

Company Directive

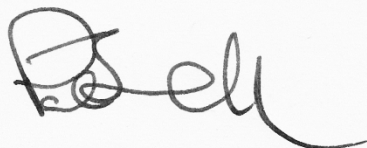
ENGINEERING SPECIFICATION EE SPEC: 82/1

Specification for Single Core Wet Design of 11kV Medium Voltage EPR Insulated Cables

Author: Peter White

Implementation Date: December 2013

Approved by:



Policy Manager

Date:

16 December 2013

IMPLEMENTATION PLAN

Introduction

This document defines the 11kV EPR underground cable used within WPD and provides a standard with which the Purchasing section can go out to tender with.

Main Changes

The document has been updated to take into account the changes made to the British Standards upon which this document is based.

Impact of Changes

Procurement Team only.

Implementation Actions

Immediate.

Implementation Timetable

This policy can be implemented with immediate effect.

Document Revision & Review Table		
Date	Comments	Author
16/12/13	This document has been updated to reflect the changes that have been made to the British Standard upon which this document is written.	Peter White

1.0 SCOPE

This Specification deals with Western Power Distribution (WPD's) requirements for a medium voltage, quasi wet design of ethylene propylene rubber insulated cable suitable for use on an 11kV, three phase, impedance earthed, 50 Hz underground distribution system.

The finished cable shall generally meet the requirements of BS 7870: Part 4.10 2011, or equivalent standard, except where modified by this Specification.

2.0 VOLTAGE DESIGNATION

The minimum rated voltage U_o/U (U_m) as defined in BS 7870 Part 4.10 2011, or equivalent standard, shall be 6.35/11 (12) kV.

3.0 CONDUCTORS

For three sizes of 11kV single core circular cables, the conductors shall be solid circular aluminium, meeting the requirements of either BS EN 60228 or IEC 60228 or equivalent standard. The sizes are given below: -

Sizes – 95, 185 and 300 mm².

In addition to these three aluminium sizes there is also a requirement for three single core circular, compacted, stranded copper conductor, cables which meet the requirements of either BS EN 60228 or IEC 60228 or equivalent standard. The sizes are given below: -

Sizes – 300, 400 and 630 mm²

Provision shall be made to prevent the longitudinal and radial transmission of water in the stranded copper conductor, using tape water blocking material.

4.0 INSULATION AND SCREENS

The insulation and the semi-conducting screens shall be applied as a continuous single pass triple extrusion, free of factory repairs.

The extruded conductor screen shall comply with the requirements of BS 7870, Part 4, 2011 clause 4.2.2, or equivalent standard; a semi-conducting tape is permitted between the conductor and conductor screen, provided that this is agreed with the Cable Policy Section of WPD.

The insulation shall be ethylene-propylene rubber (EPR), complying with the requirements of BS 7870, Part 4: 2011 or equivalent standard. The insulation shall be applied by extrusion and cross-linked to form a compact and homogeneous layer. The insulation shall have a smooth surface, free from the defects described in Appendix A and shall meet the requirements of the special tests for water and electrochemical treeing described in Appendix B.

The thickness of the insulation shall conform to the specifications in Tables 1 to 3 in BS 7870 Part 4.10 2011.

For 11kV cables the insulation screen shall be an extruded layer of cold peeling semi conducting compound, meeting with the requirements of Clause 4.2.4 of BS 7870 Part 4.10 2011, or equivalent standard.

The insulation screen shall be nominally 1mm thick and shall not permit indentations of the copper wire screen to penetrate to the insulation. A semi-conducting fabric bedding tape may be applied.

5.0 REMOVAL OF BI-PRODUCTS

Once the two semi-conducting layers and the insulation have been extruded, in a single pass, the completed cable shall be stored in such a manner as to remove the bi-products produced during the cable manufacture down to a level of 1%. At **no time** is the cable to pass onto the next process of cable manufacture without the removal of the bi-products from the newly insulated core.

6.0 METALLIC SCREEN

The metallic screen shall consist of a layer of copper wires applied spirally or in an 'SZ' configuration with a maximum gap between wires of 4mm. The minimum outside diameter of each screen wire shall be no less than 1.04mm.

The wires in the screen shall be equalised by either a lapped Copper tape or wire. The tape or wire shall have a minimum cross-sectional area of 0.75 mm².

For 11kV cables the cross-sectional area of the screen shall be capable of carrying an earth fault current of 3kA for 3 seconds adiabatically.

7.0 PHASE MARKER TAPE

A coloured phase marker tape shall be applied to each phase of the triplexed cables, see clause 12 of this specification, so that the individual phases of the cable can be identified. The relevant phase marker tape shall be laid on top of the copper screen wires. The phase marker tapes shall be coloured as follows: -

L1 = Brown.

L2 = Black.

L3 = Grey.

8.0 SHEATH

The sheath shall be medium density polyethylene (MDPE) coloured red. Thickness of the sheath shall be in accordance with BS 7870 Part 4.10 2011, or equivalent standard. This sheath shall be subjected to a retraction test, as defined in BS EN 60811 and the **shrinkage shall not exceed 3%.**

The density of the compound, corrected in accordance with clause 2.4.3.7 of BS 6469, shall be within the range 0.925g/cm^2 to 0.94g/cm^2 . The test method for checking the density shall be determined by BS 6469 clause 2.4.

The sheath shall be indelibly printed with numerical distance markers at one-(1) metre intervals.

A graphite coating shall not be provided on the 11kV cables.

The manufacturers shall supply supporting evidence that red coloured MDPE is not seriously degraded by sunlight.

9.0 EMBOSSING/MARKING

Embossing/markings shall be in accordance with BS 7870 Part 4.10 2011 clause 4.5, or equivalent standard, in addition to the embossing/markings given in clause 4.5.1 the year of manufacture shall be included on the external surface of the cable as detailed in clause 4.5.2. In addition the manufacturer shall add a unique number, which shall identify that particular cable to a batch that is tied into the quality assurance system of the company so that all materials can be traced in the production of the said cable. This unique number shall be indelibly applied to the oversheath.

The embossing shall be clear and distinct.

Other forms of identification will be considered upon application to the Cable Policy Section of WPD.

10.0 SEALING AND DRUMMING

To be in accordance with BS 7870 Part 4.10 2011, clause 4.6 or equivalent standard. Drum lengths for 11kV single core cables shall be nominally: -

95mm ²	1000 metres
630mm ²	500 metres

Except for the stranded copper 630mm² cable, a three-core, laid-up or triplex version of the 95, 185, 300 and 400mm² 11kV cables shall have a drum length that will not exceed 250m, except in agreed circumstances.

Before dispatch all cables shall be sealed to prevent the ingress of moisture as per BS 7870 part 4.10 2011, clause 4.6.

11.0 TESTS

Routine, Sample and Type Tests shall be conducted in accordance with BS 7870 Part 4.10 2011, or equivalent standard. In addition to these tests, if the cables have not been used within WPD before, a random sample from the first batch of cable produced shall be submitted to the EA Technology, Capenhurst, thereby enabling Capenhurst to carry out their "Short term water treeing sample test". Thereafter "Short term water treeing sample tests" at EATL shall be carried out on a random basis at WPD's discretion. The cost of the Capenhurst tests will be for the manufacturer to bear.

Where cables have not been used within WPD it will be necessary for the manufacturer to prove that all the relevant type testing of all the cables has been carried out, to the satisfaction of WPD. In addition they will need to provide references of who has or is using their cables.

The following Insulation Screen Cutting Test shall also be conducted on a routine basis, on every production drum length of cable:

The insulation screen at each end of the cable shall be cut longitudinally for a distance of 100mm at its thinnest part using a guarded knife with the blade set at a depth of 0.3mm. The screen shall then be removed and the insulation examined. If there is no cut in the insulation the whole cable length shall be regarded as satisfactory.

As a routine test every production drum length of cable shall be subjected to the oversheath abrasion test detailed in HD 605 S1: 1994/A2: 2001 – Electric Cables Additional Test Methods, clause 2.4.22. The temperature of the test, the weight to be applied, the speed and the number of abrasions or scratches shall be as detailed in Table 4C Requirements of Sheathing Compounds of HD 620 S1: 1996/A1: 2001 – Distribution Cables with Extruded Insulation. The result of this test shall be recorded along with the relevant drum/batch number.

The information requested in this clause shall be sent, electronically to the Cable Policy Engineer in WPD, Avonbank, Feeder Rd., Bristol as and when the cable is despatched.

12.0 LAID UP OR TRIPLEX VERSION

WPD purchase the majority of their EPR in laid up or triplex version of this cable. This involves taking three separate single core cables and putting a right hand lay on the three single cores prior to sealing and drumming. The cable sizes that are required to be triplex or laid up are as follows, aluminium conductors: - 95mm², 185mm² and 300mm².

The cable sizes that are required to be triplex or laid up are as follows, stranded copper conductors: - 300mm² and 400mm².

A coloured phase marker tape, as per clause 7 of this specification, shall be applied under each oversheath of each phase of the cable so that the individual phases of the triplexed cable can be identified.

The three single-core cables shall be laid up with a right hand direction of lay and the lay length shall be $1.35 \pm 0.25\text{m}$.

This laid up version of the three cable sizes would have a maximum drum length of five hundred metres (500m) per drum in agreed circumstances.

13.0 SINGLE CORE CABLES

The cable sizes that are required to be single core are as follows, solid aluminium conductor: - 95mm^2 and stranded copper conductor: - 630mm^2 .

14.0 LENGTHS

It should be noted that the term route length, used here and in Schedule 2, of this specification; for the following triplex cable sizes: - 95mm^2 , 185mm^2 , 300mm^2 and 400mm^2 , assumes a three-phase circuit length. The remaining cable sizes, i.e. single core 95 and 630mm^2 , give a single cable total length of cable required; the value is shown in Schedule 2.

With all the various cable sizes on the 11kV tender approximately 85 (eighty five) per cent of the various cross sectional areas (csa) of 11kV cable is supplied on a cut length scheme and delivered to site by the supplier, the remaining 15 (fifteen) per cent of the various csa is supplied on standard drum lengths of 250m.

15.0 TECHNICAL AUDIT-ABILITY

To assist in the audit-ability of mv polymeric cables it is necessary that manufacturers provide information, which will enable WPD to check that the cables being supplied at any point in time during the contract are the same as those that were, proposed to be supplied at the time of tendering process. i.e. No compounds or processes have been changed, without prior agreement from the Cable Policy Engineer.

In addition the manufacturer shall provide proof, in the form of a data logger report from the Continuous Catenary Vulcanisation line's (CCV) Programme Logic Controller (PLC) alternatively a report or print out from the X-Ray thickness monitoring equipment adjacent to the extruder head, that each run of cable meets the technical requirements of this specification. It should be noted that the WPD preference is for a report from the X-Ray machine located adjacent to the extruder head. i.e. This report will show that both the screens and insulation have the required thickness of material. These reports will indicate to which cable drums the reports apply too. The information requested in this clause shall be sent to the Cable Policy Engineer in WPD, Avonbank, Feeder Rd., Bristol as and when the cable is despatched.

16.0 APPROVAL

All cables supplied shall hold the relevant type test approval and it shall be shown to WPD that there is a continuous programme of harmonised long term testing as detailed in BS 7870 Part 2 2011 of the cable under offer.

APPENDIX A

The conductor and insulation screens must be bonded to the insulation with no traces of dissociation between them, see Fig. 1a. There shall be no detectable traces of any inclusions between the screen and the insulation, see Fig. 1b. The insulation material shall not have broken through the screen, see Fig. 1c. Nor shall there be any penetration of the insulation by the screen material, see Fig. 1d.

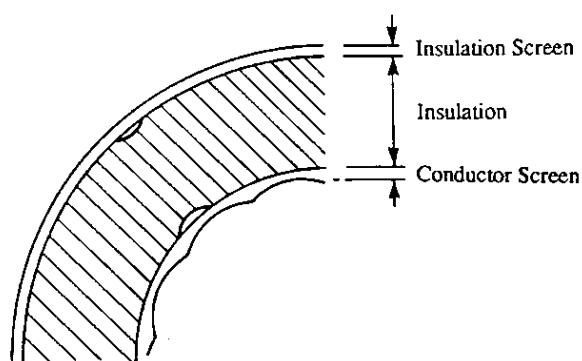


Fig. 1a

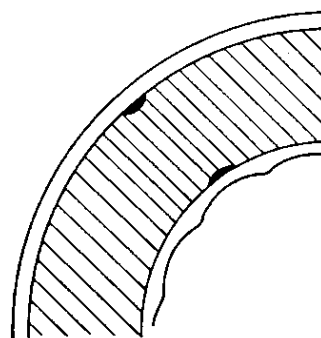


Fig. 1b

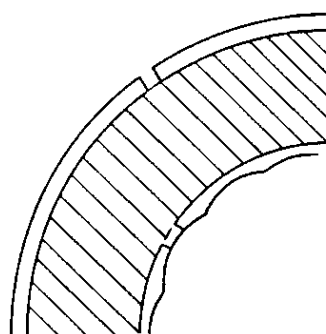


Fig. 1c

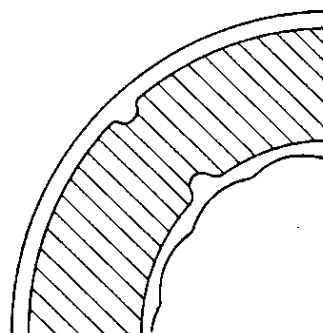


Fig. 1d

Fig. 1 Possible Defects in Extruded Insulation

VOID AND CONTAMINANT DETERMINATION

Samples shall be prepared as follows: - Fifty millimetres of the sample shall be cut helically or in some other convenient manner to produce thin samples of the insulation and screens. The wafers shall be approximately 0.635mm thick. The cutting blade shall be sharp and shall produce a sample with uniform thickness and with very smooth cut surface. The sample shall be kept clean and shall be handled carefully to prevent scratching the cut surfaces.

The entire specimen shall be viewed by reflected light for general determination of freedom from voids and contaminants in the insulation and between the insulation and the screens.

1. A contaminant is any solid or liquid material, which is not inherent to EPR insulation.
2. The entire area of 20 consecutive wafers shall be examined with a minimum power of 15 magnifications.
3. A tabulation of numbers and sizes shall be made with a minimum power of 15 magnification of: -
 - a. All voids, 0.0508mm in greatest dimension and larger
 - b. All contaminants, 0.0508mm in greatest dimension and larger

This tabulation shall be recorded and reported to WPD

1. The largest void and the largest contaminant shall be marked by encircling and must be subsequently measured on a micrometre microscope.
2. The number of voids and contaminants per cubic cm (cm^3) of insulation shall be calculated from the tabulation. (The volume of the 20 wafers, or equivalent turns, may be determined by any convenient method.) If the 20 wafers constitute less than 1 cm^3 and if the void or contaminant count exceeds the allowable number, then a sufficient number of wafers from the sample shall be examined to total 1 cm^3 of insulation.

The largest void and contaminant marked on the sample shall be measured with a micrometer microscope using a minimum of 40-power magnification. The largest dimension shall be measured only. If voids and contaminant exceed the limits in Appendix A3, the sample shall be considered to have failed to meet the test requirements.

The contact area between the insulation and the screen extrusions, both the conductor screen and the insulation screen, on the 20 wafers or equivalent turns shall be examined, using a minimum of 15-power magnification. The sample shall be considered to have failed to meet the test requirements if the contact surface between these extrusions and the insulation has protrusions or irregularities, which exceed the limits specified in Appendix A2.

APPENDIX A2

The contact surface between semi conducting extrusions and the insulation shall be free from protrusions or irregularities, which extend from the cylindrical surface of the extrusion by more than 0.127mm towards the insulation or 0.254mm away from the insulation for the conductor screen, or $\pm 0.254\text{mm}$ for the insulation screen.

APPENDIX A3

The insulation shall be a high quality, ozone resistant, ethylene propylene rubber. The colour of the insulating compound shall be in contrast to the colour of the semi conducting insulation screen so that any remaining particles can be readily seen if they remain on the surface of the insulation. The insulation of the completed cable shall be free from: -

- 1) Any void larger than 0.127mm.
- 2) Any contaminant larger than 0.254mm in its largest dimension. The number of contaminants of sizes between 0.0508mm and 0.254mm shall be recorded and reported for engineering information only.

The method of examination of sampling shall be in accordance with Appendix A1.

APPENDIX B

SPECIAL TESTS FOR WATER AND ELECTROCHEMICAL TREEING

The manufacturer shall conduct the following tests and record the results for the purpose of type approval.

A 15m length of 95mm² insulated core complete with metallic screen but with the MDPE sheath removed shall be formed into a coil of diameter not less than 750mm and with the ends suitably terminated to permit energising at the specified test voltages. The coil shall then be immersed in water with the terminations exposed above the water surface. The water temperature shall be maintained at $70 \pm 3^{\circ}\text{C}$ with circulation to give a reasonably even distribution of temperature. The metallic screen shall be connected to earth.

The coil shall be energised at 16kV for a period of 3000 hours continuously (except when IR and tan delta measurements are to be conducted).

Measurements of insulation resistance and tan delta shall be conducted at the start of the test and at every 500 ± 50 hours afterwards at voltages of 500V and 5kV. The tests shall be conducted at $70 \pm 3^{\circ}\text{C}$ and at room ambient temperature. The coil may be removed from the tank for these tests, provided that the period does not exceed two hours.

After completion of 3000 hours at 16kV the coil of cable shall be removed from the water, one metre cable shall be cut off each end and the remainder suitably re-terminated. The cable shall then be tested at 50kV.

If the cable withstands 50kV for 6 hours, the test shall be continued for a further 14 hours to give a total test time of 20 hours.

If a fault develops within 3 metres from a termination, the faulted part shall be removed and both lengths of cable re-terminated and the test continued on both lengths.

Notes

1. Although the preferred size of cable for this test is 95mm², other sizes may be used, but the test voltages should be adjusted to give the same stress at the conductor screen as that of the 95mm².
2. It is permissible to use an open spiral metal tape applied over the insulation semi-conducting screen in place of the copper wire screen. For the purpose of approval the cable shall withstand a minimum of 6 hours at 50kV. The record of tan delta and insulation resistance values shall be recorded for engineering purposes only.

Special Sample Tests

Shall be conducted at the frequency given in IEC Publication 60502 Section 15. The tests required are:

- (i) Insulation screen strip ability in accordance with BS 7870 Part 2 2011 Clause 2.2.8.6 at a temperature of $(20 \pm 5)^{\circ}\text{C}$;
- (ii) Inspection for voids, contaminants and protrusions following the method given in Appendix A1 for EPR.

One sample shall be taken from each end of a production run of any one conductor size and the sample prepared following the method set out in Appendix A1 examined under good light with normal or corrected vision without magnification.

The conductor and insulation screens, subject to BS 7870 Part 4.10 clause 7 test, must be completely bonded to the insulation with no trace of dissociation between them (see Figure 1a). There shall be no detectable traces of any inclusions between the screen and insulation (Figure 1b). The insulation material shall not have broken through the screen (Figure 1c), nor the screen through the insulation (Figure 1d).

Retraction Test

The retraction test described in BS EN 60811-1-3 shall be conducted at a rate of one test per hundred kilometres cable manufactured. The maximum shrinkage requirement for the oversheath shall be 4%.

Special Tests for Water and Electrochemical Treeing

The special test detailed in Appendix B of this Specification, shall be conducted for the purpose of type approval prior to any contract for the supply of medium voltage cable commencing and shall be conducted at least once during every contract when 100km or more (core length) of cable are to be purchased. Further testing shall be as agreed between WPD Cable Policy Section and the cable manufacturer.

Where the cable manufacturer has completed an alternative test for water and electrochemical treeing and has a system continuous periodic testing for water and electrochemical treeing this may, by agreement with WPD, be accepted as an alternative to the test specified in Appendix B of this Specification.

SUPERSEDED DOCUMENTATION

This document supersedes EE SPEC: 82 dated July 2003 which should now be withdrawn.

Schedule 1 - Technical Particulars for Tender Assessment

Single Core and Triplex 11kV EPR Insulated Cables

Information to be supplied for all conductor sizes and designs are detailed in Schedule of Technical Particulars below.

This schedule is to be completed by the Supplier to show the values, which can be guaranteed to apply to the size and design of cable, supplied.

No	Item	Value
1	Voltage designation (U_o/U (U_m))	kV
2	Nominal cross sectional area of conductor	mm ²
3	<i>Conductor details</i>	
	3.1 Material	
	3.2 Type of construction	
	3.3 Overall Diameter	mm
	3.4 Moisture blocking tape	
4	<i>Barrier tape under conductor screen</i>	
	4.1 Material	
	4.2 Nominal thickness (minimum average)	mm
5	<i>Extruded conductor screen</i>	
	5.1 Material	
	5.2 Nominal thickness (minimum average)	mm
	5.3 Minimum thickness	mm
	5.4 Nominal diameter over conductor screen	mm
	5.5 Thermal resistivity	⁰ Cm/W
	5.6 Nominal volume resistivity at 90 ⁰ C	Ω /m
6	<i>Maximum design dielectric stress at nominal voltage U_o</i>	
	6.1 At conductor screen (assumed smooth)	kV/mm
	6.2 At core screen	kV/mm
7	<i>Insulation</i>	
	7.1 Material	
	7.2 Maximum level of particle content	
	7.3 Nominal (minimum average) thickness of insulation between conductor screen and core screen	mm
	7.4 Minimum thickness	mm
	7.5 Thermal resistivity	⁰ Cm/W
8	<i>Extruded Insulation screen</i>	
	8.1 Material	
	8.2 Nominal thickness (minimum average)	mm
	8.3 Minimum thickness	mm
	8.4 Nominal diameter over screen	mm
	8.5 Thermal resistivity	⁰ Cm/W
	8.6 Nominal volume resistivity at 90 ⁰ C	Ω /m

No	Item	Value
9	<i>Extrusion process</i>	
	9.1 Type of extrusion line (catenary, vertical, etc.)	
	9.2 Disposition of extruders	
	9.3 Screening filter	
10	<i>Curing process</i>	
	10.1 Medium under which curing is carried out (dry nitrogen, silicone oil, etc.)	
	10.2 Curing temperature	⁰ C
	10.3 Curing Pressure	bar
11	<i>Cooling process</i>	
	11.1 Cooling medium (water, dry nitrogen, etc.)	
	11.2 Pressure	bar
12	<i>Heat treatment of cable core</i>	
	12.1 Manufacturing stage at which carried out	
	12.2 Heating method (current loading, vacuum, etc.)	
	12.3 Temperature	⁰ C
	12.4 Duration	hours
13	<i>Copper wire screen</i>	
	13.1 Number and diameter of wires	No/mm
	13.2 Number and thickness of equalizing tapes	No/mm
14	Nominal diameter over metallic screen	mm
15	<i>Oversheath</i>	
	15.1 Number of layers	
	15.2 Materials	
	15.3 Nominal thickness (minimum average)	mm
	15.4 Minimum thickness at any point	mm
	15.5 Nominal overall diameter of completed cable	mm
16	Nominal weight of completed cable	kg/mm
17	<i>Minimum radius of bend round which cable can be laid:</i>	
	17.1 Laid direct or in air	m
	17.2 In ducts	m
	17.3 Adjacent to joints or terminations	m
	Nominal internal diameter of pipes or ducts	mm
	Maximum dc resistance of conductor at 20 ⁰ C	μΩ/m
	Maximum ac resistance of conductor at 90 ⁰ C	μΩ/m
	Equivalent star reactance of three phase circuit at 50Hz	μΩ/m
	Maximum dc resistance of metallic screen/sheath of cable at 20 ⁰ C	μΩ/m
	Maximum electrostatic capacity per core	ρF/m
	Maximum charging current per conductor per metre of cable at nominal voltage	mA/m

No	Item	Value
18	<i>Current carrying capacity:</i>	
	Winter continuous	A
	Winter peak cyclic	A
	Summer continuous	A
	Summer peak cyclic	A
19	<i>Installation and operating conditions on which current carrying capacities stated in Item 28 are based:</i>	
	19.1 Depth to top of upper cable	mm
	19.2 Details of sheath bedding	
	19.3 Number of circuit	
	19.4 Winter Rating	
	Maximum conductor temperature	°C
	Ground Ambient temperature	°C
	Soil thermal resistivity	°C m/W
	Backfill thermal resistivity	°C m/W
	19.5 Summer Rating	
	Maximum conductor temperature	°C
	Ground Ambient temperature	°C
	Soil thermal resistivity	°C m/W
	Backfill thermal resistivity	°C m/W

Cable Policy Section
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December 2013

SCHEDULE 2

SINGLE CORE WET DESIGN OF EPR 11kV MEDIUM VOLTAGE POLYMERIC INSULATED CABLES – LAID UP

ITEM NO.	SHOPS CODE	DESCRIPTION	ESTIMATED QUANTITY PER ANNUM	PRICE PER km £	PRICE FOR ESTIMATED QUANTITY	Metal Factors Cu. Al.
1	40039	95mm ² SAC, Single core, EPR, CWS, MDPE Oversheath				
2	41337	95mm ² SAC, Triplex, EPR, CWS, MDPE Oversheath				
3	41338	185mm ² SAC, Triplex, EPR, CWS, MDPE Oversheath				
4	41339	300mm ² SAC, Triplex, EPR, CWS, MDPE Oversheath				
5	41340	300mm ² water blocked, Stranded Cu, Triplex, EPR, CWS, MDPE Oversheath				
6	TBA	400mm ² water blocked, Stranded Cu, Triplex, EPR, CWS, MDPE Oversheath				
7	40043	630mm ² water blocked, Stranded Cu, Single core, EPR, CWS, MDPE Oversheath				

KEY

SAC = Solid Aluminium Conductor.
 EPR = Ethylene Propylene Rubber.
 CWS = Copper Wire Screen.
 MDPE = Medium Density Polyethylene.
 Cu. = Copper.