WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales
Gwasanaethu Canolbarth a De Orllewin Lloegr a Chymru

Company Directive

ENGINEERING SPECIFICATION
EE SPEC: 93/2

Specification for Single Core Wet Design of 66kV High Voltage EPR Insulated Cables

Author:	**Peter White**
Implementation Date:	**November 2014**
Approved by:	
	Policy Manager
Date:	11 December 2014

IMPLEMENTATION PLAN

Introduction

This document defines the 66kV EPR underground cable used within WPD and provides a standard with which the Purchasing section can go out to tender with.

Main Changes

This document has been updated to reflect the increased steady state earth fault current that Primary System Design requested.

Impact of Changes

None.

Implementation Actions

Immediate.

Implementation Timetable

This policy can be implemented with immediate effect.

Document Revision & Review Table		
Date	**Comments**	**Author**
26/11/14	This document has been updated to reflect increased steady state earth fault current that Primary System Design requested.	Peter White

1.0 SCOPE

This Specification deals with Western Power Distribution (WPD's) requirements for a high voltage, wet design of ethylene propylene rubber insulated cable suitable for use on a 66kV, three phase, impedance earthed, 50Hz underground distribution system.

The finished cable shall generally meet the requirements of IEC 60840 or equivalent standard, HD 605 S1: 1994/A2: 2001 or equivalent standard, HD 620 S1: 1996/A1: 2001 or equivalent standard, HD 383 or equivalent standard, BS EN 60811 or equivalent standard, BS 6469 or equivalent standard, BS 7870 or equivalent standard, or except where modified by this Specification.

2.0 VOLTAGE DESIGNATION

The minimum rated voltage U_o/U (U_m) as defined in IEC 60840, or equivalent standard, shall be 38/66 (72) kV.

3.0 CONDUCTORS

For 66kV single core cables the conductors shall be stranded, compacted, circular copper, meeting the requirements of BS EN 60228 or IEC 60228.

Size – 185mm², 300mm², 400mm², 630mm² and 1000mm²

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 IEC 60840, or equivalent standard, a semi-conducting tape is permitted between the conductor and conductor screen, provided that this is agreed with the Cable Policy Engineer of WPD.

The insulation shall be ethylene-propylene rubber (EPR), complying with the requirements of IEC 60840 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 described in Appendix B.

For 66kV cables the insulation screen shall be an extruded layer of fully bonded semi conducting compound, meeting with the requirements of IEC 60840, 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 manufacturer may apply a copper equalizing tape, provided that this is agreed with the Cable Policy Engineer of WPD. 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 mm^2.

For 66kV cables the cross-sectional area of the screen shall be capable of carrying an earth fault current of 7kA for 3 seconds adiabatically.

7.0 SHEATH

The sheath shall be medium density polyethylene (MDPE) coloured black. The thickness of the sheath shall be in accordance with IEC 60840, or equivalent standard. This sheath shall be subjected to a retraction test, as defined in BS EN 60811 and **shrinkage shall not exceed 2%.**

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 66kV cables.

8.0 EMBOSSING/MARKING

Embossing/marking shall be in accordance with BS 7870 Part 4.10 clause 4.5, or equivalent standard, in addition to the embossing/marking 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 produced the said cable.

The embossing shall be clear and distinct.

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

9.0 SEALING AND DRUMMING

To be in accordance with BS 7870 Part 4.10, clause 4.6 or equivalent standard. Drum lengths for 66kV single core cables shall be nominally: -

185mm²	250 metres
300mm²	250 metres
400mm²	250 metres
630mm²	250 metres
1000mm²	250 metres

The drum length 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, clause 4.6.

10.0 TESTS

Routine, Sample and Type Tests shall be conducted in accordance with IEC 60840, 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 0.6mm. 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.

11.0 LENGTHS

It should be noted that the term route length, used here and in Schedule 2, of this specification; for the following cable sizes: - 300mm^2, assumes a three-phase circuit length.

12.0 TECHNICAL AUDIT-ABILITY

To assist in the audit-ability of hv 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 in electronic format to the Cable Policy Engineer WPD, Avonbank, Feeder Rd., Bristol as and when the cable is despatched.

13.0 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 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.

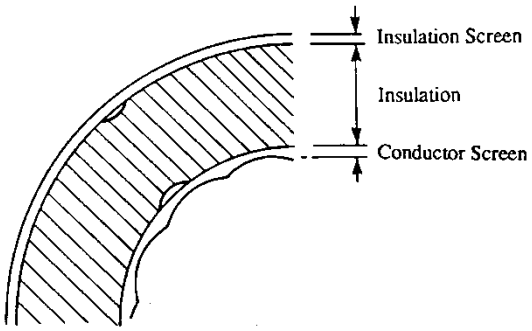

Fig. 1a

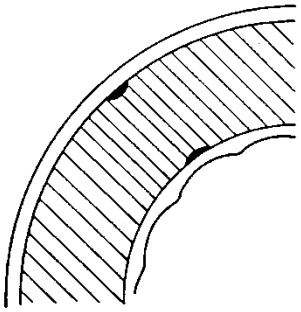

Fig. 1b

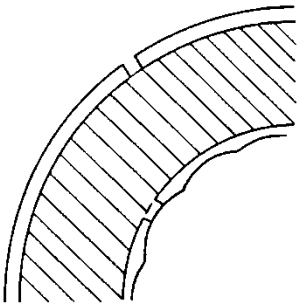

Fig. 1c

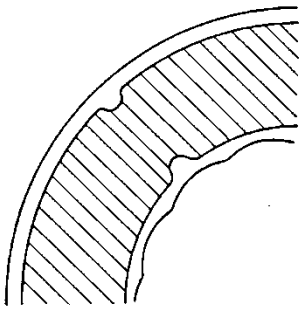

Fig. 1d

Fig. 1 Possible Defects in Extruded Insulation

APPENDIX A1

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 the Cable Policy Engineer in WPD

1. The largest void and the largest contaminant shall be marked by encircling and must be subsequently measured on a micrometer 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 1cm^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 ± 0.254mm 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 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 1999 Clause 2.2.8.6 at a temperature of (20 ± 5)°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 3%.

Special Tests

Further testing shall be as agreed between WPD Cable Policy Engineer and the cable manufacturer.

APPENDIX C

SUPERSEDED DOCUMENTATION

This document supersedes EE SPEC: 93/1 dated December 2013 which should now be withdrawn.

Schedule 1 - Technical Particulars for Tender Assessment

Single Core 66kV EPR Insulated Cables

Information to be supplied is 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 cable, supplied.

No	Item	Value
1	Voltage designation (U_o/U (U_m)	kV
2	Nominal cross sectional area of conductor	mm^2
3	*Conductor details*	
	3.1 Material	
	3.2 Type of construction	
	3.3 Overall Diameter	mm
	3.4 Moisture blocking tape	
4	*Barrier tape under conductor screen*	
	4.1 Material	
	4.2 Nominal thickness (minimum average)	mm
5	*Extruded conductor screen*	
	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 90^0C	Ω/m
6	*Maximum design dielectric stress at nominal voltage U_o*	
	6.1 At conductor screen (assumed smooth)	kV/mm
	6.2 At core screen	kV/mm
7	*Insulation*	
	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	*Extruded Insulation screen*	
	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 90^0C	Ω/m

No	Item	Value
9	*Extrusion process*	
	9.1 Type of extrusion line (catenary, vertical, etc.)	
	9.2 Disposition of extruders	
	9.3 Screening filter	
10	*Curing process*	
	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	*Cooling process*	
	11.1 Cooling medium (water, dry nitrogen, etc.)	
	11.2 Pressure	bar
12	*Heat treatment of cable core*	
	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	*Copper wire screen*	
	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	*Oversheath*	
	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	*Minimum radius of bend round which cable can be laid:*	
	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	*Current carrying capacity:*	
	Winter continuous	A
	Winter peak cyclic	A
	Summer continuous	A
	Summer peak cyclic	A
19	*Installation and operating conditions on which current carrying capacities stated in Item 28 are based:*	
	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	^{0}C
	Ground Ambient temperature	^{0}C
	Soil thermal resistivity	^{0}C m/W
	Backfill thermal resistivity	^{0}C m/W
	19.5 Summer 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

Cable Policy
Western Power Distribution
Avonbank
Feeder Road
Bristol BS2 0TB

November 2013

SCHEDULE 2

SINGLE CORE WET DESIGN OF 66kV EPR MEDIUM VOLTAGE POLYMERIC INSULATED CABLES.

ITEM NO.	SHOPS CODE	DESCRIPTION	ESTIMATED QUANTITY PER ANNUM	PRICE PER km £	PRICE FOR ESTIMATED QUANTITY	Metal Factors Cu. Al.
1	TBA	185mm2 water blocked Stranded Cu conductor, Single core, EPR, CWS, MDPE Oversheath	1 *			
2	41481	300mm^2 water blocked, Stranded Cu conductor, Single core, EPR, CWS, MDPE Oversheath	1 *			
3	TBA	400mm^2 water blocked, Stranded Cu conductor, Single core, EPR, CWS, MDPE Oversheath	1 *			
4	TBA	630mm^2 water blocked, Stranded Cu conductor, Single core, EPR, CWS, MDPE Oversheath	1 *			
5	TBA	1000mm^2 water blocked, Stranded Cu conductor, Single core, EPR, CWS, MDPE Oversheath	1 *			

KEY

SAC = Solid Aluminium Conductor.
EPR = Ethylene Propylene Rubber.
CWS = Copper Wire Screen.
MDPE = Medium Density Polyethylene.
Cu. = Copper.
* = Total single core length.