. An alternative procedure is to sag and tension each span and install permanent hardware as the cable is being deployed.

Back-pull Method

This method of cable installation is most frequently used for ADSS fibre optic cable. Its primary application is for long spans on EHV power facilities. It also is most effective for application on distribution facilities, where there are many obstacles, such as lateral branches or taps. This method is very economical in urban areas and offers the fastest deployment of cable. A brief method of the “Back Pull” or “Stationary Reel” method is shown in Figure 12:

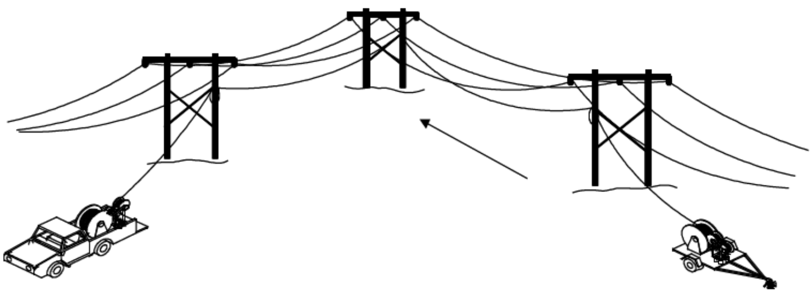


Figure 12 The Back-pull (Stationary Reel) Installation Method (6km/day)

The cable reel is placed on a reel stand or reel trailer, supported by the arbour holes, at a stationary location. A braking device applies minimal tension to the reel to prevent overrun.

At the same location as the cable reel, the bull wheel is placed in-line between the cable reel and the first two structures. The ADSS cable is then fed through the bull wheel.

Holes are drilled and bolts or comparable hardware is mounted to the structure at the appropriate mounting height. At dead-end and tensioning locations, down-guys are placed at the desired framing location of each support structure.

Travelers are placed just above or below the desired cable framing location of each support structure.

Small pilot lines are run through the travellers at each support structure. The pulling line is pulled from the pulling location back through each traveller using the small pilot lines. After the pulling line is fed through the entire section to be pulled, it is attached to the ADSS cable with a swivel link and a wire mesh grip as seen in Figure 4.

The ADSS cable is then pulled through the entire section with the puller and tensioner. Care must be exercised to keep the cable under minimal load. Several pulling stages may be required to place the cable through the entire system.

With the cable deployed, starting at an end location, each dead-end-to-dead-end cable segment can be sagged

Communications

Proper communications during fibre cable deployment are critical to assure safe and efficient installations.

The “Drive-off Method” requires minimal communication between different personnel on the installation crew. It is recommended to have good communications between the operator of the vehicle used to deploy the cable, and the individual at the cable reel. If traffic control is necessary, the flagman shall also have communication with the vehicle operator to assure safe traffic routing.

The “Back-pull Method” requires good communications between the operator of the tensioner and the operator of the puller. In addition, intermediate check points such as road crossing and obstacles, i.e. power conflicts, should have spotters to inform the puller and tensioner of potential problems. The types of communication devices are dependent on local availability. Maintenance radio, cellular telephone and dedicated talk circuits over copper pair facilities with temporary station wire, are all viable alternatives. Systems such as citizen band radio or power line carrier systems are not recommended.

3.9. Installation Considerations

Reel Preparation Prior to Beginning a Pull.

The ADSS manufacturer generally ships the cable reels with the inner tail securely connected to the outside of the reel flange. This connection should be loosened, but not removed, prior to stringing. This allows the inner layers of cable to adjust themselves to the varying tensions seen during installation. As the cable makes these adjustments, the inner tail may lengthen, or “grow,” requiring periodic attention to ensure that the cable continues to be in a state where it can “grow” out.

Pull, Tension, Anchor, and Splicing Sites. The selection of pull, tension, anchor and splicing sites must consider many factors from system design issues to logistics and capability of equipment. In the “Back-pull Method”, the reel is stationary, thus the cable for the system is pulled in several segments. These segment lengths are dependent on allowable splices, accessibility of the sites for vehicles, capability of the installation equipment, obstacles in the right-of-way, and cable reel length. Other factors that will affect the site selection are the maximum load the cable can handle, maximum structure load and availability of adequate grounding systems when necessary.

Equipment Locations

The location of the tensioner and puller relative to the structure must be selected so that the structure is not overloaded. Where possible, a pulling slope of four or five horizontal (See Figure 13) to one vertical is considered good practice. This ratio will minimize the load on the cable, traveller, and structure. It may also be necessary to place temporary guys to prevent overloading the structures. The tensioner and reel stand must be placed in-line with the first two structures to prevent twisting of the cable or any abrasion to the cable by rubbing on the sides of the traveller groove.

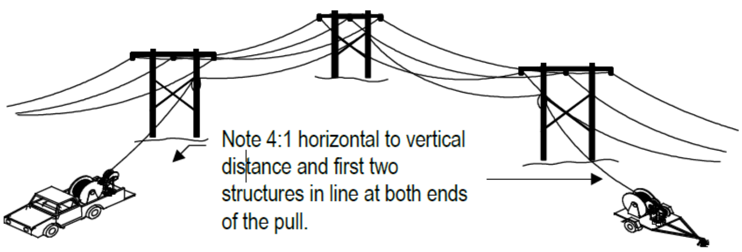


Figure 13 Proper Puller and Tensioner Placement

Anchors and Hardware

Anchors and support structure hardware shall be rated above the anticipated environmental load of the cable, plus a safety factor. The amount of the safety factor is dependent on the utilities existing procedures. In applications where aeolian vibration becomes an issue, the safety factor shall be increased due to the potential for degradation of the hardware. At locations where the cable is tensioned to achieve proper cable sag, the structure may require a temporary down-guy and anchor to prevent unbalance of the structure. At these locations, a minimum ratio of two horizontal to one vertical for the slope of the guy is considered good practice. Anchor types shall match the soil conditions and loading considerations. All down-guys shall be properly tensioned or re-tensioned prior to starting the cable installation.

Crossing Structures

When crossing roads, highways, railroads, energized lines, etc., some supplemental support is necessary to prevent the minimum clearance from not being met and posing a safety hazard. One method is to erect "H" frame structures on both sides of the crossing point. With these guard posts, the cable can be maintained above the minimum height. In some cases, rope nets can be strung between the two structures to provide more positive protection. Another method is to string travellers on temporary ropes or guys at the crossing point, that will maintain clearance if tension should be lost. It is recommended that a spotter with communications to the puller and tensioner be at the crossing location, while the cable is being pulled into place.

Terrain Considerations

The terrain of each pull section must be analysed to assure there are no potential conflict areas that would impair installation. In areas where ground clearance or minimum clearance under power facilities becomes a concern, uplift or hold down blocks may be required. Where ground clearance is a concern, a spotter with communications to the puller and tensioner should be utilized to assure no abrasion to the cable.

Traveller Installation

Travelers are typically attached directly to the structure. On pole structures, a standoff pole bracket may be considered to allow free movement of the traveller. The socket eyes, used to support the traveller, shall be consistent with ultimate working load and rating of the traveller. Shackles used on towers to support the traveller shall be rated above the ultimate working load. When electrical hazards exist, observe local practices for the placement of traveller grounds. As a minimum, traveller grounds should be installed at the first and last tower between the tensioner and puller.

Grip Installation

The pulling grip, as described in the apparatus section, shall be rated above the maximum pulling tension anticipated. Use the manufacturer's instructions for the proper application. When installed properly, no special preparation of the cable end, or aramid yarns, are required. It may be recommended by the grip manufacturer to band the end of the grip to prevent slippage. Apply vinyl tape over the banding to minimize damage to the traveller coatings. A layer of friction tape can be used under the grip to provide an additional level of protection.

A matched double-clevis type swivel is recommended to help prevent twisting of the cable during pulling. The swivel should be matched to load rating of the grip. It is not recommended to pull the swivel through bull wheels under any significant tension. When removing the grip after the cable has been pulled in, cut off a minimum of 5m past the end of the grip to assure no stressed cable is used.

Cable Pulling

Pulling rates of 2 to 5 miles per hour usually provide safe, smooth, efficient passage of cable. Once the cable movement has started, it should be maintained at a constant rate until the cable segment has been pulled into place. At all times during the pull, the tensioner operator should monitor the tension meter to assure that the maximum pulling tension is not exceeded. The maximum tension during the pulling operation should not exceed that which is necessary to clear obstacles. In general, pulling tension should not exceed more than one-half the maximum initial sagging tension. If greater tensions are required, consideration must be given to the fact that when long lengths of cable are pulled, the tension at the pulling end may exceed the tension at the tensioner by significant amounts. This difference is due to the length of cable to be strung, changes in the line angle, number of travellers and differences in elevation of the route and structures. Light and steady back tension is required at the cable pay-off reel to prevent overrunning of the reel. It may be necessary to periodically loosen the brake on the pay-off reel as it empties. As the reel empties, the moment arm available to overcome the brake drag is reduced, and the tension rises.

Aeolian Vibration

Aeolian vibration is a resonant vibration caused by low velocity wind blowing across a cylindrical conductor under tension, see Figure 14. Although the vibration will not typically affect the optical or mechanical performance of the ADSS fibre optic cable, it can cause severe degradation to the cable support hardware. Vibration dampers can be very effective in controlling aeolian vibration when used on ADSS fibre optic cable. Both resonant and interference type vibration control systems will work when properly applied.

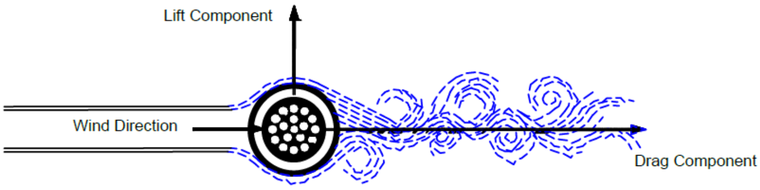
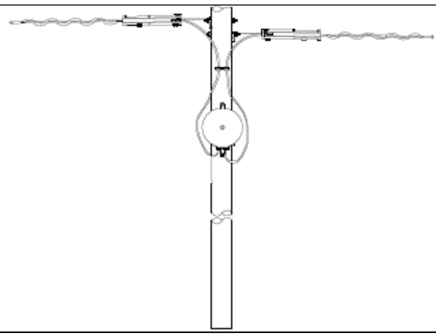


Figure 14 Aeolian Vibration Effect

SVD (Spiral wrap Vibration Dampers) be utilized to protect attachment hardware when the cable spans exceed 100m and/or the cable tension exceeds 15% of the calculated cable breaking strength, and there is a prevailing laminar wind between 2 and 20 mph.

Splicing

At the locations where a splice is required, additional cable must be provided to provide extra fibre and cable to physically accommodate the splicing process. In the outdoor environment, AFL recommends that splicing be accomplished on the ground and not in an aerial bucket. Consideration must be made to the type of splicing, mechanical or fusion, and the respective environmental requirements of each. If fusion is the method, a splice vehicle may be required, and enough cable will be required to reach the vehicle. In general, enough cable should be provided to reach the base of the structure and reach the intended splicing site. DO NOT FORGET TO REMOVE 5M OF CABLE FROM THE GRIP TO REMOVE ANY STRESSED CABLE. It is also recommended that the spare cable at splice points be stored in an enclosure, either mounted to the pole or in an underground housing, See Figure 15.

After the excess cable length is determined, coil the cable and store at the structure until the splice housing has been installed (be sure to maintain the minimum bend radius of the cable). Be sure to place end caps on the exposed cable ends or seal with vinyl tape to prevent water penetration.	

3.10. Sagging & Tensioning

After the cable has been placed throughout the entire length of the system, sagging and tensioning can now be started. Sagging and tensioning of a system is worked progressively from one end of the system towards the opposite end. Typically, the cable slack is worked back toward the payoff reel in order to recover as much cable as possible.

Termination Point

Pull enough extra cable to assure that the termination location is reached, and enough fibre optic cable is spared to facilitate cable splicing. The spare fibre required in the splice tray is dependent on type of fibre organizer and splicing method. Typically, four to six feet of fibre is required to facilitate splicing. Assure that 5m of cable is cut off at the wire mesh grip to assure no damaged fibre is used. Excess cable may also be required to provide sufficient cable to splice it on the ground.

Termination Structure

At the last structure establish a dead-end assembly. Assure that the bend radius requirements are maintained where the cable is run down the structure. If the ADSS fibre cable is run down the structure, it is recommended that cable riser guards are used to protect the cable as it makes the transition of aerial cable to the building entrance conduit.

Remove all excess cable slack out of the span; or if in the case of several in-line structures, series of spans. This is not pre-stressing or even tensioning. This removal of excess cable slack is necessary to properly position the temporary dead-end pulling grip. To remove the slack, reverse the tensioner and pull the cable back toward the reel, being careful not to exceed the pulling criteria of one-half the maximum installation tension. **Do not attempt to tension the cable using the tensioner and the cable on the reel; this may exert an excess crushing force on the cable. The actual tensioning process is described in the next step.**

With the cable slack removed, apply a temporary dead-end assembly 1.5 to 2 dead-end assembly lengths (approximately six to ten feet) from the structure. In many cases, the AFL Temporary Tensioning Grip (Please see figure 8) can be used and will save time and money in comparison with the use of standard formed wire dead ends. This will be utilized as a tensioning grip to achieve the proper span sag and tension, prior to installing the permanent dead-end assembly. Attach the tensioning rig, comprised of a sufficiently rated chain hoist, dynamometer and bull chain, to the structure and the temporary dead-end. Take up the load and begin to tension the span per the provided sag and tension charts. Please note the pictures of these pieces of equipment in the "Installation Equipment" section of this document.

Typically, the cable is worked dead-end to dead-end segment back to the payoff reel and trying to avoid angles greater than 30 degrees. After the spans are at proper sag and the dead-ends attached, the suspension or tangent hardware is installed and attached to the structures by working back to the dead-end, a span at a time.

Once the permanent dead-end is installed, and the hardware is attached to the structure, the tension can be released on the tensioning rig or chain hoist and the temporary dead-end removed. As the next permanent dead-end is installed on the adjacent span, make sure that the expansion loop under the dead-ends is properly formed, maintaining minimum bend radius. This means the cable is typically 14 inches lower than the cable framing location. This process is repeated until all spans are sagged and tensioned for the complete system.

3.11. Cable Support Hardware

Hardware Types

The hardware used to support the cable at the structure is similar in appearance and application to the type used for power utility metal conductors.

In general, there are three are three basic types of supports: dead-ends, suspension, and tangent assemblies.

Dead-end Assemblies

Dead ends are used at points of cable termination, on structures where the line angle is greater than 30° (or 22° when used with the Trunnion clamps), or across road, river or railroad crossings. There are two basic types of dead-end assemblies: preformed wire dead-end assemblies, and Mechanical Dead-End assemblies.

Preformed Wire Dead-End Assembly

The basic elements that are included in a preformed wire dead-end assembly, refer to Figure 15, are the Structural Reinforcement Layer (SRL), the dead-end grip, the thimble clevis an extension link.

Preformed wire dead end assemblies should be applied no more than two (2) times due to the fact that the grit and glue used to provide friction will degrade with multiple uses, and the dead end loses its holding power.

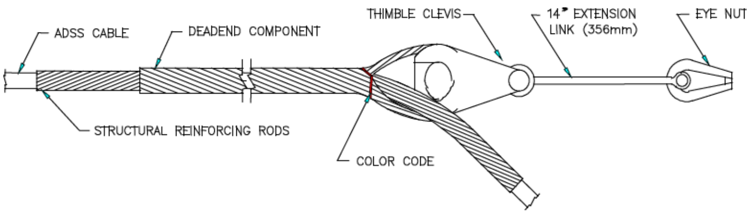


Figure 15 Preformed Wire Dead-End Assembly

Structural Reinforcement Layer (SRL) -The SRL is a formed wire subset of armour rods that are the first layer applied to the ADSS cable. They are spiralled in a precise twist lay to address the diameter and maximum anticipated load of a specific cable. Typically, they are grouped together in a sub-set of 3 or 4 individual rods, with grit applied to the inside for better slip resistance.

Dead-end Grip -The dead-end grip is a set of armour rods that have been formed with a loop in the centre. It, too, has a precise twist lay that matches the diameter of the SRL and cable. Its length is dependent on the maximum anticipated load. It has grit applied to the inside and also has a colour band 450mm from the loop.

Thimble Clevis -The thimble clevis, sometimes called the clevis shackle, is a cast aluminium or steel piece of hardware used to maintain the seat diameter of the dead-end loop and attach the dead-end loop to the extension link, and ultimately the structure.

AGS Suspension Assembly

Suspension assemblies are used where the line angle is from 0° to 30°, and most often on longer spans (See span limits in next page) where tangent clamps cannot be used. Typical suspensions have rated slip strengths of approximately 650kg – 900Kg. The suspension assembly is typically attached to an eye nut on a pole using a Y-clevis eye (90°).

The basic elements that are included in the suspension assembly, refer to Figure 17, are the Structural Reinforcement Layer (SRL), the AGS rods, the neoprene insert, the housing, strap, and nuts/bolts.

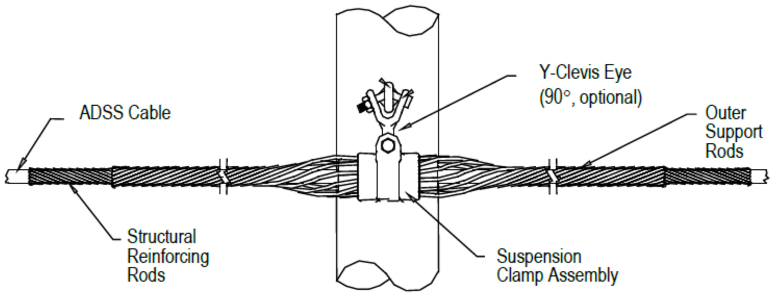


Figure 17 Suspension Assembly

AGS Parts

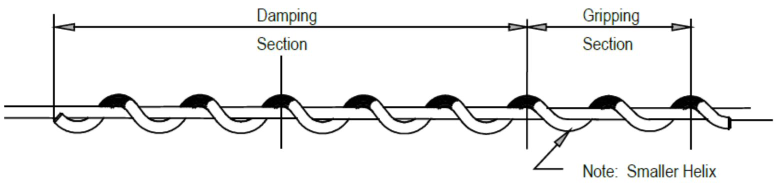
Structural Reinforcement Layer (SRL). The SRL for the suspension assembly is very similar in function as the SRL for the dead-end. However, the colour band is at the centre of the rods.

Armor Grip Suspension (AGS) Rods. The AGS rods are individual rods that are typically larger in diameter than the SRL rods. They too have a colour code band at the centre of each rod.

Insert, Housing, Strap and Nuts/Bolts. The neoprene insert cushions the load transfer from the SRL to the AGS rods. The housing is a cast steel clamp that acts

Vibration Dampers

Vibration dampers are recommended in various quantities for span lengths greater than 350 feet. Please contact your AFL representative for specific vibration damper recommendations. A spiral vibration damper, the most often used damper type for low voltage applications, is shown below in Figure 19.



Downlead or Guide Clamps

These clamps are used to secure the cable to the pole. Typically, one clamp is used every 2.5 - 3m down the length of the pole. A picture of a clamp for wooden poles is shown in Figure 20.

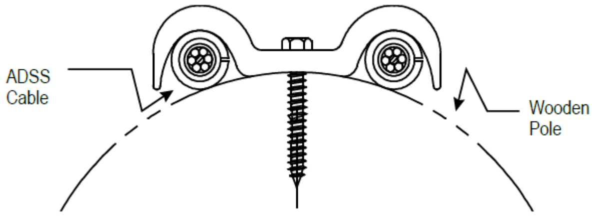


Figure 20 Cable Clamp for Wooden Poles

For applications on lattice steel towers, an adaptor is used to attach the cable to the lattice steel angle as shown below in Figure 21.

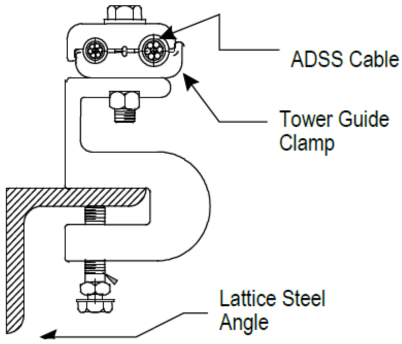


Figure 21 Cable Clamp for Lattice Steel Towers

3.12. Route Identification

Identification of the fibre optic cable and the cable route with warning signs helps prevent inadvertent cable damage caused by company personnel or the general public. This is most important on joint-use distribution pole lines where more than one company may have facilities on the structure. The proper warning signs should use industry accepted wording and visual indicators stating warnings.

Fibre Optic Cable Warning Signs

At each structure, the cable should be tagged with a cable warning sign. These signs can be a snap around plastic tag in high visibility orange, stating "WARNING-FIBRE OPTIC CABLE" or similar wording. The tags are typically applied to the expansion loop under the double dead-ends. Other type of cable warning signs are small plastic or painted metal signs with the same type of wording but are affixed to the structure at the cable framing locations.

Fibre Optic Cable Route Warning Signs

At locations where the cable may go underground or change to a different structure type, it is recommended to identify the cable route direction with a fibre optic cable route warning sign. This helps to identify the route during an emergency restoration and during preventative maintenance programs, when the cable route is periodically inspected. Again, the use of industry accepted wording and colours are recommended.

3.13. Records

Records are an integral part of the equipment required to maintain and restore a fibre optic system. During an outage condition, having a records package readily available eliminates unnecessary delays locating and accumulating information required for the restoration process.

Coordination

Due to the number of departments involved in the design, construction, turn-up, and maintenance of fibre optic systems, records can be lost or misplaced after the initial installation of the fibre optic system. This can be a catastrophe during a system outage because this information is necessary for comparison against trouble-shooting information.

Documentation

AFL Telecommunications recommends that for each fibre optic system the following information be included in a records documentation package.

Key Map

The key map is a geographical map showing the system route in relation to roads and highways. Its purpose is to provide general bearings to quickly access key areas of the system, such as field splice points and major road crossings. Sheath meter marks should be indicated on the map for splice points, road crossings, river crossings, etc.

Composite Schematic

The composite schematic is a straight-line schematic identifying the construction sequence of cable reels by reel number, meter markings to major construction points such as splice points, and major road crossings. The cable reel section length and a cumulative cable length should be marked at each of these points. Also, the cable and fibre type and count shall be identified for each reel section.

As-Built Construction Sheets

The construction sheets identify the actual apparatus units at each structure. Other information such as the structure type and dimensions, cumulative distance to each termination points from the structure, any grounding or bonding detail, etc. These sheets are typically the construction detail sheets that have been corrected to reflect any changes during construction.

Circuit Diagram

The circuit diagram is a schematic that identifies the actual fibre circuits, system number, working and protect fibres, fibre/buffer colours, priority sequence during restoration and other pertinent information such as transposed fibres.

Test Acceptance Sheets

The test acceptance sheets are the recorded values of the transmitter output power, receiver input power, and measured attenuation levels at the receiver. Other information to be included in the test acceptance package are the Optical Time Domain Reflectometer (OTDR) plots or photographs of each fibre and its terminated pigtail, shot in both directions at both 1300nm and 1550nm. Other recommended documentation includes the bi-directional average of the loss of each splice, including pigtail splices with connector insertion loss.

Manufacturer Provided Documentation. The manufacturer provided documentation would include, cable data sheets of each cable reel, documentation provided on the fibre, equipotential plots of the field strength levels relative to different structure types, and sag and tension charts provided for construction.

Emergency Restoration Plans An emergency restoration plan is extremely critical in network operation. These plans should include well-defined responsibilities, as well as procedures and locations for all restoration materials.

The original copy should be maintained by the engineering group and a copy distributed to the maintenance group. One copy of the records package should be placed at each end of the termination points to the fibre optic system. When changes in the system are required due to supplemental construction or emergency restoration, the records package should be revised and redistributed.

Annual System Check

Periodically, the system attenuation level shall be verified against the turn-up attenuation measurement. If this attenuation level has changed more than 3 db, it is recommended that the cause be investigated and corrective action taken.

3.14. Arrangement Drawings

Arrangement	Northern Powergrid Arrangement Drawing	See Appendix " "

3.15. Support Fittings

3.15.1. Splice Points

Fibre optic jointing shall be carried out using fusion type fibre splices. All splicing shall be carried out in strict accordance with the cable manufacturer's and splicer manufacturer's instructions. The Contractor shall be suitably trained in such jointing techniques. The colour code for identifying each fibre is detailed in NPS/002/024 Technical Specification for Fibre Optic Cables and Fibre Wrap

The contractor shall identify each fibre optic cable with a waterproof type of cable marker system before it enters the splice.

Wherever practicable the cable preparation and splicing work shall be carried out either in the back of the splicing vehicle or a suitably covered work area, and not on the support structure. The loose tubes containing the optical fibres shall be cut back to the required length using the appropriate tools. The fibres must have all traces of gel removed from their external surface.

The splice cassette shall, on completion of all splicing, contain nominally 2m but not less than 1.5m of excess fibre. The excess fibre should be securely stored observing the minimum bending radius requirements of the fibre.

The cable central strength member shall be either clamped or directed away from the fibres, and be free to move without obstruction or stressing the fibres.

All fibres shall be fusion spliced (as opposed to mechanical splicing) using a suitable splicing machine. Completed splices shall be protected by a mechanical splice protector. The protected splices shall be placed in the splice organiser (splice trays) within the splice enclosure, which should be sealed upon completion of the work to the manufactures recommended procedures.

Splice Losses – the mean splice loss must be equal to or less than 0.15dB the maximum individual splice loss shall be equal to or less than 0.2dB.

Non-conforming splice losses shall be reworked, the splice will be cut out, the fibres re-cleaved and re-spliced. If the splice still does not conform to the specification, the process must be repeated, up to a maximum of three times. Evidence of these attempts shall be recorded as OTDR traces and presented back to Northern Powergrid with the final test results in the "As built records".

If the attenuation measurement, after the third splice attempt, still does not conform, then the following concessions will apply:

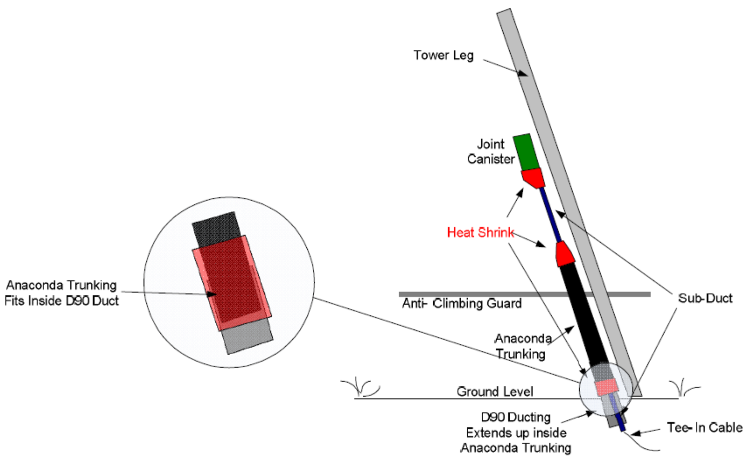
Mean splice loss <= 0.15dB

Maximum splice loss must not be greater than 0.3dB

If after splicing the fibre the third time, the concession criteria are not met, an alternative splicing machine must be used. If non-conformance still applies, then this effectively eliminates the splicing techniques as a source of the fault, thus implying the fault lies within the fibre optic cable. This shall then be discussed with the project manager.

3.16. Interface with Underground Fibre Systems

Where ADSS installations interface with underground fibre cable installations, the underground cable shall arrive at the tower base via standard 96mm duct and subduct. Transiting from this duct to the joint canister location the fibre cable must be installed within a 32mm standard telecoms sub-duct and from the 96mm duct to a point above the anti-climbing guard. The 32mm sub-duct must in turn be housed inside anaconda galvanised steel piping or capping. At the transit points from the 96mm to the Anaconda, from where the Anaconda ends above the climbing guard and where the 32mm sub-duct interfaces with the joint canister a heat-shrink sleeve must be used to protect the network from water ingress. The Anaconda trunking must be fixed to the tower leg using Anaconda tower leg clamps.



3.17. Fibre Optic Testing Requirements

3.17.1. Testing Prior to Installation

Once the conductor drums have been delivered to the Contractor, tests at 1550nm on each fibre from the conductor end on the outside of the drum shall be taken to ensure that there is no damage prior to installation. Testing at the 1550nm wavelength will show up any microbends from the manufacture process. Northern Powergrid reserves the right to witness these tests. The contractor shall inform Northern Powergrid of any conductor damage discovered before any installation works begin.

3.17.2. Testing After Cabling

After the ADSS has been installed but before any route splicing occurs, OTDR (Optical time–domain reflectometer) tests shall be carried out on each fibre length in one direction to ensure that there is no damage post-installation. These tests shall be carried out at 1550nm to check for macrobends or breaks caused by cabling damage and the results shall be presented to Northern Powergrid.

3.17.3. End to End Testing Following Completion of Terminations

Northern Powergrid Telecoms or their approved contractors shall carry out termination works of all fibre cables within the Northern Powergrid building. This shall include the internal cabling, mounting of fibre wall boxes, installation of cabinets and ODFs etc. On completion of the installation works the fibre route shall be subjected to bi-directional end to end OTDR and insertion loss measurement (ILM) test at both 1310nm and1550nm. The results shall be recorded and presented to Northern Powergrid for evaluation and comparison with those provided by the installation contractor.

3.17.4. As Built Records

In addition to the OTDR trace files and insertion loss measurements, the contractor shall provide photographs of each splice enclosure with close ups of the splice trays using a macro camera setting so that the quality of fibre preparation and splicing work is clearly visible. Further photographs of the splice enclosure fitted on the tower (with the tower reference number) shall also be submitted to verify that the close up is of the correct support.

The contractor shall also provide a report including showing the following information as part of the final project record:-

- Details of the optical route
- Date of the tests
- A end identity and B end identity
- Section length in km
- Total number of splices
- The location of each slice and its location in the route i.e. overhead or underground
- Type and location of splice joints including grid ref and OHL tower or pole number.
- Wavelength used for testing
- OTDR – make, model calibration date
- Calculated route attenuation from A end connector to B end connector

Copies of the OTDR traces are to be supplied to Northern Powergrid by the contractor in a digital form.

Optical Power Loss Test

ILM tests are to be carried out on each fibre in the route, in both direction, at 1310nm and 1550nm. All results are to be recorded on the test report.

The test report must contain the following:-

- Details of the optical route
- Optical budget for the route as provided by Northern Powergrid
- ‘A’ end and ‘B’ end identification

- Date of test
- Total number of splices
- Equipment details
- Fibre identification number
- Operating wavelength
- Launch Power (dB)
- Attenuation of A-B and B-A (dB)
- Average attenuation (dB)
- Pass / Fail

In addition the contractor shall provide Northern Powergrid with a complete set of map sheets at 1:500 scale marked up to show the as built duct route with all chambers and splice positions marked up accordingly.

3.18. Accessories and Fittings

All ADSS fittings and accessories shall be tested in accordance with ENA 43-126 “Fittings for Overhead Line Optical Cables – Part 4 Fittings for O/H Line Optical Cables - ADSS”.

4. References

4.1. External Documentation

Reference	Title
ENA 43-126	Fittings for Overhead Line Optical Cables – Part 4 *Fittings for O/H Line Optical Cables - ADSS*

4.2. Internal Documentation

Reference	Title
NPS/004/024	Technical Specification for Fibre Optic Cables, Wrap, OPGW and ADSS

4.3. Amendments from Previous Version

Reference	Title
n/a	

5. Definitions

Reference	Title
ADSS	All Dielectric Self Supporting
Anti-climbing Devices	Methods of preventing unauthorised access to pole and tower tops. Usually involves loops of barbed wire.
Attenuation	The reduction in optical power as a signal passes along a fibre due to dispersion, absorption and scattering. Usually expressed in decibels (dB).
De-energised	Free from connection to a source of potential difference or electric Charge, and not having a potential different to that of the ground. This term only refers to current carrying parts and is not normally earth-wires unless they are insulated. Even if the circuit is De-energised it may be electrically charged through induction from nearby circuits.
Earth Bond	Bond to electrically connect equipment to ground potential for safety purposes.
Energised	Electrically connected to a source of potential difference, or electrically charged so as to have a potential different to that of the ground.
Fittings	Any hardware attached to a fibre optic cable or related to its connection to a tower, conductor or another cable.
ILM	Insertion Loss Measurement - insertion loss is the loss of signal power resulting from the insertion of a device in an optical fibre route and is usually expressed in decibels (dB).
Jumper	The loop of conductor/earth-wire formed between incoming and outgoing conductors or earth-wires at a dead-end structure.
Live Line Working	Term used to describe working condition for earth-wire installations when all adjacent phase circuits are energized.
NBL	Nominal Breaking Load. 95% of RTS.
ODF	Optical Distribution Frame
Optical Budget	The optical power budget in a fibre-optic communication link is the allocation of available optical power (launched into a given fibre by a given source) among various loss-producing mechanisms such as launch coupling loss, fibre attenuation, splice losses, and connector losses, in order to ensure that adequate signal strength (optical power) is available at the receiver. In optical power budget attenuation is specified in decibels (dB).
Optical Fibre	A strand of very thin, optically pure glass that can carry digital information over long distances
OTDR	Optical time-domain reflectometer – An OTDR tester is used for testing and fault finding within fibre optic networks and fibre cables
Overhead Splice Box	A splice box designed to be mounted on the conductor or earth-wire.
Patch Lead	Short length of fibre optic cable, with a connector at each end, used to join items of equipment such as optical distribution frame and relay panel
RTS	Rated tensile strength. Calculated by adding the strengths of the individual wires making up the cable.
Shackle	U-shaped piece of metal secured with a pin or bolt across the opening.
Single-mode Fibre	An optical fibre designed to carry only a single ray (mode) of light.
Structure	A general expression for a tower or pole.

6. Authority for Issue

6.1. CDS Assurance

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

		Date
Liz Beat	Governance Administrator	04/03/2024

6.2. Author

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

Review Period - This document should be reviewed within the following time period.

Standard CDS review of 3 years	Non Standard Review Period & Reason	
No	Period: 5 Years	Reason: Update will be dictated by contact renewal date or any significant changes in the specification or documents referenced

		Date
G Hammel	Senior Policy & Standards Engineer	07/03/2024

6.3. Technical Assurance

I sign to confirm that I am satisfied with all aspects of the content and preparation of this document and submit it for approval and authorisation.

		Date
S Salkeld	Policy & Standards Engineer	05/03/2024

6.4. Authorisation

Authorisation is granted for publication of this document.

		Date
Paul Black	Head of System Engineering	25/03/2024

Appendix 1 – ADSS Section Structure – (Tails down to Splice Box)

Appendix 2 – ADSS Section Structure – (Straight Through Arrangement)

Appendix 3 – ADSS Intermediate Structure – (Suspension Arrangement)

Appendix 4 – ADSS Terminal Structure

Appendix 5 – ADSS Terminal Structure with Underground Splice Connection

Appendix 6 – ADSS Tee-off Splice Arrangement

Note the list of Appendix detailed above have been included as place holders to update this document further once we have photo’s or drawing available for each of the standard arrangement.