NPS/002/024 – Technical Specification for Fibre Optic Cables, Wrap, OPGW and ADSS

1. Purpose

The purpose of this document is to detail the technical requirements for Fibre Optic Cables, Fibre Wrap, OPGW and ADSS for use on Northern Powergrid (the Company) distribution network.

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

Reference	Version	Date	Title
NPS/002/024	4.0	Feb 2017	Technical Specification for Fibre Optic Cables, Wrap, OPGW and ADSS

2. Scope

This specification is split into three parts:-

a. The specification for the optical fibres used in the fibre (cable or carrier systems)

b. The specification for the host fibre optic cables (cable used to carry the fibres in an underground ducted system)

c. The specification for the host Fibre Wrap cable (cable designed to carry the fibres as an external wrap onto overhead line earth-wire or phase-wire conductors

d. The specification for the host earth wire / OPGW conductor (Composite conductor providing functionality of the earth wire and a fibre carrier system.

e. The specification for the host ADSS (All Dielectric Self Supporting) cable

Note

The Fibre optic systems detailed in this specification are for installation into the following fibre systems:-

- Underground cable duct systems as detailed in NSP/002/001
- Fibre Wrap installations onto existing 11-132kV overhead lines as detailed in NSP/004/123
- OPGW – Optical earthwire for tower lines as detailed in NSP/004/124
- ADSS – Self-supporting fibre installations onto existing 11-132kV overhead lines as detailed in NSP/004/125 – Not on CDS Tracker

Technical documents referenced within this specification refer to the latest versions of the relevant International Standards, British Standard Specifications and all relevant Energy Networks Association Technical Specifications (ENATS) current at the time of supply.

2.1. Table of Contents

3. Technical Requirements

3.1. Optical Fibres

The optical fibres used by the Company shall be Single Mode, Non Dispersion Shifted Fibre (NDSF) to BSEN 60793-2-50:2016 type B1.3 "*Product Specification – Sectional Specification for class B single mode Fibres*"

The optical fibre coating material shall be mechanically strippable and be capable of being spliced by the fusion splicing technique.

The following details of the optical fibre shall be included and supplied in accordance with Appendix 4:

- the optical fibre type,
- the attenuation (dB/km),
- the refractive index of the optical core,
- the fibre manufacturer, and,
- the manufacturing process.

3.1.1. Colour Coding Scheme

When multiple fibres are housed in a single buffer tube, the colour coding of the fibre optic cables enables the installer/administrator to easily identify the individual fibres. The buffer tube colours and fibre colours shall be compliant with TIA/EIA-598 (See Appendix 2 for details). Buffer tubes supplied to the Company shall be coloured orange and blue. See clause 3.1.2 for buffer tubes associated with OPGW

3.1.2. Stainless Steel Tube Identification (OPGW only)

Optical fibres installed in OPGW shall be contained within stainless steel buffer tubes referred to as the (optical sub-unit). Where more than one tube is provided a permanent method of identification of the buffer tubes housing the optical fibres shall be provided as follows:-

Tube 1 Single ring marks spaced no greater than 500mm apart on the outer surface of the SLT, marked with permanent ink, which cannot be removed or degraded by normal cleaning techniques.

Tube 2 Two ring marks spaced no greater than 500mm apart on the outer surface of the SLT, marked with permanent ink, which cannot be removed or degraded by normal cleaning techniques.

Buffer tubes shall be filled with a compound to provide resistance to water penetration, vibration damping and for shock absorption. The filling compound shall pass the drip test specified in IEC 60794-1-2.

3.2. Fibre Optic Underground Cable

Underground cables shall be non-armoured all dielectric cables manufactured to BSEN 60794-3-10 "Optical fibre cables, Outdoor cables, Family specification for duct, directly buried or lashed aerial optical telecommunication cables" and in accordance with Appendix 1 and the following technical requirements.

The cable shall be circular in cross section and free from pinholes, joints, repairs and other defects. Materials used in the construction of the cable shall not affect the physical or optical properties of the fibres and shall be compatible with each other.

The required number of fibres will be specified in the individual contract document. Where this has not been specified, the default cable design shall incorporate 24 single mode fibres. The cable shall be arranged with a minimum of 2 loose buffer tubes, where each tube contains 12 fibres. The remaining space shall be occupied with dummy tubes to maintain the circularity of the cable.

The preferred material for the outer sheath of the cable is High Density Polyethylene with a 2.5% loading of carbon black (well dispersed) for weather resistance purposes. The composition of the polyethylene sheath shall comply with Section 4 of BS 6234 and conform to the physical and mechanical requirements detailed in Appendix 4 of this specification.

Other sheath materials offering similar properties to polyethylene shall only be used with the approval of the Company.

Before shipment and after testing the cable ends shall be capped to prevent the ingress of water.

Unless specified otherwise within the order, fibre optic underground cable shall be supplied as 2km drum lengths although it is possible to obtain lengths up to a maximum length of 7Km.

3.2.1. Additional Performance Requirements for Duct Type Fibre Optic Cables

- The optical fibres shall not be subjected to any critical stress when the cable is wrapped and unwrapped around a mandrel of twelve times the diameter of the cable for four complete turns.
- The cable shall withstand a crush load of 1000 N load applied at right angles laterally, via a 25mm diameter rod, without damage to the optical fibres. Alternatively the cable shall withstand a crush load of 5000 N applied with a 100mm flat plate
- Informative: it is preferred that the crush test is performed using a 25mm round bar to simulate a load from a second cable crossing at right angles under external pressure. A load of 5000 N applied with a 100mm flat plate has found to be of similar severity.
- The fibre tubes shall be filled with a water-blocking compound to prevent water penetration and for shock absorption.
- A water blocking compound shall be used in the interstices of the cable or alternatively a water blocking tape may be used beneath the outer sheath.
- The optical fibre cables shall have an installed design life of at least 25 years.
- Duct type fibre optic cable and installed fibres shall be rated for operation in close proximity to power cables having a maximum thermal rating of 85°C.

3.3. Fibre Optic Conductor Wrap Cables

Fibre optic conductor wrap cables shall be all dielectric cables designed in accordance with IEEE 1594 – 2008 and are available in two design formats allowing them to be helically wrapped around overhead line conductors. They are available in two basic formats.

- Fibre Wrap (Full Fibre Count)
- Fibre Wrap (Reduced Fibre Count)

3.3.1. Fibre Optic Conductor Wrap (Full Fibre Count)

Fibre Optic Conductor Wrap (Full Fibre Count) systems are normally only applied to tower lines and can be installed on lines operating at voltages up to and including 132kV. The cable can be supplied in two formats suitable for installation onto either Earth Wire or Phase Wires. Both designs shall be supplied using shotgun resistant jacket designs.

Note

Care must be taken when selecting the required type of Fibre Wrap (Full Fibre Count) as the only difference between the two products is the type of sheathing material used to protect the cable. Further details can be found in clause 3.3.2.

Both types of Fibre Wrap (Full Fibre Count) cable shall compose of 4 buffer tubes, with each tube carrying 6 single mode fibres as detailed in clause 3.1, providing a total fibre count of 24 with each fibre and tube colour coded in accordance with TIA/EIA-598.

Fibre Optic Conductor Wrap (Full Fibre Count) cable is capable of accommodating up to 6 tubes with 12 fibres per tube providing a maximum available fibre count of 72.

Appendix 1b provides constructional data for fibre wrap (Full Fibre Count) – Phase Wire Wrap.

Appendix 1c provides constructional data for fibre wrap (Full Fibre Count) – Earth Wire Wrap.

The joint when filled with filling medium i.e. resin, shall still match the 15kV induced withstand voltage of the cable.

3.3.2. Sheath

- The outer jacket or sheath shall be designed to house and protect the inner elements of the cable from damage due to moisture, sunlight, environmental, thermal mechanical and electrical stress. The jacket material shall be dielectric, non-nutrient to fungus, and consist of a polyethylene material containing carbon black and an antioxidant.
- The jacket shall be extruded over the underlying element and shall be of uniform diameter. The minimum jacket thickness at any cross section shall not be less than 70% of the nominal thickness
- When installed on earth wires, electrical stress requirements and concerns do not normally apply however for some EHV Tower lines the earth wire may exhibit higher than normal surface gradients (i.e. 10kv/cm). In these cases, a track resistant jacket shall be applied to the earth wire wrap. The need for track resistant sheaths will be identified by the fibre wrap supplier during the project assessment stage after we provide details of the tower types proposed. However it is envisaged that this will not normally be required.
- Where cable is required for wrap onto phase wire conductors, the jacket shall default to a track resistant design of polyethylene.
- Cable sheaths shall be designed to pass the 2000hrs exposure to UV ageing test providing at least 75% of the initial tensile strength and elongation to break.
- The sheath shall provide a cut through resistance force of > 100N.
- The sheath shall be manufactured from a gunshot resistant material.

3.3.3. Buffer Tubes

Buffer tubes shall be of the loose tube design with gel filling that is compatible with the tubing material, fibre coating, and colouring to protect the optical fibre and protect the optical fibres and prevent moisture ingress.

To ensure the buffer tubes are waterproof, they shall be subjected to the following routine test. A horizontal 1m length of cable shall resist a 1m head of water applied at one end for 24 hours with no water penetration to the other end of the sample.

In addition the tube design shall be type tested without the protection of a cable sheath to ensure that the tubes shall have hydrolysis resistance of >20 years @ 40°C, 60% relative humidity.

3.3.4. Temperature Range

- The installed cable shall function over an ambient temperature range of -40 to +85°C when wrapped, and –40 to +65°C when loose (e.g. down tower legs) within the following limits:
- <0.05dB/km loss increase @1550nm (single mode fibre)

- The gel on the loose tubes shall pass the following gel drip test: <0.05g gel drip @ 65°C after 24 hours
- The cable shall retain winding flexibility onto a 140mm mandrel @-30°C.
- All cables shall survive a short term fault current conductor temperature of at least 260°C and up to 300°C in the case of cross linked sheath cables. After the test there shall be no breach of the outer jacket or fibre attenuation increase >0.25 dB/km @ 1550nm.
- All cables shall survive the effects including high temperature effects, associated with lightning strikes.

3.3.5. Cable Mechanical Properties

- Tensile properties - The fibre wrap cable shall have a strain margin of at least 0.5% to provide the following properties:-
- The loss increase @ 1550nm <0.05dB/km (single mode fibre)
- The cable breaking strength > 1000N.
- Crush properties - The cable shall resist a crushing force of 1000N between a flat plate and a 25mm mandrel with no permanent measurable increase in loss.
- Torsion properties - The cable shall resist torsion of 1 twist per metre with no permanent measurable increase in loss.
- Impact properties - The cable shall resist a single impact of 5N-m applied on a 12.5mm radius anvil with no permanent measurable increase in loss.

3.3.6. Bending

The cable shall withstand repeated wrapping and unwrapping around a 100mm mandrel without damage or attenuation change. In addition the cable shall withstand without fracture or fatigue of any components 2500 bends of +90° around a 50mm radius.

3.4. Fibre Optic Conductor Wrap (Reduced Fibre Count)

Fibre Optic Conductor Wrap (Reduced Fibre Count) cable is a light weight, small diameter, reduced fibre count version of the Fibre Optic Conductor Wrap (Full Fibre Count) cable. It is only available in a single format design with an anti-tracking, gunshot resistant sheath designed for installation onto phase wires of wood poles lines operating at up to and including 66kV.

The product is limited to a 12 fibre design arranged in 4 buffer tubes, with 3 fibres per tube.

Appendix 1d provides constructional data for fibre wrap (Reduced Fibre Count) – Phase Wire.

3.5. OPGW – Optical Ground Wire / Earthwire

3.5.1. General

OPGW is an optical fibre ground wire that provides the functionality of a standard earthwire without any change in the overall electrical or mechanical characteristics of a standard earthwire whilst also containing optical fibres. The conductive part of the cable serves to bond adjacent towers to earth and shield the current carrying conductors from lightning strikes whilst the optical fibres can be used to carry high speed, high bandwidth telecommunications and protection signals.

The sizes of OPGW detailed in Appendix 3 are designed to be direct equivalents for Horse and Keziah earthwires providing a design life of at least 40 years. This system is often referred to as the “Hexacore System”

See Appendix 1E for technical data associated with each size of OPGW. Conductor to be ordered on a section length basis with maximum section lengths normally limited to 6km.

3.5.2. Type Tests

Type tests are required to verify the characteristics of the conductor, which depend mainly on its design and manufacturing process. The manufacturer shall provide documentary evidence to show that the following tests have been satisfactorily completed.

3.5.2.1. Fatigue Life

The manufacturer shall produce test data or offer other evidence to show that the fatigue life of the conductor including that of the optical sub-unit is in excess of 10^8 cycles at a peak to peak amplitude corresponding to 300μ strain on the outer strands at the last point of contact with a metal clamp with a radius similar to a suspension clamp.

3.5.2.2. Fault Current I^2t Measurement

A sample of conductor shall be raised to an initial temperature of 65°C and the rated I^2t pulse in as detailed in the technical data in Appendix 1F and applied in less than 1 sec following the method described in IEC 60794-4-1 E.

During the test the temperature of the optical sub-unit shall be measured, the maximum temperature attained shall be less than the maximum temperature specified by the manufacturer and shall not lead to deterioration of the optical performance of the cable within its 40-year design life. The test shall be completed twice with 30 minutes between tests. Finally the conductor shall be dismantled and the optical sub-unit examined along its length for any signs of deterioration.

3.5.2.3. Lightning Simulation

The mid-point of a sample of optical conductor shall be subjected to a simulated lightning strike as described in IEC 60794-4-1 F having four consecutively applied components.

Table 1

Component	Parameter	Value	Tolerance
Initial Stroke	Peak Current Action Integral Pulse Length Rise Time	200 kA 2 $(kA)^2S$ < 500 μS < 25 μS	±10% ±10%
Intermediate Current	Mean Amplitude Pulse Length Charge Transfer	2kA <5ms 10C	±10% ±10%
Continuing Current	Amplitude Duration Charge Transfer	200 - 800 A 250 - 1000 ms 200C	 ±10%
Re-strike	Peak Amplitude Action Integral Pulse Length	100 kA 0.25 $(kA)^2S$ < 500 μS	±10% ±10%

Following the complete test, the strength of all strands shall be measured. The total residual strength, including that of any other metal parts, shall be greater than 75 % of the NBL in Appendix 1E or 1F.

3.5.2.4. Running Blocks

A sheave test shall be carried out to demonstrate that the running blocks specified for conductor erection by tension stringing or cradle block shall not damage the conductor mechanically or optically.

3.5.2.5. Temperature Cycling

The test shall be conducted in accordance with IEC 60794 with TA= -30°C, TB= +80°C and the duration t1 = 4 hours

3.5.2.6. Sample Testing

The manufacturer shall provide evidence that the minimum breaking load and the maximum D.C. resistance for the complete conductor do not exceed the values in Appendix 1E or 1F.

3.5.2.7. Site Tests

If the supply forms part of an installation contract optical testing shall be completed after delivery and after installation to ensure that no degradation has occurred between manufacture and commissioning. The optical cable shall be tested with an Optical Time Domain Reflectometer (OTDR) on each fibre core from each end, to characterise the attenuation of the installation and to ensure that no physical damage has occurred to the optical fibre during installation. There shall be no point discontinuities.

An end-to-end attenuation measurement shall be taken in each direction on each fibre using an optical source and an optical power meter. The overall attenuation of the installed optical cable shall not exceed that calculated using the attenuation values specified in this document after subtracting splice losses.

3.6. ADSS

3.6.1. General

ADSS is an entirely non-metallic cable which is very like a conventional fibre optic cable in appearance and behaviour. It is installed by fixing to the support structures (poles or towers) of an overhead line rather than burying it underground. ADSS cables are typically supplied in drum lengths of between 3 and 6km which have been ordered on a single or multiple section length basis to limit the need for intermediate splice positions.

ADSS cables contain optical fibres inside one or more plastic buffer tubes. The tubes are stranded around a central FRP (Fibre Reinforced Plastic) strength member which provides rigidity to the cable design. The bundle of tubes and CSM (Central Strength Member) is called the optical core, and this is protected from the external environment by one or more layers of sheath material and high strength yarns of glass and/or aramid filaments. The design of the cable must take into account the parameters of the aerial environment, such as sunlight, pollution, wind loading, ice loading, temperature cycling, vibration, unsupported span length and the strength of the electric field surrounding the power conductors on the overhead line.

To minimise the sag associated with this cable type and to simplify the optimum mechanical rating to suit span lengths varying between 80-400m spans this specification requires the use of ADSS with a Maximum Optical Working Tension (MOWT) of 28.5kN. Installation tensions shall be selected that accommodate the following design loading scenarios:-

Loading Conditions	Overhead Line Construction	
	Wood Pole, Steel Mast & Knursling Tower Lines	Tower Lines (eg PL16, L4M or L3)
Wind Speed/Pressure	25m/s or 380n/m^2	
Radial Ice (mm)	9.5	12.5
Loaded Design Temp (°C)	-5.6	
Ice Density (kg/m^3)	915	

3.7. Cable Marking

All fibre cables systems shall have the outer sheath clearly marked in white with the following information every metre:

llll M	-	Northern Powergrid Optical Cable	ffff F tttt logo yyyy
llll	-	Sequential Length Mark	
ffff	-	Fibre Count	
tttt	-	Fibre Type e.g. 9/125	
logo	-	Manufactures Logo	
yyyy	-	Year of Manufacture	

4. References

The products shall comply with the relevant International Standards, British Standard Specifications and all relevant Energy Networks Association Technical Specifications (ENATS) current at the time of tendering, except where varied by this standard. In respect the following documents are particularly relevant.

4.1. External Documentation

Reference	Title
60793-1-20	Optical fibres. Measurement methods and test procedures. Fibre geometry
60793-1-32	Optical fibres. Measurement methods and test procedures. Coating strippability
60793-1-33	Optical fibres. Measurement methods and test procedures. Stress corrosion susceptibility. Section 33 Stress corrosion susceptibility
60793-1-34	Optical fibres. Measurement methods and test procedures. Fibre curl
60793-1-40	Optical fibres. Measurement methods and test procedures. Attenuation
60793-1-42	Optical fibres. Measurement methods and test procedures. Chromatic dispersion
60793-1-44	Optical fibres. Measurement methods and test procedures. Cut-off wavelength
60793-1-45	Optical fibres. Measurement methods and test procedures. Mode field diameter
60793-1-47	Optical fibres. Measurement methods and test procedures. Macrobending loss
60793-1-48	Optical fibres. Measurement methods and test procedures. Polarization mode dispersion
BS 6234	Specification for polyethylene insulation and sheath of electric cables
BSEN 60793-2-50	Optical fibres. Product specifications. Sectional specification for class B single-mode fibres
BSEN 60794-3-10	Outdoor cables – Family specification for duct, directly buried and lashed aerial optical telecommunication cables
IEEE 1594	IEEE Standard for Helically Applied Fibre Optic Cable Systems (Wrap Cable) for Use on Overhead Utility Lines
PD IEC TS 61941	Optical fibres. Polarization mode dispersion measurement techniques for single-mode optical fibres
TIA/EIA-598	Telecommunications Industry Associations optical Fibre cable colour coding

The supplier shall provide with the tender full technical details of the equipment offered and shall indicate any divergence from these standards or specifications.

4.2. Internal Documentation

Reference	Title
NSP/002/001	Technical Specification for Earthing Materials
NSP/004/123	Guidance document on the installation of Fibre Optic Wrap onto Overhead Line Conductors
NSP/004/124	Code of Practice for the Installation of Optical Ground Wire (OPGW) on Tower Lines
NSP/004/125	Code of Practice for the Installation of ADSS (All Dieletric Self-Supporting) on wood pole and Tower Lines – not on CDS Tracker

4.3. Amendments from Previous Version

Clause / Subject	Title
1.0 & 2.0 Purpose & Scope	The purpose and scope of this document has been expanded to cover the requirements for ADSS and OPGW. Together with the inclusion of new references to installation guidance documents for ADSS and OPGW.
3.1 Optical Cables	The reference to BSEN60793-2-50:2013 has been updated to the 2016 version
3.1.2 Stainless Steel Buffer Tubes	New clause inserted to detail the requirements of the stainless steel buffer tubes used within OPGW conductor
3.3.1 Fibre optic conductor Wrap	Additional requirement added into this clause to require the use of shotgun resistant jackets designs for wrap type cables
3.5 OPGW	New clause added to this specification to detail the technical requirements relating to OPGW
3.6 ADSS	New clause added to this specification to detail the technical requirements relating to ASDSS
4.2 Internal documentation references	References added to NSP/004/124 and NSP/004/125
6.0 Authority for issue	Updated sign-off template applied
Appendices 1E & 1F	New appendices added to detail the technical requirements for OPGW and ADSS conductors

5. Definitions

Term	Definition
ADSS	All Dielectric Self Supporting
Interstices	Gap between strands or tubes in a round cable
OPGW	Optical Ground Wire
OTDR	Optical time-domain Reflectometer - An OTDR tester is used for testing and fault finding within fibre optic networks and fibre optic cables.

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	05/02/2024

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
Should this document be displayed on the Northern Powergrid external website?		Yes

		Date
Ged Hammel	Senior Policy & Standards Engineer	07/02/2024

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.

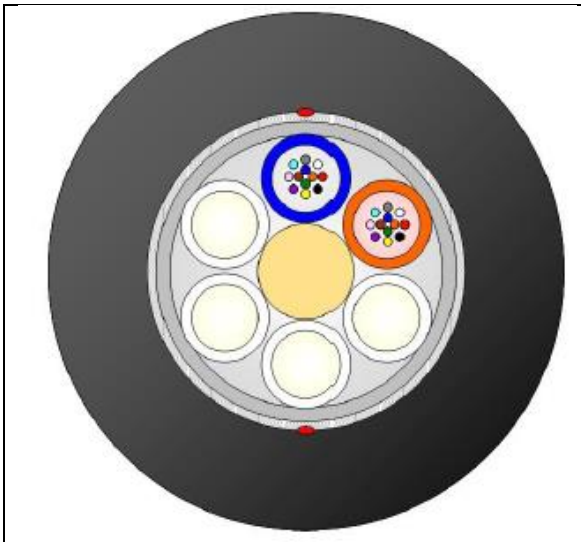
		Date
Steven Salkeld	Policy & Standards Engineer	12/02/2024

6.4. Authorisation

Authorisation is granted for publication of this document.

		Date
Paul Black	Head of System Engineering	22/02/2024

Appendix 1a – Constructional design details for fibre optic u/g duct cable



Application

Duct cables shall be designed with cable strength suitable for pulling into ducts and sub ducts with a low friction jacket

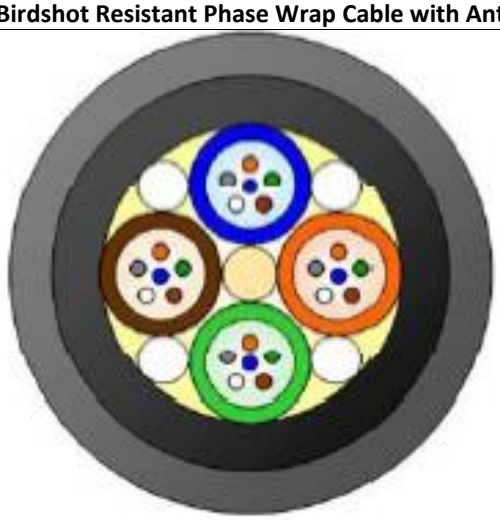
Construction		OD (mm)
1	Central Strength Member	2.25
2	6 Gel Filled Loose Tubes, 2 tubes containing 12 fibres per tube	2.1
3	Cabling of tubes and Central Strength Member	6.85 (± 0.2)
4	Glass Yarn Armouring and Mylar Tape	7.1
5	Outer Jacket and Ripcords	10.5(± 0.2)

Cable Properties			
Weight		87	kg/km
Diameter		10.5	mm
Cross Section		86.6	mm^2
Attenuation at 1310nm		0.36	dB/km
Attenuation at 1550nm		0.21	dB/km
Bend radius	Static Dynamic	210 1000	mm
Maximum Optical Working Tension (MOWT)		2	kN
Cable Breaking Strength		5.6	kN
Modulus		3.7	GPa
Operating temperature range		-40 to 85	°C

Applicable Standards	
Tube / Fibre Colours:	Fibre and Tube Colours are to EIA – 598
Testing standards	IEC-60794-1-E1, EIA-455-33B
Quality	Cable is designed, manufactured and tested in accordance with ISO 9001

Appendix 1b – Constructional design details Fibre Optic Conductor Wrap (Full Fibre Count) - (Phase wire)

(Birdshot Resistant Phase Wrap Cable with Anti-Tracking Sheath)



Application:

Small lightweight optical cable for installation by helical wrapping onto the phase wire of overhead electric power lines

Features and Benefits:

Stranded loose tube design ensures that fibres are always free from mechanical strain under all service conditions
Dual layer anti-tracking sheath provides protection against shotgun damage, UV light, pollution, lightning and fault current conditions and electric field effects
No metallic or conductive components
Small size and low weight ensures minimum loads are applied to the overhead line

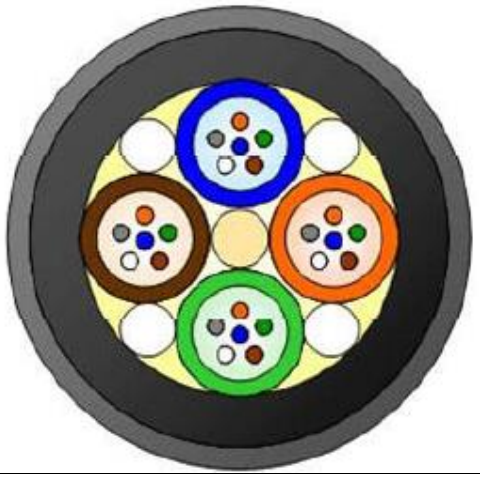
Construction		OD (mm)
1	Central Strength Member	1
2	4 Gel Filled Buffer Tubes, with up to 6 fibres per tube.	2
3	4 Fillers	0.9
4	Cabling of tubes, Fillers, and Central Strength Member; Water Block Gel.	5
5	Sheath	8.0 ±0.2

Cable Properties			
Weight		60	kg/km
Diameter		8.0 ±0.2	mm
Effective cross sectional area		50	mm^2
Maximum Cable Length		3188	m
Maximum Optical Working Tension		300	N
Minimum Bend Radius		150	mm
Sheath Colour		Black	
Sheath Thickness		1.5	mm
Operating temperature range		-40 to 85	°C
Maximum short term temperature		250	°C
Installation temperature range		-10 to 50	°C
Storage temperature range		-20 to 50	°C
Typical attenuation (G-652 fibre)	1310 nm	0.36	dB/km
	1550 nm	0.22	

Applicable Standards	
Fibre	Compatible with low water peak, NZDS and standard single-mode fibres (G652, G655, G656) and multi-mode fibres
Tube / Fibre Colours:	Fibre and Tube Colours are to EIA – 598
Testing standards	IEEE 1594, IEC-60794, EIA-455
Quality	Cable is designed, manufactured and tested in accordance with ISO 9001

Appendix 1c - Constructional design details for Fibre Optic Conductor Wrap (Full Fibre Count) - (Earth Wire)

(Birdshot Resistant Earth Wire Wrap)



Application:

Small lightweight optical cable for installation by helical wrapping onto the earth wire of overhead electric power lines

Features and Benefits:

Stranded loose tube design ensures that fibres are always free from mechanical strain under all service conditions

Dual layer sheath provides protection against shotgun damage, UV light, pollution, lightning and fault current conditions

No metallic or conductive components.

Small size and low weight ensures minimum loads applied to overhead line

Construction		OD (mm)
1	Central Strength Member	1
2	4 Gel Filled Buffer Tubes, with up to 6 fibres per tube.	2
3	4 Fillers	0.9
4	Cabling of tubes, Fillers, and Central Strength Member; Water Block Gel.	5
5	Sheath	7.3 ±0.2

Cable Properties			
Weight		45	kg/km
Diameter		7.3 ±0.2	mm
Effective cross sectional area		42	mm^2
Maximum Cable Length		3652	m
Maximum Optical Working Tension		300	N
Minimum Bend Radius		150	mm
Sheath Colour		Black	
Sheath Thickness		1.1	mm
Operating temperature range		-40 to 85	°C
Maximum short term temperature		250	°C
Installation temperature range		-10 to 50	°C
Storage temperature range		-20 to 50	°C
Typical attenuation (G-652 fibre)	1310 nm	0.36	dB/km
	1550 nm	0.22	

Applicable Standards	
Fibre	Compatible with low water peak, NZDS and standard single-mode fibres (G652, G655, G656) and multi-mode fibres
Tube / Fibre Colours:	Fibre and Tube Colours are to EIA – 598
Testing standards	IEEE 1594, IEC-60794, EIA-455
Quality	Cable is designed, manufactured and tested in accordance with ISO 9001

Appendix 1d - Constructional design details for Fibre Optic Conductor Wrap (Reduced Fibre Count) - (Phase Wire)

(Birdshot Resistant Phase Wrap Cable with Anti-Tracking Sheath)

Application:

Very small lightweight optical cable for installation by helical wrapping onto medium voltage overhead distribution lines

Features and Benefits:

Stranded loose tube design ensures that fibres are always free from mechanical strain under all service conditions

Dual layer anti-tracking sheath provides protection against mechanical damage, UV light, pollution, lightning and fault current conditions and electric field effects

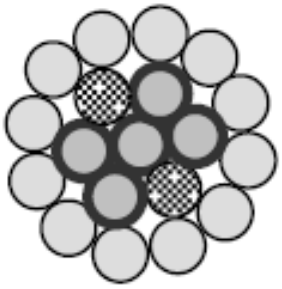
Very small size and low weight ensures minimum loads applied to overhead line

Construction		OD (mm)
1	Central Strength Member	0.7
2	4 Gel Filled Buffer Tubes, with up to 3 fibres per tube.	1.6
3	4 Fillers	0.7
4	Cabling of tubes, Fillers, and Central Strength Member; Water Block Gel.	4
5	Sheath	5.6 ±0.2

Cable Properties			
Weight		28	kg/km
Diameter		5.6 ±0.2	mm
Effective cross sectional area		25	mm^2
Maximum Cable Length		1000	m
Maximum Optical Working Tension		150	N
Minimum Bend Radius		110	mm
Sheath Colour		Black	
Sheath Thickness		0.8	mm
Operating temperature range		-40 to 85	°C
Maximum short term temperature		250	°C
Installation temperature range		-10 to 50	°C
Storage temperature range		-20 to 50	°C
Typical attenuation (G-652 fibre)	1310 nm	0.36	dB/km
	1550 nm	0.22	

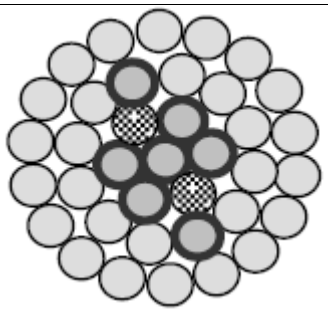
Applicable Standards	
Fibre	Compatible with low water peak, NZDS and standard single-mode fibres (G652, G655, G656) and multi-mode fibres
Tube / Fibre Colours:	Fibre and Tube Colours are to EIA – 598
Testing standards	IEEE 1594, IEC-60794, EIA-455
Quality	Cable is designed, manufactured and tested in accordance with ISO 9001

Appendix 1E – Technical Details for Horse Equivalent (OPGW)

Technical Data					
Electrical & Mechanical (Based on Hexacore System)					
BS EN 50182 Description					
Maximum Overall diameter			13.95mm		
Nominal Breaking Load			58.33 kN		
Maximum Weight per unit length			438 kg/km		
Mass of Grease per unit length			6.9 kg/km		
L38 Greasing Category			Cat 3		
Minimum Youngs modulus (E)			90 kN/mm^2		
Weight of Al-Alloy			203 kg / km		
Weight of Aluminium Clad Steel (ACS)			205 kg / km		
Maximum coefficient of thermal expansion			17.7x10^{-6}		
Maximum DC resistance at 20°C			0.3705 Ω/km		
Conductivity of Alloy Wires			32.79 Sm/mm^2		
Minimum 1 sec Short circuit current rating which will cause a temperature rise in the conductor from 65°C to 200°C			9.10kA		
Conductor Construction (all dimensions in mm)			**Al-Alloy**	**ACS***	**SLT ***
Outer layer	Number of Strands	12	12 x 2.79	-	-
2nd Layer	Number of Strands	6	-	4 x 2.79	2 x 2.50
3rd Layer	Number of Strands	-	-	-	-
Centre Strand			-	1 x 2.79	-
Cross sectional area of individual materials (mm)^2			73.36	30.57	9.82
Cross sectional area of conductive materials (mm)^2			103.93		
Requirements for the Optical sub-units(s)					
Nominal Operating temperature range			-30°C to 80°C		
Number of Fibres per tube			Two tubes of 12 fibres		
Individual Fibre Specification			Single Mode, Non Dispersion Shifted Fibre (NDSF)		

Material Code
Al-Alloy = Aluminium Alloy
ACS = Aluminium Clad Steel
SLT = Stainless Steel Tube

Appendix 1F – Technical Details for Keziah Equivalent (OPGW)

Technical Data					
Electrical & Mechanical (Based on Hexacore System)					
Maximum Overall diameter			20.58mm		
Nominal Breaking Load			113.10 kN		
Maximum Weight per unit length			897 kg/km		
Mass of Grease per unit length			21 kg/km		
L38 Greasing Category			Cat 3		
Minimum Youngs modulus (E)			80.4 kN/mm^2		
Weight of Al-Alloy			527 kg / km		
Weight of Aluminium Clad Steel (ACS)			319 kg / km		
Maximum coefficient of thermal expansion			18.9x10^{-6}		
Maximum DC resistance at 20°C			0.1542 Ω/km		
Conductivity of Alloy Wires			32.05 Sm/mm^2		
Minimum 1 sec Short circuit current rating which will cause a temperature rise in the conductor from 65°C to 200°C			20.9kA		
Conductor Construction (all dimensions in mm)			**Al-Alloy**	**ACS**	**SLT**
Outer layer	Number of Strands	18	18 x 2.94	-	-
2nd Layer	Number of Strands	12	10 x 2.94	2 x 2.94	-
3rd Layer	Number of Strands	6	-	4 x 2.94	2 x 2.80
Centre Strand			-	1 x 2.94	-
Cross sectional area of individual materials (mm)^2			190.08	47.52	12.32
Cross sectional area of conductive materials (mm)^2			237.6		
Requirements for the Optical sub-units(s)					
Nominal Operating temperature range			-30°C to 80°C		
Number of Fibres per tube			Two tubes of 12 fibres		
Individual Fibre Specification			Single Mode, Non Dispersion Shifted Fibre (NDSF)		

Appendix 1G – Technical Details for ADSS – 48 Fibre (LD-48DJ6/28)

Application

ADSS cables are designed for use on HV & EHV distribution lines supports on Wood poles or steel Masts and Towers

Features and benefits

Stranded Loose Tube design ensures that fibres are always free from mechanical strain under specified loading conditions
No metallic or conductive components
Torsionally- balanced aramid yarn strength elements provide stable cable design
UV-resistant polyethylene sheath is compatible with fittings from all major suppliers and is suitable for use up to 12kV space charge potential

Construction		OD (mm)
1	Central Strength Member	2.25
2	6 Gel Filled Loose Tubes, up to 12 fibres per tube	2.1
3	Cabling of tubes, Central Strength Member, and Assembly Water Blocked	6.45
4	Inner Jacket and Ripcords	8.05 ± 0.2
5	Aramid Strength Members - Torsionally Balanced	11.6
6	Outer Jacket and Ripcords	15 ± 0.2

Cable Properties		LD-48DJ6/28	
Weight		179	kg/km
Diameter		15	mm
Effective cross sectional area		177	mm^2
Bend radius		300	mm
Maximum Optical Working Tension (MOWT)		28.5	kN
Cable strain at MOWT		0.7	%
Cable Breaking Strength		79.8	kN
Modulus		23	GPa
Operating temperature range		-40 to 85	°C
Expansion coefficient		1.81E-06	$°C^{-1}$
Typical attenuation* *G.652. Other fibre is available upon request	1310 nm 1550 nm	0.36 0.21	dB/km

Applicable Standards	
Tube / Fibre Colours:	Fibre and Tube Colours are to EIA – 598
Testing standards	IEEE 1222, IEC-60794-1, EIA-455
Quality	Cable is designed, manufactured and tested in accordance with ISO 9001

Appendix 2 – TIA/EIA-598 Colour Code

Fibre Position	Fibre Colour	Tracer Colour	Illustration
1	Blue		
2	Orange		
3	Green		
4	Brown		
5	Slate		
6	White		
7	Red		
8	Black		
9	Yellow		
10	Violet		
11	Rose		
12	Aqua/Turquoise		
13	Blue	Black	<50mm>
14	Orange	Black	
15	Green	Black	
16	Brown	Black	
17	Slate	Black	
18	White	Black	
19	Red	Black	
20	Neutral	Black	
21	Yellow	Black	
22	Violet	Black	
23	Rose	Black	
24	Aqua/Turquoise	Black	<50mm>
25	Blue	Black	
26	Orange	Black	
27	Green	Black	
28	Brown	Black	
29	Slate	Black	
30	White	Black	
31	Red	Black	
32	Neutral	Black	
33	Yellow	Black	
34	Violet	Black	
35	Rose	Black	
36	Aqua/Turquoise	Black	
37	Blue	Black	
38	Orange	Black	
39	Green	Black	
40	Brown	Black	
41	Slate	Black	
42	White	Black	
43	Red	Black	
44	Neutral	Black	
45	Yellow	Black	
46	Violet	Black	
47	Rose	Black	

Appendix 3 - Schedule of Requirements

Item	Description	Commodity Code
1	Fibre Optic Cable containing 24 single mode NDSF fibres arranged in 2 tubes of 12 fibres per tube supplied on 2km drums	171621
2	Fibre Optic Conductor Wrap (Full Fibre Count), c/w birdshot resistant jacket for use on Phase wires containing 24 single mode NDSF fibres arranged in 4 tubes of 6 fibres per tube supplied on cassette lengths up to 3.6km	TBA
3	Fibre Optic Conductor Wrap (Full Fibre Count), c/w birdshot resistant jacket for use on Earth wires containing 24 single mode NDSF fibres arranged in 4 tubes of 6 fibres per tube supplied on cassette lengths up to 3.6km	TBA
4	Fibre Optic Conductor Wrap (Reduced Fibre Count), c/w birdshot resistant jacket for use on Phase wires containing 12 single mode NDSF fibres arranged in 4 tubes of 3 fibres per tube supplied on cassette lengths up to 1km.	TBA
5	OPGW – 70mm ACSR (Horse) Equivalent – 24 Fibre – Two tubes of 12	TBA
6	OPGW – 160mm AACSR (Keziah) Equivalent - 24 Fibre – Two tubes of 12	TBA
7	ADSS – 28kN All Dielectric Self Supporting Fibre Cable with 48 Fibre	TBA

Appendix 4 – Self Certification Conformance Declaration

Fibre Optic Cable is required to be supplied against this specification shall comply with the latest issues of the relevant ENATS, British and International Standards specified. The following tables are intended to amplify and/or clarify the requirements of elements of these Standards but do not preclude meeting all requirements of the standards.

The manufacturer shall declare conformance or otherwise, clause by clause, using the following levels of conformance declaration codes, where appropriate indicating if tests are type or routine tests.

Conformance declaration codes

N/A = Clause is not applicable/ appropriate to the product
Cs1 = The product conforms fully with the requirements of this clause
Cs2 = The product conforms partially with the requirements of this clause
Cs3 = The product does not conform to the requirements of this clause
Cs4 = The product does not currently conform to the requirements of this clause, but the manufacturer proposes to modify and test the product in order to conform.

Instructions for completion

- When Cs1 code is entered no remark is necessary.
- When any other code is entered the reason for non-conformance shall be entered.
- Prefix each remark with the relevant 'BS EN' 'IEC' or 'ENATS' as appropriate.

Manufacturer:
Product Reference:
Details of the Cable Type (Conductor Type and Size)
Name:
Signature:
Date:

NOTE: One sheet shall be completed for each type of cable offered.

Specification for Fibre Optic Cables - The following requirements apply to single-mode NDSF Type B1.3 optical fibres:						
Standard	**Clause**	**Limit Value**	**(Northern Powergrid preferred value)**	**Test Method**	**Conformance Code**	**Remarks / Comments**
IBS EN 60793-2-50						
Coating Diameter	5.2	255 ± 10 µm	(242 ± 5 µm)	BS EN **60793-1**2 (A3)		
Coating concentricity Error	n/a	<= 12 µm		BS EN 60793-1-20		
Coating non-circularity	n/a	Not specified		BS EN 60793-1-20		
Coating fibre curl	5.3	≥ 2.0	(≥ 4.0 metres radius of curvature)	BS EN 60793-1-34		
Coating proof Stress	5.3	>= 0.69 GN/m2)	100 kpsi (0.7 GN/m2)	BS EN 60793-1-33		
Cladding Diameter	5.2	125 ± 1.0 µm	(125 ± 0.7 µm)	BS EN 60793-1-20		
Cladding Non-circularity	5.2	≤ 1 %		BS EN 60793-1-20		
Mode field Diameter @ 1310nm	Table C3	8.6 – 9.5 ± 0.4 µm	(9.2 ± 0.4 µm)	BS EN 60793-1-45		
Mode Field Concentricity error	Table C3	≤ 1µm	(<= 0.5 µm)	BS EN **60793-1**2 (A2)		
Proof Strain	5.3	≤ 1 %		BS EN 60793-1-32		
Stripping force	-	≤ 3.2 N		60793-1-32		
Attenuation 1300 nm	Table C3	≤ 0.4 dB/km	(≤ 0.35 dB/km)	60793-1-40		
Attenuation 1550 nm	Table C3	≤ 0.25 dB/km	(≤ 0.20 dB/km)	BS EN 60793-1-40		
Chromatic dispersion 1285 –1330 nm	5.4.2	≤ 3.5 ps/(km.nm)		BS EN 60793-1-42		
Chromatic dispersion 1550 nm	5.4.2	≤ 20 ps/(km.nm)	(≤ 18 ps/(km.nm))	BS EN 60793-1-42		

Standard	Clause	Limit Value	(Northern Powergrid preferred value)	Test Method	Conformance Code	Remarks / Comments
Zero dispersion wavelength	5.4.2	1310 nm		C5B		
Cut-off wavelength	5.4.4	≤1260 nm		BS EN 60793-1-44		
Polarisation mode distortion individual fibre length	5.4	≤ 0.5ps/_km		IEC TS61941		
Polarisation mode distortion link of concatenated fibres	5.4	≤ 0.1ps/_km	(≤ 0.08ps/_km @1550nm)	BS EN 60793-1-48		
Index of refraction	-	1.4675 at 1310nm	1.4681 at 1550nm	-		
Macrobending Loss	C3	<= 0.1dB		BS EN 60793-1-47		

Notes: The values within brackets are Northern Powergrid preferred specification values for the fibre rather than minimum values as specified with the BS EN 60793-2-50 type B1.3 specification.

Appendix 4a – Technical Data for Optical Cable

Optical Fibre Cable

The following design constraints apply and approval tests shall prove that the optical fibre cable meets these requirements:

- Maximum outer diameter 20 mm
- Maximum weight (W) 400 kg/km
- Conformity of sheath thickness ± 1 mm
- Operating temperature range - 25 to 85ºC

Cable Parameter	Limit	IEC 60794-1
Tensile performance	≥ 2 x W x 9.81 N	E1
Abrasion resistance sheath	≥ 300 cycles	E2A
Abrasion resistance marking	≥ 300 cycles	E2B
Crush 25 mm round bar	≥ 1000 N	E3
Crush 100 mm flat plate	≥ 5000 N	E3
Impact	≥ 50 Nm	E4
Torsion ± 90º	10 cycles	E7
Cable bend radius 12 x dia	4 turns 10 cycles	E11
Cut through resistance	≥ 500 N/mm	E12
Tear resistance	≥ 30 N/mm	-
Temperature cycling; 4 cycles	- 25 +40ºC	F1
Water penetration	–	F5
Bleeding of tube compound 24 h 60ºC	none	E12

Appendix 5 - Addendum to Supplier Requirements

Packaging/Delivery Information

Details of how this product will be packaged and delivered shall be provided.

Drum and Packaging Requirements

The Fibre optic duct cable shall be supplied on returnable drums, as specified in Appendix 1. Standard drum lengths are detailed in Appendix 1 together with a requirement for section lengths to be ordered as required (OAR).

Standard Drum Dimensions for Duct Cable

Maximum flange diameter 1200mm, maximum drum width of 1000mm (this dimension shall include any bolt heads or studs located on the side of the drum) and a minimum barrel diameter of 600mm.
The spindle hole shall have a diameter between 80 – 100mm. The gross weight shall not exceed 670kg.
For all drum types the two outer flanges shall be drilled with two 25mm diameter holes opposite to each other and 275mm from the central spindle hole.

All drums shall be designed to take a round spindle and be lagged to protect the conductor, whilst on the drums, from the risk of damage during transportation and handling on site.
The inner end of the conductor projecting from the drum shall be secured and protected to avoid damage with the direction of rolling being indicated on the outer flange of drum.

All returnable drums shall be labelled on one flange and the label must state:

- Manufacturer's name
- Conductor type
- Conductor cross section and stranding
- Conductor length in metres (either standard or OAR)
- Drum net weight excluding lagging
- Drum gross weight
- The Company order number and date
- The Company commodity code

Labelling shall be by any method that fulfils all of the following criteria:

- is not affected by rain or other adverse weather
- is not affected by ultra violet light
- is, and remains, legible

However the use of cards or papers whether or not enclosed is **NOT ACCEPTABLE.**
Drums shall be lagged using weatherproof wood fibreboard (an example of this is Nolco-flex) providing suitable protection to the conductor and secured with a circumferential banding system.

Standard Drum Dimensions and Labelling for Fibre Wrap Cable

Drum or cassette dimensions will be project specific.
All labels shall be adhesive and weather resistant.
All cassettes/reel labels should include, but not be limited to, the following:

- Cable description
- Manufacturing batch number
- Planned cable length requirement
- Actual cable length supplied
- Structure numbers. Destination from and to for each reel
- Manufacturing and quality control inspection stamp
- Planned cassette/single reel number.

Test Results

Each drum shall be supplied with details of the OTDR tests carried out at the factory before dispatch

Project Specific Requirements

Any project specific requirements will be provided by Northern Powergrid for inclusion in this appendix.

Appendix 6 – Technical Information Check List

The following information shall be provided by the supplier for review by Northern Powergrid. Additional information shall be provided if requested.

Requirement	Provided (Y/N)
Full product descriptions and part number/reference	
Complete set of constructional drawings for each item	
Type test evidence	
Manufacturing routine test plan	
Packaging/delivery information	
Instructions/Manuals for transportation & handling, installation, maintenance and disposal	