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Electricity Specification 400C14

Issue 8 July 2025

132kV Cables with XLPE Insulation

Amendment Summary

ISSUE NO. DATE	DESCRIPTION
Issue 5 **October 2021**	New template applied throughout. Prepared by: D M Talbot Approved by: Policy Approval Panel and signed on its behalf by Steve Cox, Engineering and Technical Director
Issue 6 **April 2023**	Document reformatted to remove sections relating to installation and commercial topics. Cable Construction requirements updated. • Increase of range of cross sections required up to 2000mm^2 Milliken • Reduction of insulation minimum thickness to 15mm Testing Requirements updated to reflect latest routine, sample and type test sequences in IEC 60840/BS7912/BS7970. Prepared by: P Howell Approved by: Policy Approval Panel and signed on its behalf by Steve Cox, Asset & Technology Director
Issue 7 **August 2024**	Updated to latest ES format. Update on specification for grade of Aluminium used in SWAS cables Cable Construction requirements of designs with foil and copper wire screens updated to specify minimum cross-sectional area of copper wires to be minimum 285mm^2 Prepared by: P Howell Approved by: Policy Approval Panel and signed on its behalf by Paul Turner, PAP Chairperson
Issue 8 **July 2025**	Removal or requirement for ENWL commodity code on label – replaced with project reference/purchase order number. Prepared by: P Howell Approved by: Policy Approval Panel and signed on its behalf by Paul Turner, PAP Chairperson

Contents

1 Scope

This Specification covers the technical requirements for 132kV cables for use on the Electricity North West Limited (hereinafter referred to as ENWL) Distribution System.

It covers the manufacture and supply of cables for use on ENWL network operating at 132kV (U_m = 145kv).

The Supplier will be responsible for the design, manufacture, testing and delivery to site of approved 132kV Cables.

Cables based on this specification may be purchased as separate items, or they may be procured as part of a larger project including system design, installation, supply of accessories, jointing, civil or other electrical work packages.

All cables offered must be compatible with suitable accessories as detailed in ENWL specification ES400 CS132.

This specification represents ENWL baseline specification for 132kV cables which must be fully complied with, however where there is any specific project requirement which is in addition to, or deviates from the requirements of this document, then this shall be fully documented within the Tender documents for that project.

This Specification covers the supply and delivery of 132kV XLPE insulated single core cables with either copper or aluminium conductors ranging from 300mm^2 up to 2000mm^2
The cable metallic screen shall be constructed using one of the following options.

(a) Smooth Welded Aluminium Sheath (SWAS)

(b) A combination of copper wire screens and a polymeric laminated metallic foil laminate layer.

(c) Seamless extruded lead alloy sheath (with or without additional copper wire screens to meet the short circuit rating)

Option (c) is the least preferred design and will only be considered in circumstances where options (a) and (b) cannot be offered.

The Tenderer shall provide the Schedule of Technical Particulars and the Compliance Conformance Schedule for every design and cross section offered.

All cables offered must be approved by the ENWL Circuits Policy Manager including the stated manufacturing location and extrusion line.
The Tenderer shall not supply previously approved designs that are manufactured on any new extrusion line and/or location without undergoing a full approval process.

2 Definitions

Approval	Sanction by the ENWL Circuits Policy Manager that specified criteria have been satisfied
Contract	The agreement between ENWL and the Contractor for the execution of the Works including therein all documents to which reference may properly be made in order to ascertain the rights and obligations of the parties under the said agreement.
Contractor	The person or person's firm or company, including personal representatives, successors and permitted assigns, who's Tender has been accepted by ENWL.
Design, Established	Design accepted by ENWL.
Design, Unestablished	New design not yet accepted by ENWL.
Installer	The person or persons or any company body, corporate or otherwise, carrying out work for ENWL in accordance with this Specification.
Maximum Voltage U_m	Maximum sustained power-frequency voltage between phase conductors, for which the cable is suitable
MDPE	Medium density polyethylene.
Rated Voltage U	Nominal power-frequency voltage between phase conductors, for which the cable is suitable
Rated Voltage U_0	Nominal power-frequency voltage between any conductor and earth for which the cable is suitable
Specification	The Specifications and schedules (if any) agreed by the parties for the purpose of the Contract.
Supplier	Any person or person's firm or company who supplies goods to ENWL or to its Contractor.
SWAS	Smooth Welded Aluminium Sheath
Tender	An offer in writing to execute work or supply goods at a fixed price.
Tenderer	The person or person's firm or company, including personal representatives, successors and permitted assigns, invited by ENWL to submit a Tender.
XLPE	Cross-Linked Polyethylene.

3 General Requirements for Approvals and Testing

3.1 Product not to be Changed

Compliance with this clause shall be in accordance with ES001.

3.2 Electricity North West Limited Technical Approval

Compliance with this clause shall be in accordance with ES001.

3.3 Quality Assurance

Compliance with this clause shall be in accordance with ES001.

3.4 Formulation

Compliance with this clause shall be in accordance with ES001.

3.5 Identification Markings

Compliance with this clause shall be in accordance with ES001.

3.6 Minimum Life Expectancy

The minimum life expectancy of all products covered by this Specification is 60 years.

3.7 Product Conformity

Compliance with this clause shall be in accordance with ES001.

3.8 Confirmation of Conformance

The Tenderer shall complete the conformance declaration sheets in Appendix B.

Failure to complete these declaration sheets may result in an unacceptable bid.

4 Requirements for Type and Routine Testing

Compliance with this clause shall be in accordance with ES001.

4.1 Requirement for Type Tests at Suppliers Premises

Compliance with this clause shall be in accordance with ES001.

4.2 Requirement for Routine Tests at the Supplier's Premises

Compliance with this clause shall be in accordance with ES001

5 Operational Conditions

The following are general conditions of operation for 132kV cables:

- Nominal system voltage U_0/U (U_m): 76/132 (145)kV.
- Nominal system frequency: 50Hz.
- Suitable for maximum single phase to earth short circuit withstand of 31.5kA for a period not exceeding 2 seconds.

6 Installation Conditions

132kV Cables specified in this document shall be installed in accordance with ENWL specification document ES400E5: Installation, Commissioning and Repair of Underground Cables Operating at 33kV and 132kV.

132kV Cables specified in this document will be pulled or laid direct into open trenches, pulled into ducts or installed in air. The cable can also be run in troughs, cement bound sand or suspended in cleats from the side walls. It is not envisaged that cables with increased fire performance properties shall be installed, but if required this shall be specified in the individual project Tender documents.

During storage and after installation cables can be expected to be subjected to the full range of climatic conditions encountered in the UK.

132kV Cables shall be available for continuous operation at their stated design loading for 365 days a year, 24 hours per day. A service life of up to 60 years is expected.

132kV Cables may be surrounded by ground water for most of their operating lives. Where cable is installed in ducts, flooding of ducts can occur resulting in permanently wet sections along the cable route. Cables installed above ground will be supported by means of cleats either vertically or horizontally and these cables may be exposed to direct sunlight for significant periods.

When required, the Cable Supplier shall liaise with the cable Installer in providing any technical advice to the best methods and precautions to be taken in the installation and preparation for jointing of the cable.

7 Design and Construction Requirements

7.1 Design

132kV cables shall be a single core extruded XLPE insulation design and supplied on drums in single core configuration only.

132kV cables supplied against this specification shall comply with the latest versions of the relevant British and International Standards specified. These are:

- IEC 60840
- BS 7912
- BS7970

7.2 Reliability

Reliability is paramount. When any Tender for 132kV cables is evaluated, preference will be given to proven established designs.

The Supplier shall demonstrate reliability for the offered design of the cable by providing evidence of satisfactory service life.

Cable designs offered must have successfully undergone CIGRE long term ageing tests in accordance with amendment 3, clause 5.4.15 to CENELEC HD 605.

7.3 Cable Construction

7.3.1 Conductor

The conductors shall be circular compacted stranded plain annealed copper or stranded aluminium conductor complying with BS EN 60228. The conductors shall be clean and free from metallic and foreign particles, which may contaminate the insulation and cause high stress points.

Conductors shall prevent the longitudinal penetration of water along the conductor using water blocking tapes.

Segmental Milliken conductors (S) will be required for conductor sizes above 1000mm^2. Oxidized or enamelled Milliken conductors will only be considered where the manufacturer can provide evidence that conductor jointing can be carried out without additional abrading of the conductor or by use of bespoke connectors.

Conductor sizes of 300, 630,800,1000,1200S,1400S,1600S & 2000Smm^2 will be required.

7.3.2 Extrusion Process

The semi-conducting screens and insulation shall be applied over the conductor together as a single pass extrusion free from factory repairs through in a triple head extruder. If a screening filter is fitted in the extruder head, it shall be as fine as possible without producing clogging and pressure rise which could lead to premature formation of cross-linking particles or distortion or rupture of the filter.

To avoid contamination due to material handling, all contact with the factory atmosphere shall be eliminated. Consequently, a clean room environment fed by filtered air, with positive pressure shall be used for the opening of the packaging holding the polymer together with a completely enclosed system for transferring the granules from the clean room to the extruder.

A dry curing process only shall be used. The vulcanisation tube shall be filled with either dry nitrogen or with an oil compatible with the insulation and screen materials: the gas or oil shall be maintained under a sufficiently high hydrostatic pressure to control void formation from the by-products of the cross-linking process. **Steam curing shall not be used.**

Cooling of the core after completion of the cross-linking process shall be carried out by means of water, dry nitrogen, or oil of the same type used for the curing process. The cooling medium shall be maintained at a sufficiently high pressure to control void formation in the insulation and screens from by-products of the cross-linking process.

7.3.3 Conductor Screen

The conductor screen shall comprise a continuous layer of extruded cross linked semi-conducting thermo-setting compound compatible with the insulation material and having an allowable operating temperature range equal to or greater than that of the insulation. The outer surface of the conductor screen shall be cylindrical and shall be firmly and continuously bonded to the overlying insulation.

The average thickness of the conductor screen shall be 1mm with a minimum thickness of any one point on the circumference not less than 0.6mm. The maximum thickness shall not be greater than 2.5 times the minimum value.

The volume resistivity of the screen shall not exceed 500-ohm metre at 90^{o}C.

A semi-conducting tape is permitted between the conductor and conductor screen.

7.3.4 Insulation

The insulation shall be super-clean XLPE and shall be the same nominal thickness over the whole range of conductor size. The nominal design thickness shall not exceed 18mm but shall have a minimum thickness of 15mm.

The maximum design stresses shall not exceed 6.94kV/mm at the conductor screen and 4.09kV/mm at the insulation screen.

ENWL`s Circuits Policy Manager may consider, subject to the availability of electrically compatible joints and terminations, an insulation thickness less than the values stated above. However, the reduced insulation thickness shall be such that the nominal maximum stresses on the smallest conductors does not exceed the levels quoted above.

Acceptance by ENWL of the insulation thickness or subsequent reductions in thickness shall be as a result of satisfactory completion of type tests.

Ultrasonic and advance digital processing technologies shall be used during continuous in-line quality monitoring of the cable insulation.

The quality of the XLPE material and extrusion process shall be such that:

- There shall be no voids greater than 75µm in diameter and the number of voids larger than 50µm in diameter shall not exceed 20 per 15,000mm^3.
- There shall be no contaminant (any solid or liquid which is opaque or non-homogeneous cross-linked polyethylene) larger than 150µm in any dimension. The number of such contaminants between 50µm and 150µm shall not exceed 10 per 15,000mm^3.

7.3.5 Insulation Screen

The insulation screen shall comprise a continuous layer of extruded cross linked semi-conducting material compatible with the insulation material and having an allowable operating temperature range equal to or greater than that of the insulation. The insulation screen shall be firmly bonded to the insulation and the contact surface shall be as free as possible from irregularities. Individual irregularities shall be permitted provided they do not have prominent peaks and protrude more than 0.06mm into or away from the insulation.

The ratio of base to height of irregularities between 0.03mm and 0.06mm high shall not be less than 3:1. Irregularities with a height less than 0.03mm shall be ignored.

The nominal thickness of the Insulation screen shall be 1mm with a minimum of 0.6mm at any one point around the circumference.

The volume resistivity of the screen material shall not exceed 500 Ohm metre at 90°C.

7.3.6 Removal of By-products Prior to Metallic Screening/Sheathing

At an appropriate stage of manufacture following completion of the extrusion and curing process and prior to the application of the metallic sheath and/or screen, the completed cable core shall be maintained at an elevated temperature, not exceeding 80ºC, for a sufficient period to reduce the gaseous and volatile by-products formed by cross linking down to a level below 1%.

7.3.7 Longitudinal Sealing Against Moisture

Semi-conducting moisture swelling tape or tapes, or an equivalent longitudinal moisture barrier shall be applied, depending on the construction of the cable, over the extruded insulation screen in lead sheath, smooth welded aluminium constructions and in foil barrier designs where the axial water barrier is over the copper screen wires.

An additional semi-conducting moisture swellable tape shall be installed over the copper screen wires where the copper screen wires are used in conjunction with a metallic foil or lead sheath.

The volume resistivity of the moisture swellable tape shall not exceed 500 Ohm metres at 90ºC.

7.3.8 Metallic Sheath Options

Moisture impervious (i.e. “dry”) cable designs shall include in their construction either a smooth welded aluminium or lead alloy sheath with or without additional copper wires, or a polymeric laminated metallic foil together with a copper wire screen.

7.3.9 Smooth Welded Aluminium Sheath (SWAS)

This metallic sheath shall consist of a longitudinally smooth welded aluminium alloy tube over the longitudinal moisture barrier.

The composition of the aluminium shall be declared in the Schedule of Technical Particulars with the Tender submission. The aluminium shall be Grade 1050 to ASTM B491/B491M or a similar Grade with equivalent or superior properties for mechanical strength and corrosion resistance (e.g. Grade 3003).

Glued designs are not permitted. Corrugated designs are not permitted. The aluminium sheath shall be fully bonded to the extruded oversheath.

The aluminium sheath shall be Longitudinally welded only. Circumferential welds are not permitted.

The nominal and minimum thickness of the sheath shall be declared in the Schedule of Technical Particulars and shall be such that the aluminium sheath can carry, without detriment, the through earth fault current for the specified duration.

7.3.10 Overlapped Metallic Foil Water Barrier and Copper Wires

If an overlapped aluminium or copper metallic-foil polymeric laminate is offered as the axial water barrier then copper wires shall be applied to the cable, so it can carry, without detriment, the through earth fault current for the specified duration , and meet the minimum required cross sectional area as described in 7.3.12.

The laminated moisture barrier shall comprise a longitudinally overlapped aluminium or copper foil continuously bonded to the oversheath.

The seam of the foil overlap shall be continuously and adequately bonded so as not to separate when subject to repeated bending, continuous thermal cycling or through earth fault current.

Cables with a metallic foil water barrier must be type tested to include the additional testing for laminate foils as described in Section 8.6.

7.3.11 Lead Sheath with or without Copper Wires

The metallic sheath shall consist of a seamless tube of lead alloy extruded over the longitudinal moisture barrier.

The lead alloy sheath thickness shall not be less than 2mm over any point, and shall be of a suitable thickness such that the lead sheath can carry, without detriment, the full through earth fault current, or alternatively in combination with additional copper wires as described in 7.3.12 ,the lead alloy sheath and copper wires can carry the full through earth fault current for the specified duration.

The composition of the lead alloy together with the nominal and minimum thickness of the lead sheath, the size and number of any copper wires and dimensions of the equalising tape shall be declared in the Schedule of Technical Particulars.

7.3.12 Copper Screen Wires

Evenly distributed copper wires in contact with a helically wound copper equalising tape shall be used under any laminate foil or lead alloy sheaths (if required). The copper wires and equalising tape shall be in intimate contact with the laminate foil or lead sheath.

The gap between individual wires shall not exceed 4mm at any point around the cable core.

The copper wire screens (or combination of copper wire screen and lead alloy sheath) shall be designed to carry the earth fault current for the required duration stated in Section 6 , without the current ceasing to flow because of the lengthening power arc path established between the phase conductor and the earth fault conductor.

For cable designs using metallic foil as a water barrier, the copper wires shall have a minimum total cross-sectional area of 285mm^2, or greater if calculations show it is required to meet the earth fault current rating stated in Section 6.

The metallic foil layer (irrespective, if it is copper or aluminium) shall not be used in any calculations to determine the size of earth fault conductor.

7.3.13 Oversheath

The oversheath shall consist of a layer of high or medium density polyethene and shall be effectively bonded to the metallic sheath to prevent the passage of moisture along the two interfaces and also to provide adequate mechanical performance.

A continuous outer graphite or other semi-conducting extruded coating shall be applied to the oversheath to provide an electrode for sheath tests prior to and following installation. The oversheath colour shall be Black if a graphite coating is applied or Red if a semi-conducting extruded Black compound top layer coating is applied over the polyethene sheath.

Preference will be given to cables having a semi-conducting extruded material.

The nominal average thickness shall be declared in the Schedule of Technical Particulars. The minimum thickness at any point on the circumference shall not fall below the declared nominal average value by more than 5%.

7.3.14 Identification Markings

The oversheath shall be legibly embossed with the following legend along two or more lines evenly spaced around the circumference of the cable shall be marked at intervals not exceeding 1 metre along the oversheath:

- **ELECTRIC CABLE 132000 VOLTS*** (*The letter "V" may be used in place of the word VOLTS).
- The standard of cable specification (e.g. **IEC60840**) and conductor size (e.g. **1 x 800**)
- The **identification of the manufacturer**, and the **year of manufacture** July 25

Other markings such as Month of manufacture, Batch number and Metre markings can be applied by inkjet or embossing/indenting.

8 Testing Requirements

8.1 Factory Routine Tests

The routine factory production tests listed in Table 2 below shall be carried out on a sample from every drum length of the same type and size of cable.

Table 2: Schedule of Routine Tests to be carried out on every drum length

TEST	DESCRIPTION OF TEST	TEST METHOD	TEST PASS REQUIREMENT AND COMMENTS
1	Partial Discharge Test	IEC 60840 Clause 9.2 BS 7912 Clause 12.6	Applied voltage: 1.75 U_0 (133kV) for 10sec then 1.5 U_0 (114kV) Sensitivity: < 10 pC. **No detectable discharge.**

2	High Voltage Test	IEC 60840 Clause 9.3 BS 7912 Clause 12.10	190 kV AC / 30 min. **No breakdown**
3	DC voltage test on oversheath	IEC 60840 Clause 9.4 BS 7912 Clause 9.5	Spark test during manufacturing AC voltage: max. 15 kV, or a DC voltage test with max. 25 kV

Results for each routine test shall be recorded with reference to the unique drum number and copies of the Routine test report shall be provide to ENWL Circuit Policy Manager.

8.2 Factory Sample Tests

The additional tests listed in Table 3 shall be carried out on samples taken from the manufactured batch. The frequency of testing is dependent upon the total length of cable manufactured for each Contract and is shown in Table 4.

Table 3 Factory Sample Tests

TEST	DESCRIPTION OF TEST	TEST METHOD	TEST PASS REQUIREMENT AND COMMENTS
1	Conductor Examination	IEC 60840, clause 10.4	IEC 60840 Clause 10.4
2	Measurement of electrical resistance of conductor and metallic sheaths	IEC 60840, clause 10.5	Corrected dc resistance at 20^0C shall not exceed stated value
3	Measurements of thickness: a) Conductor screen b) Insulation c) Insulation screen d) Oversheath	IEC 60840, clause 10.6 BS 7912, clause 12.4	a) as per 7.3.3 b) as per 7.3.4 c) as per 7.3.5 d) as per 7.3.13
4	Measurement of thickness of metallic sheath: a) SWAS Design b) Lead sheath designs)	IEC 60840, clause 10.7	a) as per 7.3.9 b) as per 7.3.11
5	Measurement of diameters: a) Core Diameter b) Overall Diameter	IEC 60840, clause 10.8	a) as per stated value b) as per stated value
6	Hot set test for XLPE insulation	IEC 60840, clause 10.9	IEC 60840: Table 8

		BS 7912, clause 13.9	
7	Measurement of cable capacitance	IEC 60840, clause 10.10	Maximum 8% above Stated Nominal Value
8	Water penetration test	IEC 60840, clause 10.13	IEC 60840: Annex E & F
9	Tests on cables with longitudinal metal tape or foil, attached to the oversheath	IEC 60840, clause 10.14	IEC 60840: Annex G

Table 4 Sample Testing Frequency

MANUFACTURED CABLE LENGTH (KM)	NUMBER OF SAMPLES TO BE TESTED ACCORDING TO TABLE 3
Up to 5 Km	1
5.1 to 10	2
10.1 to 15	3
15.1 to 20	4
20.1 to 25	5

Results for each sample test shall be recorded with reference to the unique batch identifier and copies of the Sample test reports shall be provide to ENWL Circuit Policy Manager.

8.3 Type Tests

A type test certificate signed by the representative of a competent witnessing body, or a report by the manufacturer giving the test results and signed by the appropriate qualified officer shall be acceptable as evidence of type testing.

Once successfully completed, type approval tests on cables do not need to be repeated unless there is a fundamental change in the design, material or manufacturing process. However, preference will be made to type test reports less than 5 years old to ensure continuous validation of the cable design and process.

Where a company is, for example, international and comprises of several dispersed manufacturing locations, the Type Approval of one manufacturing unit shall not imply automatic Approval of the other units in the company.

The results of type tests on cables with either aluminium or copper conductors shall be accepted for the same design of cable with conductors of the other metal.

8.3.1 Type Test Procedure

The sequential type tests are intended to assess the performance of the cable design together with associated joints and terminations and the ability of the manufacturer or manufacturing unit to manufacture the cable.

Where accessories are offered as part of a Tender, the preference will be to have type testing carried out with loops consisting of both the offered cable and accessories together.

ENWL requires all the electrical type tests listed in Table 5 to be successfully completed on the smallest and largest sizes of cable likely to be offered together with the non-electrical tests listed under Table 6. In addition, to prove the performance of foil moisture barriers and screens further type tests listed in Table 7 shall be carried out on either the smallest and largest conductor cross sections in the range for Approval.

In order to supply any conductor cross sections smaller or larger than originally approved, the sequential electrical tests and appropriate special sample tests on the foil moisture barrier shall be repeated on the revised smallest or largest size of cable.

8.4 Electrical Type Tests.

The the electrical type tests in Table 5 shall be performed on samples of complete cable of at least 10 m in length excluding the test accessories.

All the tests shall be applied in the listed sequence to the same sample.

Table 5: Schedule of Sequential Electrical Type Tests

TEST	DESCRIPTION OF TEST	TEST METHOD	TEST PASS REQUIREMENT AND COMMENTS
1	Check of insulation thickness of cable for electrical type tests	IEC 60840, clause 12.4.1 BS 7912, clause 12.4	
2	Bending Test (preconditioning)	IEC 60840, clause 12.4.3 BS 7912, clause 12.5	
3	Partial discharge	IEC 60840, clause 12.4.4 BS 7912, clause 12.6	Applied voltage: 1.75 U_0 (133kV) for 10sec then 1.5 U_0 (114kV) Sensitivity: < 10 pC. **No detectable discharge.**
4	Tan delta measurement in relation to voltage plus capacitance	IEC 60840, clause 12.4.5 BS 7912, clause 12.8	Tan δ at 76 kV ≤10 x 10^{-4} Increment of Tan δ between 36 kV and 152 kV ≤10 x 10^{-4}
5	Tan delta measurement in relation to temperature	IEC 60840, clause 12.4.5 BS 7912, clause 12.8	At 76kV: max difference between Tan δ (95°C) and Tan δ (ambient) = 10 x 10^{-4}
5	Heat cycle voltage test	IEC 60840, clause 12.4.6 BS 7912, clause 12.9	No breakdown after 20 cycles

6	Partial Discharge Test at ambient and high temperature	IEC 60840, clause 12.4.4	Applied voltage: 1.75 U_0 (133kV) for 10sec then 1.5 U_0 (114kV) Sensitivity: < 10 pC. **No detectable discharge.**
7	Lightning Impulse Voltage test	IEC 60840, clause 12.4.7.2 BS 7912, clause 12.10	10 negative impulses followed by 10 positive impulses **– there shall be no failure of the insulation**
8	Power Frequency Voltage Test	IEC 60840, clause 12.4.7.2	190kV for 15 mins. **No failure of the insulation shall occur**
9	Cable examination	IEC 60840, clause 12.4.8 BS 7912, clause 12.12	The condition of the insulation and screens shall be recorded in type test report
10	Resistivity of semi-conducting screens	BS 7912, clause 10.4	≤ 500 Ω m
11	Measurement of semi-conducting water blocking tape resistivity	BS 7912, clause 10.8	≤ 500 Ω m
12	Internal thermal resistance of complete cable	BS 7912, clause 15.5	The internal thermal resistance as determined by conductor load, measured temperature and dimensions shall not exceed the declared value by more than 10 %.

8.5 Non-Electrical Type Tests

The tests in Table 6, unless otherwise specified, shall be carried out on small sections of materials or components taken from a sample of complete cable.

Table 6: Schedule of Non-Electrical Tests

TEST	DESCRIPTION OF TEST	TEST METHOD	TEST PASS REQUIREMENT AND COMMENTS
1	Check of cable construction	IEC 60840, clause 12.5.2 BS 7912, clause 13.1	IEC 60840, clause 10.4, 10.6 & 10.7
2	Tests for determining the properties of insulation before and after ageing	IEC 60840, clause 12.5.4 BS 7912, clause 13.3	IEC 60840, Table 6

3	Tests for determining the properties of oversheath before and after ageing	IEC 60840, clause 12.5.4 BS 7912, clause 13.3	IEC 60840, Table 7
4	Additional ageing test on pieces of complete cable to check compatibility of materials	IEC 60840, clause 12.5.5 BS 7912, clause 13.2	IEC 60840, Table 6 IEC 60840, Table 7
5	Pressure test at high temperature on oversheath	IEC 60840, clause 12.5.7 BS 7912, clause 13.4	IEC 60840, Table 7
6	Hot set test for XLPE insulation	IEC 60840, clause 12.5.11 BS 7912, clause 13.9	IEC 60840, Table 8
7	Measurement of carbon black content of black PE oversheath	IEC 60840, clause 12.5.13 BS 7912, clause 13.10	2.5% +/- 0.5%
8	Water penetration test	IEC 60840, clause 12.5.15 BS 7912, clause 14	No water shall emerge from ends of test piece
9	Shrinkage test for XLPE insulation	BS 7912, clause 13.11	≤ 4.0%
10	Shrinkage test on PE sheath	IEC 60840, clause 12.5.18 BS 7912, clause 13.12	≤ 3.0%
11	Moisture content of the; a) Insulation b) semi conductive screens	BS 7912, clause 10.7	a) ≤ 150ppm b) ≤ 500ppm
12	Confirmation of degassing of XLPE insulation by thermal history measurement	BS 7912, clause 10.9	BS 7912, clause 10.9
13	Examination for contaminants in insulation	BS 7912, clause 10.10	No voids ≥ 75 µm Voids ≥ 50 µm shall not exceed 20 per 15 000 mm^3
14	Visual examination of semi conductive screens	BS 7912, clause 13.8	The semi conductive screens shall be smooth and free from protrusions and irregularities.
15	Impact test	BS 7912, clause 15.2	No oversheath penetration.

			No damage to the semi-conducting screen, i.e. penetration, loss of adhesion. No permanent thinning of the insulation.
16	Abrasion, penetration, bending and saline bath test on anti-corrosion coverings	BS 7912, clause 15.3	BS 7912, clause 15.3

8.6 Additional Type Tests for Metallic Foil Moisture Barriers

The following special sample tests listed in Table 7 are intended to prove the adequacy of performance, under representative operational conditions, of metallic foil-laminates as axial moisture barriers. Unless otherwise stated, the tests shall be carried out on cable preconditioned as per bending test detailed in IEC 60840, clause 12.4.3 or BS 7912, clause 12.5

Table 7: Additional Tests on Foil-Laminate Moisture Barriers

TEST	DESCRIPTION OF TEST	TEST METHOD	REQUIREMENTS
	Test Sequence on Samples of Complete Cables		
1	Bending Test (preconditioning)	BS 7912, clause 12.5	
2	Heat cycle voltage test	BS 7912, clause 12.9	
2	Impact test	BS7970	Followed by corrosion test in BS7970 There shall be no evidence of corrosion of the metallic foil sheath.
3	Sidewall loading test	BS7970	Followed by corrosion test in BS7970 There shall be no evidence of corrosion of the metallic foil sheath.
	Test on Samples of Components from Cables Tested to sequence above		
5	Adhesion strength of foil-laminate	BS7970	>1.5 N/mm
6	Peel strength of overlapped foil	BS7970Error! Reference source not found.	>1 N/mm

9 Sealing, Drumming and Logistical Requirements

On completion of the specified routine and sample tests in the manufacturer's works, the cable shall be placed on timber or steel drums taking care to prevent looseness of the cable and each end of the cable shall be firmly and properly secured to the drum.

Each end of every length of cable shall be sealed in such a way as to prevent the ingress of water both during transit and on site. A factory fitted pulling eye shall be fitted to the leading end conductor and fully sealed against moisture.

Tenderers shall state at the time of Tender their proposed cable drum sizes and weights.

All drums shall be supplied with adequate protection against mechanical damage of the cable during transportation and storage on site.

The preferred method is use of robust timber battens strapped across the drum flanges. The timber battens may fully cover the circumference of the drum (fully lagged), or partially (skeletal lagged) providing any gaps between the battens are not wide enough to allow mechanical plant (e.g. lifting forks) to penetrate and damage cable sheaths. The timber battens shall be secured by two or more tension straps around the drum. Nailed battens shall not be used.The Tenderer may propose alternative methods for protection of the drums which shall be fully approved by ENWL Circuits Policy Manager before any Contract is placed.

The end of the cable left projecting from the drum shall also be adequately protected against damage during transit, storage and handling on site. The drum spindle hole shall be 125mm in diameter.

Each drum shall bear a unique distinguishing number either branded or chiselled on the outside of at least one flange, and the direction for rolling shall be indicated by an arrow. In addition, the following particulars of the cable shall be displayed on a weatherproof label fixed on one flange of the drum:

- ENWL Project reference/ Purchase Order No.*see Note Below — July 25
- Name of manufacturer.
- Supplied length.
- Manufacturing batch identifier or drum number for trackability.
- Size of conductor and type of conductor material ("Cu" or "Al").
- Rated voltage and abbreviated description of cable construction (e.g. Cu/XLPE/SWAS/MDPE).
- Gross and Nett weights.
- The metre marking start and end values.

NOTE: as 132kV cables are ordered on a project specific basis, the requirement in ES001 to include an ENWL Commodity Code in any packaging is excluded for these cable types. — July 25

Cable drums may be stored for long periods outdoors. All drum labels shall remain legible and durable under these conditions.

Delivery will generally be in specified lengths either direct to site or to a suitable storage site as directed by ENWL or by ENWL Approved Contractors.

All cable drums shall be returnable. The Tenderer shall provide details of the procedure for arranging to collect empty drums from the company's normal delivery locations.

10 Customer Support

The required minimum level of support is as follows:

- Contractual or technical advice is to be available, in English, by telephone during normal working hours.
- Attendance at site by the manufacturer, or the manufacturer's representative within 5 working days of any request made by ENWL following identification of a defect or other major issue relating to the cable.

Tenderers shall provide details of the support available including contact details of Technical Support operatives.

11 Technical Information Required with Tender

TECHNICAL INFORMATION REQUIRED WITH TENDER	UNITS
Manufacturers Data sheet including section drawing for each cable offered	
Manufacturers' Safety Data Sheets (if applicable)	
Evidence of reliability record	
Details of Quality Management system	
Details of Customer Support	
Cable drums details:	
• Approximate Diameter	Metres
• Approximate Width	Metres
• Approximate Gross Weight	kg
• Approximate Nett Weight of drum (empty)	kg
• Method of Protection	
Completed Appendix A - Schedule of Technical Requirements	
Completed Appendix B – Compliance Schedule	

12 Documents Referenced

DOCUMENTS REFERENCED	
Health and Safety at Work Etc Act 1974	
The Electricity at Work Regulations 1989.	
Control of Substances Hazardous to Health Regulations 2002.	
Manual Handling Operations Regulation 1992.	
BS EN ISO 9000	Quality management systems.
BS EN ISO 14001	Environmental management systems. Requirements with guidance for use.
IEC 60840	Power Cables with extruded insulation and their fittings for rated voltages above 30 kV (U_m = 36 kV) up to 150 kV (U_m = 170 kV). Test methods and requirements.
ASTM B491/B491M	Standard Specification for Aluminium and Aluminium-Alloy Extruded Round Tubes for General-Purpose Applications
BS 7912	Power cables with XLPE insulation and metallic sheath, and their accessories, for rated voltages from 66 kV (U_m=72.5 kV) to 132kV (U_m=145kV). Requirements and test methods.
BS 7970	Electric Cables – Metal foil and longitudinally welded aluminium sheath constructions of power cables having XLPE insulation for rated voltages from 66 kV (U_m = 72.5kV) to 132 kV (U_m = 145 kV)
BS EN 60228.	Conductors in Insulated cables
CENELEC HD 605	Electrical Cables – Additional test methods

ENWL Code of Practice CP311	ENWL Code of Practice for Approval Policy and Process
ENWL Specification ES400 E5	Installation, Commissioning and Repair of Underground Cables Operating at 33kV and 132kV
ENWL Specification ES400 CS132	Cable Systems, Including Joints, Terminations, Associated Sealants and Components for use on 132kV Underground Networks (Um = 145kV)

13 Keywords

132kV; Cable; Underground.

Appendix A – Schedule of Technical Particulars

This schedule is to be completed by the manufacturer at the time of tendering. The technical particulars entered shall be binding. No departures from these shall be permitted except with the written permission of ENWL Circuits Policy Manager.

NO	ITEM	VALUE	UNIT
1	Manufacturer		
2	Location and manufacturing extrusion line reference		
3	Voltage designation (U_o/U (U_m)		kV
4	Nominal cross-sectional area of conductor		mm^2
5	Conductor details		
	5.1 Material		
	5.2 Type of construction		
	5.3 Overall Diameter		mm
	5.4 Moisture blocking material		
6	Barrier tape under conductor screen		
	6.1 Material		
	6.2 Nominal thickness (minimum average)		mm
7	Extruded conductor screen		
	7.1 Material		
	7.2 Nominal thickness (minimum average)		mm
	7.3 Minimum thickness		mm
	7.4 Nominal diameter over conductor screen		mm
	7.5 Thermal resistivity		^{0}C m/W

NO	ITEM	VALUE	UNIT
	7.6 Nominal volume resistivity at 90ºC		Ω/m
8	Maximum design dielectric stress at nominal voltage U_o		
	8.1 At conductor screen (assumed smooth)		MV/m
	8.2 At core screen		MV/m
9	Insulation		
	9.1 Material		
	9.2 Maximum level of particle content		
	9.3 Nominal (minimum average) thickness of insulation between conductor screen and core screen		mm
	9.4 Minimum thickness		mm
	9.5 Thermal resistivity		^{0}C m/W
	9.6 Ultrasonic and advance digital processing		Type/ Method
10	Core screen		
	10.1 Material		
	10.2 Nominal thickness (minimum average)		mm
	10.3 Minimum thickness		mm
	10.4 Nominal diameter over core screen		mm
	10.5 Thermal resistivity		^{0}C m/W
	10.6 Nominal volume resistivity at 90ºC		Ω/m
11	Extrusion process		
	11.1 Type of extrusion line (catenary, vertical, etc)		

NO	ITEM	VALUE	UNIT
	11.2 Disposition of extruders		
	11.3 Screening filter		
12	Curing process		
	12.1 Medium under which curing is carried out (e.g. dry nitrogen, silicone oil, etc)		
	12.2 Curing temperature		^{0}C
	12.3 Curing Pressure		bar
13	Cooling process		
	13.1 Cooling medium (water, dry nitrogen, etc)		
	13.2 Pressure		bar
14	Heat treatment of cable core		
	14.1 Manufacturing stage at which carried out		
	14.2 Heating method (current loading, vacuum, etc)		
	14.3 Temperature		^{0}C
	14.4 Duration		hours
15	Longitudinal moisture barrier		
	15.1 Material		
	15.2 Number of tapes		
	15.3 Thickness		mm
	15.4 Thermal resistivity		^{0}C m/W
	15.5 Nominal volume resistivity at 90^{0}C		Ω/m

NO	ITEM	VALUE	UNIT
16	Copper wire screen/earth conductor		
	16.1 Number and diameter of wires		No/mm
	16.2 Number and thickness of equalising tapes		No/mm
17	Nominal diameter over metallic screen		mm
18	Extruded Lead sheath or Welded Aluminium		
	19.1 Material type		
	19.2 Composition & Grade		% by wt % % % % % %
	19.3 Nominal thickness (minimum average)		mm
	19.4 Minimum thickness		mm
	19.5 Nominal diameter over lead sheath		mm
20	Polymer-foil laminate		
	20.1 Foil material		
	20.2 Foil thickness		mm
	20.3 Foil overlap bonding strength		N/mm
	20.4 Foil to polymer bonding strength		N/mm
	20.5 Thermal resistivity		^{0}C m/W
	20.6 Nominal volume resistivity at 90ºC		Ω/m
	20.7 Nominal diameter over foil laminate		mm

NO	ITEM	VALUE	UNIT
21	Oversheath		
	21.1 Number of layers		
	21.2 Materials		
	21.3 Nominal thickness (minimum average)		mm
	21.4 Minimum thickness at any point		mm
	21.5 Nominal overall diameter of completed cable		mm
22	Nominal weight of completed cable		kg/m
23	Maximum pulling force with pulling eye		kN
24	Minimum installation temperature		^{0}C
25	Maximum permissible sidewall pressure on roller during installation		daN
23	Minimum radius of bend round which cable can be laid		
	23.1 Laid direct or in air		m
	23.2 In ducts		m
	23.3 Adjacent to joints or terminations		m
24	Nominal internal diameter of pipes or ducts		mm
25	Maximum dc resistance of conductor at 20ºC		μΩ/m
26	Maximum ac resistance of conductor at 90ºC		μΩ/m
27	Equivalent star reactance of three phase circuit at 50Hz		μΩ/m
28	Maximum dc resistance of metallic screen/sheath of cable at 20ºC		μΩ/m
29	Maximum electrostatic capacity per core		ρF/m

NO	ITEM	VALUE	UNIT
30	Maximum charging current per conductor per metre of cable at nominal voltage		mA/m
31	Current carrying capacity:		
	Winter continuous Winter peak cyclic Summer continuous Summer peak cyclic		A A A A
32	Installation and operating conditions on which current carrying capacities stated in Item 31 are based:		
	32.1 Depth to top of upper cable		mm
	32.2 Details of sheath bedding		
	32.3 Number of circuits		
	32.4 Winter Rating		
	Maximum conductor temperature		^{0}C
	Ground Ambient temperature		^{0}C
	Soil thermal resistivity		^{0}C m/W
	Backfill thermal resistivity		^{0}C m/W
	29.5 Summer Rating		
	Maximum conductor temperature		^{0}C
	Ground Ambient temperature		^{0}C
	Soil thermal resistivity		^{0}C m/W
	Backfill thermal resistivity		
33	Maximum tangent of dielectric loss angle of cable when laid direct in the ground at nominal voltage, normal frequency at conductor temperature of:		

NO	ITEM	VALUE	UNIT
	20^0C		
	90^0C		
34	Maximum dielectric loss of cable per metre of three-phase circuit when laid direct in the ground at nominal voltage, normal frequency at maximum conductor temperature		W
35	Maximum tangent of dielectric loss angle of cable at normal frequency at conductor temperature of 20ºC		
	Up to 50% nominal voltage		
	at 100% nominal voltage		
	at 200% nominal voltage		
36	Maximum change in tangent of dielectric loss angle between 50% nominal voltage and 200% nominal voltage at 20ºC		
37	Metallic core screen loss of cable per metre of three-phase circuit at nominal voltage, normal frequency at current rating given in Item 31		W/m
38	Metallic core sheath loss of cable per metre of three-phase circuit at nominal voltage, normal frequency at current rating given in Item 31		W/m
39	Conductor short circuit current carrying capacity for one second, cable loaded as Item 31, before short circuit and final conductor temperature of 250ºC		kA
40	Metallic sheath/screen short circuit current carrying capacity **for one second**, cable loaded as Item 31, before short circuit and final conductor temperature of 250ºC		kA
41	Metallic sheath/screen short circuit current carrying capacity **for two seconds**, cable loaded as Item 31, before short circuit and final conductor temperature of 250ºC		kA

Appendix B – Conformance Declaration

SECTION-BY-SECTION CONFORMANCE WITH SPECIFICATION

The Tenderer shall declare conformance or otherwise for each product/service or range of products/services, section-by-section, using the following Conformance Declaration Codes.

Conformance Declaration Codes:

N/A =	Clause is not applicable/appropriate to the product/service.
C1 =	The product/service conforms fully with the requirements of this clause.
C2 =	The product/service conforms partially with the requirements of this clause.
C3 =	The product/service does not conform to the requirements of this clause.
C4 =	The product/service does not currently conform to the requirements of this clause, but the manufacturer proposes to modify and test the product in order to conform.

Manufacturer:

Product/Service Description:

Product/Service Reference:

Name:

Company:

Signature:

SECTION-BY-SECTION CONFORMANCE			
Section	**Section Topic**	**Conformance Declaration Code**	**Remarks * (must be completed if code is not C1)**
3.1	**Product not to be Changed**		
3.2	**ENWL Technical Approval**		
3.3	**Quality Assurance**		
3.4	**Formulation**		
3.5	**Identification Markings**		
3.6	**Minimum Life Expectancy**		
3.7	**Product Conformity**		
3.8	**Confirmation of Conformance**		
4.1	**Requirements for Type Testing**		
4.2	**Requirements for Routine Testing**		
5	**Operational Conditions**		
6	**Installation Requirements**		
7.1	**Design**		
7.2	**Reliability**		
7.3.1	**Conductor**		
7.3.2	**Extrusion Process**		
7.3.3	**Conductor Screen**		
7.3.4	**Insulation**		
7.3.5	**Insulation Screen**		

7.3.6	**Removal of By-products Prior to Metallic Screening/Sheathing**		
7.3.7	**Longitudinal Sealing Against Moisture**		
7.3.8	**Metallic Sheath Options**		
7.3.9	**Smooth Welded Aluminium Sheath**		
7.3.10	**Lead Sheath with or without Copper Wires**		
7.3.11	**Overlapped Metallic Foil Water Barrier and Copper Wires**		
7.3.12	**Copper Wire Screen**		
7.3.13	**Oversheath**		
7.3.14	**Identification Markings**		
8.1	**Factory Routine Tests**		
8.2	**Factory Sample Tests**		
8.3	**Type Tests**		
8.4	**Electrical Type Tests**		
8.5	**Non-Electrical Type Tests**		
8.6	**Additional Tests for Metallic foil moisture barriers**		
9	**Sealing , drumming & Logistics Requirements**		
10	**Customer Support**		
11	**Technical Information required with Tender**		
App A	**Schedule of Technical Particulars**		