

Central Networks

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Cables, Cable Laying & Accessories Manual

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Revision Log For Cables, Cable Laying & Accessories Manual

Changes made in version 1 February 2001		
	Title	Notes about the change
Documents Removed	Section 3–Mechanical Plant for Cable Laying	Section removed, no longer appropriate.
New Documents	Section 3 – Cable Laying Specification	New section giving a specification for cable laying and installation.
Amended Documents	Sections 1&2.	Brought up to modern format.
Amended Documents	Sections 4, 5 & 6	An “Under Review” watermark added to documents.

Changes made in version 2 May 2002		
	Title	Notes about the change
Documents removed		
New Documents		
Amended documents	Section 3 – Cable Laying Technical Requirements.	Section 32.3 – specification added to 33kV tiles. Appendix G – joint hole dimensions & text amended.

Changes made in version 3 November 2002

	Title	Notes about the change
Documents Removed		
	None	
New Documents		
	None	
Amended Documents		
Cable Laying Technical Specification	Section 3 – Cable Installation	Paragraph 32.3 <ul style="list-style-type: none"> • Amendments to requirements for ducts, tapes & tiles due to introduction of Electricity Safety, Quality and Continuity Regulations 2002. Appendices A,B &C <ul style="list-style-type: none"> • Amendments to drawings showing changes as a result of Paragraph 32.3 Appendix D <ul style="list-style-type: none"> • Changes to duct size for 70mm² Triplex 11kV cable. Appendix G <ul style="list-style-type: none"> • Contractors item codes removed (no longer needed).

Changes made in version 4 November 2003		
	Title	Notes about the change
New Documents		
		None
Amended Documents		
Cable Laying Technical Specification	Section 1 - 22.1 Cable Excavation	<ul style="list-style-type: none"> Guidance Document HS(G)47 "Avoiding Danger from Underground Services" text added.
Documents Removed		
		None

Changes made in version 5 November 2004		
	Title	Notes about the change
Documents removed		
New Documents		
Amended documents	Section 3 – Cable Laying Technical Requirements.	Document modified to reflect adoption of ducting all cables Duct cable drawings added to appendices A,B,C Appendix G added showing spacing of 11kV transformer tails

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Section	Title
1.	Introduction.
2.	Cables.
3.	Cable Laying Specification.
4.	Link Boxes.
5.	Cable Corrosion.
6.	Maintenance and Faulted Cable Procedure.

EAST MIDLANDS ELECTRICITY plc

CABLES AND ACCESSORIES MANUAL

SECTION 1 - INTRODUCTION

This manual has been produced to assist Engineers and Project Managers involved in the specification and installation of cable operating at voltages up to and including 132kV on the Company's underground system.

Details of cables and accessories are specified, together with lists of approved cable installation plant. Information on cable corrosion and link boxes is also given.

Reference in this Manual to a system voltage of 11kV may be taken to include a system voltage of 6.6kV. Future extensions to the 6.6kV system should use 11kV cables.

H.V. and L.V. Jointing Procedures can be found in the current Jointing Codes of Practice 14 & 15.

Section 2.0 lists all Company current standard cable sizes giving the description, appropriate specification and ratings tables.

Sections 2.1 to 2.5 give detailed information of L.V., 11kV, 33kV, 132kV and multi-core cables, together with information of imperial size cables for commissioned non standard size cables.

Sub-Section 2.6 gives a schedule indicating the current D.C. pressure test values for both new and existing cable systems between 11kV and 132kV on site commissioning.

A section has also been included to cover certain aspects of maintenance of cables.

SECTION 2 - CABLES

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2.1 Standard Low Voltage Cables. (Services & Mains)

Cables And Specification for New Cables

Sizes of Imperial and Metric Non-Standard Cables and Specifications

2.2 Standard 11kV Cables

Standard Cables and Specification

Sizes of Imperial Non-Standard Cables and Specifications

2.3 Standard 33kV Cables

Standard Cables and Specification

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2.4 Standard 132kV Cables

Standard Cables and Specification

Sizes of Imperial Non-Standard Cables and Specifications

2.5 Multi-core Pilot, Underground Auxilliary and Telephone Cables

2.6 Cable Pressure Test Voltages (on commissioning)

SCHEDULE OF TECHNICAL PARTICULARS

CABLE	SUB-SECTION
New Cables	
LV single phase, solid aluminium conductor, XLPE insulated, concentric layer of bare copper wire neutrals (CNE), PVC sheathed.	2.1.1
LV three phase, 3 core, solid aluminium conductor, XLPE insulated, rubber bedding, copper wire waveform concentric layer (CNE), PVC sheathed.	2.1.2
LV single core, solid aluminium (sectoral conductors), XLPE insulated, aluminium wire armoured, PVC sheathed.	2.1.3
Superseded Cables	
4mm ² single phase, standard copper conductor, XLPE insulated, concentric layer of bare copper neutrals (CNE), PVC sheathed.	2.1.4
16mm ² single phase, standard copper conductor, XLPE insulated, concentric layer of bare copper neutrals (CNE), PVC sheathed	2.1.5
25mm ² & 35mm ² , three phase, solid aluminium conductor, XLPE insulated, aluminium wire waveform concentric layer (CNE), PVC sheathed.	2.1.6
70mm ² , 120mm ² , 185mm ² and 300mm ² , three phase, solid aluminium conductor, XLPE insulated, aluminium wire waveform concentric layer (CNE), PVC sheathed.	2.1.7
Two core, single phase, paper insulated, lead sheathed, steel tape armoured cables 1,100 volt.	2.1.8
Four core, three phase, stranded copper conductors, paper insulated, lead sheathed, steel tape armoured cables, 1,100 volt.	2.1.9
Four core, three phase, stranded aluminium conductors, paper insulated, lead sheathed, steel tape armoured cables, 1,100 volt.	2.1.10

STANDARD CABLES

LOW VOLTAGE CABLES

All underground low voltage services shall be as detailed in the appropriate section and schedule and the Distribution Planning Manual.

Cables shall be installed as detailed in this Code of Practice Section 3 – Technical Requirements for Cable Laying.

Single Phase Services XLPE Insulated, PVC Sheathed

For Low Voltage Network Service Extensions and Alterations

Solid aluminium conductor, single phase, XLPE insulated, concentric layer of bare copper wires forming a combined neutral earth conductor (CNE), 600/1000 volt, PVC sheathed overall to specification BS7870-3.1:1996, & ESI 09-7 Table 2 (XLPE variant).

Two sizes will be used:-

Size	Use
25mm ² Hybrid	1 ϕ Public Lighting
35mm ² Hybrid	1 ϕ House Services

Three Phase Services XLPE Insulated, PVC Sheathed

For Low Voltage Network Service Extensions and Alterations

Three phase, 3 core, solid aluminium conductor, XLPE insulated, rubber bedding, copper wire waveform concentric layer forming a combined neutral earth conductor (CNE), 600/1000 volt, PVC sheathed overall, to specification BS7870-3.4:1996.

Four sizes will be used:-

Size	Use
35mm ² CNE	3 ϕ LV Service, up to 100 Amps
95mm ² CNE	3 ϕ LV Service, up to 200 Amps
185mm ² CNE	3 ϕ LV Service, up to 300 Amps
300mm ² CNE	3 ϕ LV Service, up to 400 Amps

Three Phase Mains

For Low Voltage Network Extensions and Alterations

Three phase, 3 core, solid aluminium conductor, XLPE insulated, rubber bedding copper wire waveform concentric layer, forming a combined neutral earth conductor (600/1000 volt), PVC sheathed overall, to specification BS7870.

Two sizes will be used:-

Size	Use
95mm ² CNE	LV Mains up to 200 Amps
185mm ² CNE	LV Mains up to 300 Amps

Singles Cables

For Low Voltage Transformer Tails and Services to Large Industrial Customers

Single core, solid aluminium (sectoral conductors), XLPE insulated, aluminium wire armoured. (600/1000V), PVC sheathed overall, to specification BS5467:1997.

One size only:-

Size	Use
600mm ² single core. (one per phase, one per neutral)	315 and 500kVA transformers Transformer to LV pillar or service position
600mm ² single core (two per phase, one per neutral)	800 and 1000kVA transformers Transformer to LV pillar or service position

Solid Aluminium Conductor, Single Phase XLPE Insulated Concentric Layer of Bare Copper Wires forming a Combined Neutral Earth Conductor (600/1000v) PVC Sheathed to ESI 09-7 (table 2) (XLPE variant)

1.	Sectional area of conductor Form of phase conductor	mm ²	25 Circular	35 Solid
2.	Minimum average thickness insulation	mm	1.2	1.2
	Minimum thickness of insulation at any point	mm	1.04	1.04
3.	Concentric neutral conductor			
	Number of wires	No	27	25
	Nominal diameter of wires	mm	0.85	1.04
4.	Minimum average thickness of PVC oversheath	mm	1.4	1.4
	Minimum thickness of PVC oversheath at any point	mm	1.09	1.09
5.	Approximate overall diameter	mm	13.0	14.4
6.	Approximate weight per metre of completed cable	kg	0.35	0.45
7.	Minimum radius of bend around which cable can be laid	mm	125	125
8.	Maximum d.c. resistance of conductor per metre of cable at 20°C			
	(i) phase	μΩ	1180	851
	(ii) concentric neutral	μΩ	1240	900
9.	Maximum a.c. resistance of phase conductor per metre of cable at maximum conductor temperature	μΩ	1420	1020
10.	Star reactance per metre of cable at 50Hz	μΩ	43	41
11.	Maximum continuous current carrying capacity per phase conductor when laid direct in the ground, one circuit per trench g = 1.2°C m/W, tg = 15°C	A	115	140
12.	Maximum continuous current carrying capacity per phase conductor			
	(i) Drawn into ducts ground temperature = 15°C g = 1.2°C m/W	A	94	115
	(ii) Laid in air, ambient temperature= 25°C	A	97	120
13.	Maximum conductor temperature	°C	70	70

Three core, solid aluminium conductors, XLPE insulation, rubber bedding, copper wire waveform concentric layer, PVC oversheath, 600/1000V cable to BS 7870

1	Nominal area of phase conductor Form of phase conductor	mm²	35 Circular	95 Sector	185 Shaped Aluminium	300 Aluminium
2	Minimum average thickness of insulation	mm	0.90	1.10	1.60	1.80
	Minimum thickness of insulation at any point	mm	0.71	0.89	1.34	1.52
3	Concentric neutral/earth conductor					
	(a) Number of wires	No.	26	30	42	42
	(b) Nominal diameter of wires	mm	1.04	1.58	1.87	1.87
	(c) Nominal wavelength of wires	mm	220	250	300	440
4	Approximate thickness of bedding layer	mm	1.5	1.8	2.4	2.4
5	Minimum average thickness of PVC oversheath	mm	1.80	2.10	2.50	2.80
	Minimum thickness of PVC oversheath at any point	mm	1.43	1.68	2.02	2.28
6	Approximate overall diameter of completed cable	mm	26.5	34.5	46.9	55.9
7	Approximate weight per metre of completed cable	kg	0.97	2.1	4.05	5.5
8	Minimum radius of bend around which cable can be laid					
	(d) Pulling in	mm	400	550	700	850
	(e) Adjacent to joints and terminations	mm	275	350	470	560
9	Nominal internal diameter of ducts	mm	100	100	100	100
10	Maximum d.c. resistance per metre of cable at 20°C					
	(a) Phase/neutral conductors	μΩ	868	320	164	100
	(b) Earth conductor	μΩ	868	320	164	164
11	Maximum a.c. resistance of phase conductor per metre of cable, at maximum temperature	μΩ	1080	398	205	126
12	Equivalent star reactance per metre of cable at 50 Hz	μΩ	77	73.5	74	72.5
13	Maximum continuous current carrying capacity per phase conductor					
	(a) Laid direct, ground temperature 15°C and g = 1.2K.m/W	A	125	235	335	435
	(b) Drawn into ducts, ground temperature 15 °C and g = 1.2 K.m/W	A	100	190	275	360
	(c) Laid in air at 25°C ambient temp.	A	110	230	350	475
14	Maximum conductor temperature	°C	<-----See Note----->			

Note: The above data is based on a maximum conductor temperature of 80°C (as for Consac), it should however be noted that XLPE insulated cables are capable of operating at 90°C maximum conductor temperature.

Aluminium XLPE insulated PVC sheathed single core armoured cables to BS5497: 1997

Nominal cross-sectional area	mm ²	600
Voltage rating -		600/1000 volt
Number of cores		1
Minimum average thickness of insulation	mm	2.4
Nominal thickness of bedding	mm	1.2
Nominal diameter of armour wires	mm	2.0
Nominal thickness of oversheath.	mm	2.2
Approximate diameter under amour	mm	35.3
Approximate diameter overall	mm	42.9
Minimum bending radius	mm	350
Approximate cable weight ' '	kg/km	3925
Maximum pulling eye force	kg	1800
Maximum d.c. resistance at 20°C	Ω/km	0.0515
Maximum a.c. resistance at 90°C	Ω/km	0.067
Maximum resistance of armour at 20°C Ohms/km	Ω/km	0.20
Minimum cross-sectional area of armour wires	mm ²	160
Approximate capacitance (conductor to armour)	µf/km	0.570
Approximate inductance in Trefoil	mH/km	0.280
Approximate reactance @ 50Hz	Ω/km	0.088
Approximate impedance @ 50Hz	Ω/km	0.111
Short circuit rating		
1 second short circuit rating of conductor (90 to 250 ⁰ C)	kA	56.7
1 second short circuit rating of armour (90 to 200 ⁰ C)	kA	13.5
Current Ratings (ERA 69-30 pt V)		
Direct !n ground touching single phase	Amps	795
Direct in ground spaced single phase	Amps	736
In ducts flat and touching	Amps	627
In air horizontal spaced single phase	Amps	957
In air vertical spaced single phase	Amps	918
Direct in ground trefoil formation three phase	Amps	672
Direct in ground flat touching three phase	Amps	640
Direct in ground flat spaced three phase	Amps	620
In trefoil ducts three phase	Amps	557
In ducts flat and touching three phase	Amps	558
In air trefoil formation three phase	Amps	839
In air vertical spaced three phase	Amps	817
In air horizontal spaced three phase	Amps	872
Approx. volt drops		
Single phase touching	mV/A/m	0.24
Single phase spaced*	mV/A/m	0.31
Three phase trefoil	mV/A/m	0.2
Three phase touching	mV/A/m	0.27
Three phase spaced*	mV/A/m	0.35

*Note: The under armour and oversheath diameters are only approximate, If tolerances dimensions are required please specify at time of enquiry or order placement.

*If the Cable Spacing is larger than 1 cable diameter, then the volt drop will be larger than those specified.

If current rating in buildings is required reference should be made to BS7671 (IEE Wiring Regs.). Alternatively ratings are as BS6724 cables.

Copper Conductor Single Phase Pvc Insulated Concentric Layer of Bare Copper Wires Forming Combined Neutral/Earth Conductor (600/1000v)PVC Sheathed to E.S.I. 09-7 (Table 1)

1	Sectional area of conductor	mm²	4
	Forms of phase conductor	Circular Stranded	
	Number of wires	No	7
	Normal diameter of wires	mm	0.85
2	Minimum average thickness of insulation	mm	0.8
	Minimum thickness of insulation at any point	mm	0.66
3	Concentric neutral conductor		
	Number of wires	No	15
	Nominal diameter of wires	mm	0.67
4	Minimum average thickness of P.V.C. oversheath	mm	1.4
	Minimum thickness of P.V.C. oversheath at any point	mm	1.09
5	Approximate overall diameter	mm	8.7
6	Approximate weight per metre of completed cable	kg	0.15
7	Minimum radius of bend around which cable can be laid	mm	75
8	Maximum d.c. resistance of conductor per metre of cable at 20°C		
	(i) phase	μΩ	4520
	(ii) concentric neutral	μΩ	4800
9	Maximum a.c. resistance of phase conductor per metre of cable at maximum conductor temperature	μΩ	5410
10	Star resistance per metre of cable at 50Hz	μΩ	54
11	Maximum continuous current carrying capacity per phase conductor when laid direct in the ground, one circuit per trench g = 1.2°C m/w, tg = 15°C	A	53
12	Maximum continuous current carrying capacity per phase conductor		
	(i) Drawn into ducts ground temperature = 15°C g = 1 2°C m/w	A	44
	(ii) Laid in air, ambient temperature = 25°C	A	42
13	Maximum conductor temperature	°C	70

**600/1000 Volts, Single Core, Plus Helical Concentric Neutral Sheath, Copper Conductors, to BS
4553 : 1970**

1.	Sectional Area of Conductor	mm²	16
	Form of phase conductor		Circular Stranded
	Number of wires	No.	7
	Nominal diameter of wires	mm	1.70
2.	Minimum average thickness of insulation	mm	1.0
	Minimum thickness of insulation at any point	mm	1.0
3.	Concentric neutral conductor		
	Number of wires	No.	11
	Nominal diameter of wires	mm	1.70
4.	Concentric earth conductor		
	Number of wires	No	4
	Nominal diameter of wire	mm	2.25
5.	Minimum average thickness of P.V.C. oversheath	mm	1.5
	Minimum thickness of P.V.C. oversheath at any point	mm	1.45
6.	Approximate overall diameter	mm	18.1
7.	Approximate weight per metre of completed cable	kg	0.6
8.	Minimum radius of bend around which cable can be laid	mm	125
9.	Maximum d.c. resistance of conductor per metre of cable at 200C		
	i) phase	$\mu\Omega$	1130
	ii) concentric neutral	$\mu\Omega$	1200
	iii) concentric earth	$\mu\Omega$	1200
10.	Maximum a.c. resistance of phase conductor per metre of cable at maximum conductor temperature	$\mu\Omega$	1360
11.	Star reactance per metre of cable at 50 Hz	$\mu\Omega$	43
12.	Maximum continuous current carrying capacity per phase conductor when laid direct in the ground, one-dircuit per trench $g = 1.2^{\circ}\text{C m/W}$, $tg = 15^{\circ}\text{C}$	A	115
13.	Maximum continuous current carrying capacity per phase conductor		
	i) Drawn into ducts ground temperature = 15°C $g = 1.2^{\circ}\text{C m/W}$	A	96
	ii) Laid in air, ambient temperature = 25°C	A	97
14.	Maximum conductor temperature	$^{\circ}\text{C}$	70

Solid Aluminium Conductor, Three Phase, XLPE, Aluminium Waveform Concentric Neutral, Embedded in an Anti Corrosion Sheath (600/1000v) PVC Sheathed Overall to E.S.I. 09 (table 4)

1.	Nominal area of phase conductor	mm ²	25	35
	Form of phase conductor		Circular solid aluminium	
2.	Minimum average thickness of insulation	mm	0.90	0.90
	Minimum thickness of insulation at any point	mm	0.71	0.71
3.	Concentric neutral/earth conductor			
	Number of wires	30	30	
	Nominal diameter of wires	mm	1.05	1.23
	Nominal wavelength of wires	mm	200	220
4.	Approximate thickness of anti-corrosion layer in which neutral/earth wires are embedded	mm	3.5	3.7
5.	Minimum average thickness of PVC oversheath	mm	1.8	1.8
	Minimum thickness of PVC oversheath at any point	mm	1.43	1.43
6.	Approximate overall diameter of completed cable	mm	28.0	30.5
7.	Approximate weight per metre of completed cable	kg	1.1	1.3
8.	Minimum radius of bend around which cable can be laid:-			
	(a) in pulling-in	mm	450	500
	(b) adjacent to joints and terminations	mm	220	240
9.	Nominal internal diameter of ducts	mm	100	100
10.	Maximum d.c. resistance per metre of cable at 20°C			
	Phase conductors	μΩ	1200	868
	Neutral conductor	μΩ	1200	868
11.	Maximum a.c. resistance of phase conductor per metre of cable, at maximum conductor temperature	μΩ	1490	1080
12.	Equivalent star reactance per metre of cable at 50 Hz	μΩ	80	77.5
13.	Maximum continuous current carrying capacity per phase conductor			
	a) laid direct, ground temperature 15°C and g = 1.2°C m/W	A	100	125
	(b) drawn into ducts, ground temperature 15°C and g = 1.2°C m/W	A	84	100
	(c) laid in air, ambient temperature 25°C	A	88	110
14.	Maximum conductor temperature	°C	See Note	

Note: The current ratings given above are the same as for the paper insulated cables (CONSAC), i.e. based upon 80°C approximate maximum conductor temperature. These values are recommended as an interim measure until such time as agreement is obtained for the maximum permitted operating temperatures for the different types of insulation and cable constructions.

**Solid Aluminium Conductor, Three Phase, XLPE, Aluminium Wire Wave-Form
Concentric Neutral, Embedded in an Anti-Corrosion Sheath, (600/1000v) PVC
Sheathed Overall to E.S.I. 09-9 (table 5)**

1.	Nominal area of phase conductor	mm ²	70	120	185	300
	Form of phase conductor		Sector shaped solid aluminium			
2.	Minimum average thickness of insulation	mm	1.1	1.2	1.6	1.8
	Minimum thickness of insulation at any point	mm	0.89	0.98	1.34	1.52
3.	Concentric neutral/earth conductor					
	Number of wires		30	30	30	42
	Nominal diameter of wire	mm	1.72	2.28	2.83	2.39
	Nominal wavelength of wires	mm	220	270	300	440
4.	Approximate thickness of anti-corrosion layer in which neutral/earth wires are embedded	mm	4.9	6.1	6.7	6.1
5.	Minimum average thickness of PVC oversheath	mm	1.9	2.2	2.5	2.8
	Minimum thickness of PVC oversheath at any point	mm	1.51	1.77	2.02	2.28
6.	Approximate overall diameter of completed cable	mm	35.9	44.6	53.5	61.6
7.	Approximate weight per metre of completed cable	kg	1.9	3.0	4.3	5.8
8.	Minimum radius of bend around which cable can be laid					
	(a) in pulling-in	mm	550	700	850	950
	(b) adjacent to joints and terminations	mm	360	450	540	620
9.	Nominal internal diameter of ducts	mm	100	100	100	100
10.	Maximum d.c. resistance per metre of cable at 20°C					
	Phase conductors	μΩ	443	253	164	100
	Neutral conductors	μΩ	443	253	164	164
11.	Maximum a.c. resistance of phase conductor per metre of cable, at maximum temperature	μΩ	551	315	205	126
12.	Equivalent star reactance per metre of cable at 50Hz	μΩ	75.5	73	74	72.5
13.	Maximum continuous current carrying capacity per phase conductor					
	(a) laid direct, ground temperature 15°C and g = 1.2°C m/W	A	185	250	320	420
	(b) drawn into ducts, ground temperature 15°C and g= 1.2°C m/W	A	150	210	265	350
	(c) laid in air ambient temperature 25°C	A	165	235	310	425
14	Maximum conductor temperature	°C	See Note			

NOTE: The current ratings given above are the same as for the paper insulated cables, (Consac), i.e. based upon 80°C approximate maximum conductor temperature. These values are recommended as an interim measure until such time as agreement is obtained for the maximum permitted operating temperature for the different types of insulation and cable construction.

SUB-SECTION 2.1.8

1,100 VOLT TWIN CABLE (table 8, BS 480—Part 1.)

1	Sectional area of conductor.	sq.in	0.007	0.0145	0.0225	0.04	0.06	0.10	0.15	0.20	0.25	0.30
2	Shape of conductor		Circular	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped
3	Minimum thickness of insulation between conductors.	in	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
4	Minimum thickness of insulation between any conductor and sheath.	in	0.050	0.050	0.050	0.050	0.050	0.060	0.060	0.070	0.070	0.070
5	Minimum thickness of sheath.	in	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.070	0.070	0.070
6	Diameter over sheath:											
7	Nominal	in	0.54	0.54	0.59	0.69	0.78	0.93	1.06	1.19	1.29	1.39
8	Sheath material (as specified in BS 801)		Lead Alloy "E," Alloy "B"									
9	Armour:											
10	No. (approx) and diameter of armour wires	No./in	33/.064	33/.064	36/.064	39/.064	35/.080	40/.080	44/.080	48/.080	41/.104	43/.104
11	Thickness of each layer of steel tape.	in	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.040	0.040
12	Nominal external diameter of completed cable:											
13	Type P ₂ H ₂ or P ₂ CH	in	0.74	0.74	0.79	0.89	0.98	1.13	1.26	1.39	1.49	1.59
14	Type P ₂ JWH ₂ or P ₂ H ₂ WH ₂	in	1.03	1.03	1.08	1.18	1.30	1.45	1.58	1.71	1.86	1.96
15	Type P ₂ JTH ₂ or P ₂ H ₂ TH ₂	in	1.04	1.04	1.09	1.19	1.28	1.43	1.56	1.69	1.83	1.93
16	Type CHW(FR)	in	0.79	0.79	0.84	0.94	1.06	1.21	1.34	1.47	1.62	1.72
17	Nominal weight per yard of completed cable:											
18	Type P ₂ H ₂ or P ₂ CH	lb	2.0	2.0	2.5	3.5	4.5	6.0	7.5	10.0	11.5	13.5
19	Type P ₂ JWH ₂ or P ₂ H ₂ WH ₂	lb	3.5	3.5	4.0	5.5	7.0	8.5	10.5	14.0	16.0	18.0
20	Type P ₂ JTH ₂ or P ₂ H ₂ TH ₂	lb	3.5	3.5	4.0	5.0	6.0	8.0	10.0	12.5	15.0	17.0
21	Type CHW(FR)	lb	3.0	3.0	3.5	5.0	6.5	8.0	10.0	13.5	15.5	17.5
22	Minimum radius of bend round which cable can be laid	mm	300	300	375	375	375	450	450	525	525	600
23	Nominal internal diameter of pipes or ducts	mm	100	100	100	100	100	100	100	100	100	100
24	Maximum D.C. resistance of conductor per 1,000 yards of cable at 20°C	Ω	3.360	1.739	1.149	0.6422	0.4238	0.2519	0.1721	0.1295	0.1031	0.08408
25	Maximum A.C. resistance of conductor per 1,000 yards of cable at maximum conductor temperature	Ω	4.48	2.15	1.42	0.80	0.53	0.31	0.22	0.17	0.14	0.12
26	Equivalent star reactance per 1,000 yards of cable at 50Hz	Ω	0.092	0.082	0.079	0.072	0.069	0.067	0.064	0.063	0.063	0.062
27	Maximum continuous carrying capacity per conductor when laid direct in the ground one three-phase circuit per trench:											
28	g = 120oC./watt/cm	Amps	62	93	120	165	210	285	350	415	470	530
29	g = 90°C./watt/cm	Amps	66	99	125	180	225	310	385	450	520	580
30*	Maximum continuous current carrying capacity per conductor:											
31	Drawn into pipes or ducts, ground temperature 15°C.and g = 120°C./watt/cm	Amps	52	78	99	140	175	235	290	340	385	430
32	Drawn into pipes or ducts, ground temperature 15°C.and g = 90°C./watt/cm	Amps	54	81	100	145	180	245	305	355	405	455
33	Laid on racks or in air, ambient temperature 25°C.	Amps	55	82	105	150	190	265	335	400	460	520
34*	Maximum conductor temperature;											
35	(a) Laid direct in ground	°C	<-----80----->									
36	(b) Drawn into pipes or ducts	°C	<-----80----->									
37	(c) Laid on racks or in air	°C	<-----80----->									

*Note - The figure given in items 15,16 and 17 (b) apply to armoured cable only. The assumed maximum conductor temperature for unarmoured cable drawn into ducts [Item 17 (b)] is 90°C.

1,100 volt 4-Core Cables (tables 8 and 9, BS 480 – Part 1)

1	Sectional area of conductor	sq.in	0.007	0.0145	0.0225	0.04	0.06	0.10	0.15	0.20	0.25	0.25/ 0.20N	0.30	0.30/ 0.20N	0.40	0.40/ 0.20N	0.50	0.50/ 0.20N
			Circular	Circular	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped
2	Minimum thickness of insulation between conductors	in	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.080	0.080	0.080	0.080
3	Minimum thickness of insulation between any conductor and sheath	in	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.065	0.065	0.065	0.065
4	Minimum thickness of sheath	in.	0.050	0.050	0.050	0.060	0.060	0.070	0.080	0.080	0.090	0.090	0.090	0.090	0.100	0.100	0.110	0.110
5	Diameter over sheath: Nominal	in.	0.62	0.73	0.73	0.89	1.01	1.22	1.42	1.52	1.74	1.71	1.88	1.87	2.17	2.13	2.37	2.32
6	Sheath material (as specified in B.S. 801)																	
7	Armour: a) No. (approx.) and diameter of armour wires b) Thickness of each layer of steel tape.	No./in. in	36/.064 0.030	41/.064 0.030	41/.064 0.030	40/.080 0.030	44/.080 0.030	50/.080 0.030	45/.104 0.040	50/.104 0.040	53/.104 0.040	52/.104 0.040	57/.104 0.040	57/.104 0.040	65/.104 0.040	63/.104 0.040	58/.128 0.040	56/.128 0.040
8	Nominal external diameter of completed cable: (a) Type P ₂ H ₂ or P ₂ CH (b) Type P ₂ JWH ₂ or P ₂ H ₂ WH ₂ (c) Type P ₂ JTH ₂ or P ₂ H ₂ TH ₂ (d) Type CHW(FR)	in in in in	0.82 1.11 1.12 0.87	0.93 1.22 1.23 0.98	0.93 1.22 1.23 0.98	1.09 1.41 1.39 1.17	1.21 1.53 1.51 1.29	1.42 1.74 1.72 1.50	1.62 1.99 1.96 1.75	1.78 2.15 2.12 1.91	1.94 2.31 2.28 2.07	1.91 2.28 2.25 2.04	2.08 2.45 2.42 2.21	2.07 2.44 2.41 2.20	2.37 2.74 2.71 2.50	2.33 2.70 2.67 2.46	2.37 2.99 2.91 2.75	2.52 2.94 2.86 2.70
9	Nominal weight per yard of completed cable: (a) Type P ₂ H ₂ or P ₂ CH (b) Type P ₂ JWH ₂ or P ₂ H ₂ WH ₂ (c) Type P ₂ JTH ₂ or P ₂ H ₂ TH ₂ (d) Type CHW(FR)	lb lb lb lb	2.5 4.5 4.0 4.0	3.0 5.5 4.5 5.0	3.5 6.0 5.5 5.5	5.0 8.0 7.5 7.5	7.0 10.0 9.0 9.5	10.0 14.0 13.0 13.5	14.0 19.0 17.5 18.5	17.0 22.5 21.0 22.0	21.0 27.5 25.5 27.11	20.0 26.5 24.5 26.11	25.0 31.5 29.5 30.5	23.0 30.0 28.0 29.0	33.1 40.0 38.0 39.0	30.0 37.0 30.0 36.0	39.0 49.0 45.0 48.0	35.0 45.0 40.5 44.0
10	Minimum radius of bend round which cable can be laid	mm	375	375	375	450	450	525	600	675	675	675	750	750	825	825	900	900
11	Nominal internal diameter of pipes or ducts	mm	100	100	100	100	100	100	100	100	100	100	100	100	125	125	125	125
12	Maximum D.C. resistance of conductor per 1,000 yards of cable at 20°C (a) phase (b) neutral	Ω Ω	3.630 3.630	1.739 1.739	1.149 1.149	0.6422 0.6422	0.4238 0.4238	0.2510 0.2319	0.1721 0.1721	0.1295 0.1295	0.1031 0.1031	0.1031 0.1295	0.0841 0.1184	0.0841 0.1295	0.0626 0.0626	0.0626 0.1295	0.0510 1.0510	0.0510 0.1295
13	Maximum A.C. resistance of conductor per 1,000 yards of cable at maximum conductor temperature: (a) phase	Ω	4.48	2.15	1.42	0.80	0.53	0.31	0.22	0.17	0.14	0.14	0.12	0.12	0.081	0.081	0.067	0.067
14	Equivalent star reactance per 1,000 yards of cable at 50Hz per second -.	Ω	0.092	0.082	0.079	0.072	0.069	0.1167	0.064	0.063	0.063	0.063	0.062	0.062	0.062	0.062	0.061	0.061
15*	Maximum continuous current carrying capacity per conductor when laid direct in the ground, one three-phase circuit per trench: (a) g = 120°C./watt/cm (b) g = 90°C./watt/cm	A A	51 54	77 82	100 105	140 150	175 190	240 260	290 320	345 385	395 440	395 440	445 495	445 495	520 580	520 580	570 640	570 640
16*	Maximum continuous current carrying capacity per conductor: (a) Drawn into pipes or ducts, ground temp. 15°C. (59°F.) and g = 120°C/watt/cm (b) Drawn into pipes or ducts, ground temp. 15°C and g = 90°C/watt/cm (c) Laid on racks or in air, ambient temp. 25°C	A A A	43 45 45	65 87 69	83 86 90	115 120 125	140 150 165	105 205 225	240 255 285	285 305 345	325 345 400	325 345 400	365 385 455	365 385 455	430 455 550	430 455 550	475 500 610	475 500 610
17*	Maximum conductor temperature: (a) Laid direct in ground (b) Drawn into pipes or ducts (c) Laid on racks or in air		----- 80°C ----->															
			----- 80°C ----->															
			----- 80°C ----->															

*NOTE. The figures given in Items 15, 16 and 17 (b) apply to armoured cables only. The assumed maximum conductor temperature for unarmoured cables drawn into ducts [Item 17 {b}] is 60°C. [140°F.].

1,100 volt 4-Core Cables with Aluminum Conductors
(Tables 8 and 9, BS 480 – Part 1)

1	Sectional area of conductor	sq.in	0.007	0.0145	0.0225	0.04	0.06	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.50/ 0.30N	
			Circular	Circular	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped
	Shape of conductor															
2	Minimum thickness of insulation between conductors	in	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.080	0.080	0.080	
3	Minimum thickness of insulation between any conductor and sheath	in	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.065	0.065	0.065	
4	Minimum thickness of sheath	in.	0.050	0.050	0.050	0.060	0.060	0.070	0.080	0.080	0.090	0.090	0.100	0.100	0.110	
5	Diameter over sheath: Nominal	in.	0.62	0.73	0.73	0.89	1.01	1.22	1.42	1.52	1.74	1.88	2.17	2.13	2.37	
6	Sheath material (as specified in B.S. 801)															
7	Armour: a) No. (approx.) and diameter of armour wires b) Thickness of each layer of steel tape.	No./in. in	36/.064 0.030	41/.064 0.030	41/.064 0.030	40/.080 0.030	44/.080 0.030	50/.080 0.030	45/.104 0.040	50/.104 0.040	53/.104 0.040	57/.104 0.040	65/.104 0.040	63/.104 0.040	58/.128 0.040	56/.128 0.040
8	Nominal external diameter of completed cable: (a) Type P ₂ H ₂ or P ₂ CH (b) Type P ₂ JWH ₂ or P ₂ H ₂ WH ₂ (c) Type P ₂ JTH ₂ or P ₂ H ₂ TH ₂ (d) Type CHW(FR)	in in in in	0.82 1.11 1.12 0.87	0.93 1.22 1.23 0.98	0.93 1.22 1.23 0.98	1.09 1.41 1.39 1.17	1.21 1.53 1.51 1.29	1.42 1.74 1.72 1.50	1.62 1.99 1.96 1.75	1.78 2.15 2.12 1.91	1.94 2.31 2.28 2.07	2.08 2.45 2.42 2.21	2.37 2.74 2.71 2.50	2.33 2.70 2.67 2.46	2.37 2.99 2.91 2.75	2.52 2.94 2.86 2.70
9	Nominal weight per vard of completed cable: (a) Type P ₂ H ₂ or P ₂ CH (b) Type P ₂ JWH ₂ or P ₂ H ₂ WH ₂ (c) Type P ₂ JTH ₂ or P ₂ H ₂ TH ₂ (d) Type CHW(FR)	lb lb lb lb	2.25 4.25 3.75 3.75	2.5 5.0 4.0 4.5	2.75 5.0 4.75 4.75	3.75 6.5 6.0 6.0	5.0 8.0 7.0 7.5	6.5 10.5 9.5 10.0	9.0 14.0 12.5 13.5	10.5 16.0 14.5 15.5	12.5 19.0 17.5 18.5	14.5 21.0 19.0 20.0	19.0 26.0 24.0 25.0	16.5 23.5 21.5 22.5	22.0 32.0 28.0 31.0	18.5 28.5 24.0 27.5
10	Minimum radius of bend round which cable can be laid	mm	375	375	375	450	450	525	600	675	675	750	825	825	900	900
11	Nominal internal diameter of pipes or duels	mm	100	100	100	100	100	100	100	100	100	125	125	125	125	
12	Maximum D.C. resistance of conductor per 1,000 yards of cable at 20°C (a) phase (b) neutral	Ω Ω	6.008 6.008	2.875 2.875	1.900 1.900	1.062 1.062	0.7015 0.7015	0.4171 0.4171	0.2848 0.2848	0.2143 0.2143	0.1707 0.1707	0.1391 0.1391	0.1035 0.1035	0.1035 0.1391	0.0844 0.0844	0.08440 0.1391
13	Maximum A.C. resistance of conductor per 1,000 yards of cable at maximum conductor temperature: (a) phase	Ω	7.46	3.57	2.36	1.32	0.87	0.52	0.36	0.27	0.22	0.18	0.13	0.13	0.11	0.11
14	Equivalent star reactance per 1,000 yards of cable at 50Hz per second:-.	Ω	0.092	0.082	0.079	0.072	0.069	0.1167	0.064	0.063	0.063	0.062	0.062	0.062	0.061	0.061
15*	Maximum continuous current carrying capacity per conductor when laid direct in the ground, one three-phase circuit per trench: (a) g = 120°C/watt/cm (b) g = 90°C/watt/cm	A A	40 42	60 64	78 82	110 115	135 150	185 205	225 250	270 300	310 345	350 390	410 460	410 460	450 505	450 505
16*	Maximum continuous current carrying capacity per conductor: (a) Drawn into pipes or ducts, ground temp. 15°C. (59°F.) and g = 120°C/watt/cm (b) Drawn into pipes or ducts, ground temp. 15°C and g = 90°C/watt/cm (c) Laid on racks or in air, ambient temp. 25°C	A A A	34 35 35	51 52 54	65 67 70	90 94 98	110 115 130	150 160 175	185 200 225	220 240 275	225 270 315	290 305 360	340 360 435	340 360 435	375 395 480	375 395 480
17*	Maximum conductor temperature: (a) Laid direct in ground (b) Drawn into pipes or ducts (c) Laid on racks or in air															

*NOTE. The figures given in Items 15, 16 and 17 (b) apply to armoured cables only. The assumed maximum conductor temperature for unarmoured cables drawn into ducts [Item 17 {b}] is 60°C. [140°F.].

SCHEDULE OF TECHNICAL PARTICULARS

CABLE	SUB-SECTION
New Cables	
11kV Single Core, SAC, XLPE Insulation, triplex.	2.2.1
11kV Single Core, Stranded Copper, XLPE Insulation.	2.2.2
11kV Three Core, Stranded Aluminium, Paper Insulated, with Corrugated Aluminium Sheath (PICAS).	2.2.3
Superseded Cables	
11kV Single Core, Stranded Aluminium, XLPE Insulation.	2.2.4
11kV Single Core, Stranded Copper, Paper Insulated, with Lead Sheath.	2.2.5
11kV Three Core, Stranded Copper, Belted Cable with Paper Insulation, Lead Sheath, and Steel Wire Armour.	2.2.6
11kV Three Core, Stranded Copper, Screened Cable with Paper Insulation, Lead Sheath, and Steel Wire Armour.	2.2.7
11kV Three Core, Stranded Aluminium, Belted Cable with Paper Insulation, Lead Sheath, and Steel Wire Armour.	2.2.8
Short Circuit Ratings	
Short Circuit Ratings for SAC and PICAS Cables.	2.2.9

STANDARD CABLES

11kV CABLES

All 11kV cables shall be as detailed in the appropriate section and schedules and the Distribution Planning Manual.

Cables shall be installed as detailed in this Code of Practice Section 3 – Technical Requirements for Cable Laying.

Single Core X.L.P.E. Insulated

11kV Network Extensions and Alterations

Circular solid aluminium conductor (SAC), cross linked polyethylene (XLPE) insulated, copper wire screen, medium density polyethylene (MDPE) oversheath, three single cores laid up in triplex formation to specification BS7870 (Part 4) & IEC 502.

Three sizes will be used: -

Size	Use
70mm ² SAC, 3x1 core triplex.	- Main up to 200Amps.
150mm ² SAC 3x1 core triplex*	- Main up to 320 Amps.
185mm ² SAC, 3x1 core triplex.	- Main up to 360Amps.
300mm ² SAC, 3x1 core triplex.	- Interconnectors up to 600Amps between Primary Substations.
	- Feeders out of Primary Substations.

****This will be removed from the available options as stocks diminish and are replaced by the 185mm² SAC 3x1 core triplex (expected to be early 2001).***

11kV Transformer Tails (33/11kV transformers)

Stranded copper conductors, cross-linked polyethylene (XLPE) extruded insulation, copper wire metallic screen, medium density polyethylene (MDPE) sheathed overall single core 11kV cable to specification BS7870.

Two sizes will be used: -

Size	Use
400mm ² Stranded Copper 1 core.	12 MVA 11kV Transformer Tails (1 per ph)
400mm ² Stranded Copper 1 core.	24 MVA 11kV Transformer Tails (2 per ph)
630mm ² Stranded Copper 1 core.	40 MVA 11kV Transformer Tails (2 per ph).
	24MVA 6.6kV Transformer Tails (2 per ph)

Three Core Paper Insulated Corrugated Aluminium Sheathed (PICAS)

11kV Network Extensions and Alterations

Stranded aluminium conductors, non-draining, impregnated paper insulated belted, corrugated aluminium sheathed, 6350/11000 volt three core cable, PVC sheathed overall, to specification ESI 09-12 (PICAS)

Three sizes are available: -

Size	Use
95mm ² PICAS 3 core Aluminium ⁺	- Main up to 175Amps.
185mm ² PICAS 3 core Aluminium ⁺	- Main up to 250Amps.
300mm ² PICAS 3 core Aluminium ⁺	- Main up to 345Amps

⁺All these cables will be superseded by the XLPE triplex cables as stocks are exhausted (expected to be early 2001)

TECHNICAL SCHEDULE	SECTION 2
	SUB-SECTION 2.2.1

Single core, circular solid aluminium conductor, extruded conductor screen, XLPE insulation, strippable semi-conducting core screen, helical copper wire screen, polyethylene oversheath, TRIPLEXED, 6350/11000 cable to BS7870 Part 4-10:1999.

Nominal Area of Conductor	mm	70	95	150	185	240	300
Conductor material		aluminium					
Nominal diameter of conductor	mm	9.2	10.8	13.5	15.12	17.3	19.41
Nominal Thickness of conductor screen	mm	0.7	0.7	0.7	0.7	0.7	0.7
Minimum average thickness of insulation	mm	3.4	3.4	3.4	3.4	3.4	3.4
Minimum thickness at any point of insulation	mm	2.96	2.96	2.96	2.96	2.96	2.96
Nominal thickness of dielectric screen	mm	1	1	1	1	1	1
Nominal cross sectional area of copper wire screen	mm	25	35	35	35	35	35
Diameter of copper screen wires	mm	1.04	1.04	1.04	1.04	1.04	1.04
Number of copper wires	No.	30	42	42	42	42	42
Minimum average thickness of oversheath	mm	1.7	1.8	1.9	1.9	2.0	2.1
Nominal diameter of single core	mm	26.7	28.6	31.5	33.1	35.5	37.8
Nominal diameter over triplexed cores	mm	57.7	61.7	68	71.5	76.7	81.7
Minimum radius of bend							
(1) During installation	mm	550	575	650	675	725	775
(2) Adjacent to joints and terminations	mm	425	450	475	500	550	575
Approx. weight per 1000m of triplexed cores.	kg	7500	9500	11400	12700	14600	16700
Nominal internal diameter of ducts	mm	100	100	125	125	125	125
Maximum d.c. resistance of conductor per 1000m of cable at 20 °C	Ω	0.443	0.32	0.206	0.164	0.125	0.1
Maximum a.c. resistance of conductor per 1000m of cable at 90 °C	Ω	0.568	0.411	0.265	0.211	0.161	0.13
Inductance per core per 1000m of cable	mH	0.4	0.38	0.355	0.343	0.33	0.32
Equivalent star reactance per 1000m of cable at 50 Hz	Ω	0.125	0.119	0.112	0.108	0.104	0.101
Maximum equivalent star capacitance per 1000m of cable	μF	0.28	0.314	0.37	0.403	0.448	0.491
Maximum continuous current rating;							
(1) Laid direct ground temp 15 °C, g = 1.2 Km/W, depth 0.8 m	A	210	250	320	360	415	470
(2) Drawn into ducts ground temp 15 °C, g = 1.2. Km/W, depth 0.8m	A	210	250	310	350	400	440
(3) Installed in air ambient air temperature 25 °C	A	240	290	380	440	520	590
Maximum continuous conductor temperature	°C	90	90	90	90	90	90
Maximum short circuit conductor temperature	°C	250	250	250	250	250	250
Short circuit ratings -1.0 second duration							
(1) Conductor	kA	6.6	8.9	14.1	17.4	22.5	28.2
(2) Copper wire screen	kA	3.2	4.5	4.5	4.5	4.5	4.5

The above information is based on single core cables installed in trefoil formation, with screens solidly bonded.

TECHNICAL SCHEDULE

SECTION 2.2

SUB-SECTION 2.2.2

Single core, circular stranded copper conductor, extruded conductor screen, XLPE insulation, strippable semi-conducting core screen, helical copper wire screen (35 sq.mm), MDPE oversheath 6350/11000 V cable to BS 7870 - **(Stranded Copper)**

Nominal Area of Conductor	mm ²	400	500	630	800
Conductor material		stranded copper	stranded copper	stranded copper	stranded copper
Nominal diameter of conductor	mm	23.70	27.10	31.00	35.40
Nominal thickness of conductor screen	mm	0.70	0.70	0.70	0.70
Minimum average thickness of insulation	mm	3.40	3.40	3.40	3.40
Minimum thickness at any point of insulation	mm	2.96	2.96	2.96	2.96
Nominal thickness of dielectric screen	mm	1.00	1.00	1.00	1.00
Diameter of copper screen wires	mm	1.04	1.04	1.04	1.04
Minimum average thickness of oversheath	mm	2.20	2.30	2.40	2.50
Nominal overall diameter	mm	41.70	45.30	49.50	54.00
Minimum radius of bend					
(1) During installation	mm	850	925	1000	1100
(2) Adjacent to joints and terminations	mm	650	700	750	825
Approx. weight per 1000m of cable	kg	4565	5590	7070	8800
Nominal internal diameter of ducts	mm	100	100	100	100
Maximum d.c. resistance of conductor per 1000m of cable at 20 °C	ohm	0.047	0.0366	0.0283	0.0221
Maximum a.c. resistance of conductor per 1000m of cable at 90 °C	ohm	0.0631	0.0508	0.0414	0.0348
Inductance per core per 1000m of cable	mH	0.304	0.293	0.284	0.275
Equivalent star reactance per 1000m of cable at 50 Hz	ohm	0.095	0.092	0.089	0.087
Maximum equivalent star capacitance per 1000m of cable	microF	0.579	0.649	0.729	0.818
Maximum continuous current rating:					
(1) Laid direct ground temp 15 °C, g = 1.2 K.m/W, depth 0.8 m	Amp	672	755	844	930
(2) Drawn into ducts ground temp 15 °C, g = 1.2 K.m/W, depth 0.8 m	Amp	612	683	760	838
(3) Installed in air ambient air temperature 25 °C	Amp	887	1022	1172	1324
Maximum continuous conductor temperature	°C	90	90	90	90
Maximum short circuit conductor temperature	°C	250	250	250	250
Short circuit ratings -1.0 second duration					
(1) Conductor	kA	57.2	71.5	90.1	114.4
(2) Copper wire screen	kA	4.5	4.5	4.5	4.5

The above information is based on single core cables installed in trefoil formation, with screens solidly bonded

Current Ratings – Trefoil Solidly Bonded

1c, Copper or Aluminium, XLPE, CWS (35mm), Pe, 6.35/11 kV

Conductor Size (mm ²)	Continuous Current Rating (Direct Buried)	
	Copper	Aluminium
400	672 A	536
500	755 A	610
630	844 A	692
800	930 A	776

Ground temperature 15 °C
 Soil thermal resistivity 1.2 K.m/W
 Depth of laying 0.8 m

We know that P17 ratings are based on a ground temperature of 10 °C and TR of 0.9 K.m/W, correction factors are:

Ground temp 10 °C 1.04
 Soil TR 0.9 K.m/W 1.12

Additionally P17 ratings are based on a 5 day limited winter cyclic rating factor of 1.17

Adjusting the 630mm Cu rating gives:

$$844 \times 1.04 \times 1.12 \times 1.17 = 1150 \text{ A}$$

P17 then has a further allowance based on the fact that the cables are only 50% utilised prior to the emergency loading.

The cable makers were never involved with P17 ratings and thus always quote continuous ratings. However the REC's appear to have used P17 ratings for many years without problems.

Three core, shaped stranded aluminium conductors. paper insulated, belted, corrugated aluminium sheath, PVC sheathed, 6.35/11 kV PICAS cable to EA 09-12.

	Nominal Area of Conductor	mm²	95	185	300
1	Nominal diameter of conductor (depth)	mm	9.8	13.84	17.85
2	Mean thickness of paper insulation	mm	3	3	3
3	Nominal depth over insulation	mm	16.2	20.24	24.3
4	Nominal diameter over laid up cores	mm	34.5	42.8	51
5	Nominal thickness of belt insulation	mm	0.65	0.65	0.65
6	Nominal thickness of belt carbon screen	mm	0.15	0.15	0.15
7	Nominal thickness of corrugated aluminium sheath	mm	1.2	1.6	2
8	Nominal external root diameter	mm	40.5	49.6	58.6
9	Nominal external crest diameter	mm	45.3	56	66.6
10	Nominal diameter over PVC oversheath	mm	51.8	63.2	74.7
11	Minimum radius of bend				
	1) During installation	mm	600	750	900
	2) Adjacent to joints and terminations	mm	500	600	700
12	Maximum d.c. resistance of conductor per 1000m of cable at 20 °C	ohms	0.32	0.164	0.1
13	Maximum a.c. resistance of conductor per 1000m of cable at 65 °C	ohms	0.379	0.195	0.12
14	Equivalent star reactance per 1000m of cable at 50 Hz	ohms	0.087	0.08	0.077
15	Impedance per 1000m of cable at 50Hz and 65°C	ohms	0.389	0.211	0.143
16	Maximum equivalent star capacitance per 1000m of cable	uF	0.45	0.58	0.71
17	Maximum continuous current rating at (@ 65°C conductor temperature)				
	1) Laid direct ground temp. 15 °C, depth 1.2m and g= 0.8 K.m/W	Amps	185	270	355
	2) Drawn into ducts ground temp. 15 °C, depth 1.2m and g = 0.8 K.m/W	Amps	160	230	305
	3) Installed in air ambient temp. 25 °C	Amps	188	270	370
18	Maximum conductor temperature	°C	65	65	65
19	Maximum short circuit conductor temperature	°C	160	160	160
20	Maximum conductor short circuit rating capacity for 1 second (Conductor operating at 65°C at start of short circuit)	kA	7.4	14.4	23.4
21	Al. sheath fault level capacity for 1 second (Conductor operating at 65 °C at start of short circuit)	kA	7.4	14.4	23.4

TECHNICAL SCHEDULE

Section 2.2 Sub-Section 2.2.4

Single core, circular stranded aluminium conductor, extruded conductor screen, XLPE insulation, strippable semi-conducting core screen, helical copper wire screen (35 sq.mm), MDPE oversheath 6350/11000 V cable to BS 7870 - **(Aluminium)**

Nominal Area of Conductor	mm ²	400	500	630	800
Conductor material		Aluminium	Aluminium	Aluminium	Aluminium
Nominal diameter of conductor	mm	23.90	27.40	31.00	35.40
Nominal thickness of conductor screen	mm	0.70	0.70	0.70	0.70
Minimum average thickness of insulation	mm	3.40	3.40	3.40	3.40
Minimum thickness at any point of insulation	mm	2.96	2.96	2.96	2.96
Nominal thickness of dielectric screen	mm	1.00	1.00	1.00	1.00
Diameter of copper screen wires	mm	1.04	1.04	1.04	1.04
Minimum average thickness of oversheath	mm	2.20	2.30	2.40	2.50
Nominal overall diameter	mm	41.90	45.60	49.50	54.00
Minimum radius of bend					
(1) During installation	mm	850	925	1000	1100
(2) Adjacent to joints and terminations	mm	650	700	750	825
Approx. weight per 1000m of cable	kg	2120	2555	3000	3800
Nominal internal diameter of ducts	mm	100	100	100	100
Maximum d.c. resistance of conductor per 1000m of cable at 20 °C	ohm	0.0778	0.0605	0.0469	0.0367
Maximum a.c. resistance of conductor per 1000m of cable at 90 °C	ohm	0.1017	0.0802	0.0637	0.0517
Inductance per core per 1000m of cable	mH	0.303	0.292	0.284	0.275
Equivalent star reactance per 1000m of cable at 50 Hz	ohm	0.095	0.092	0.089	0.087
Maximum equivalent star capacitance per 1000m of cable	microF	0.583	0.655	0.729	0.818
Maximum continuous current rating:					
(1) Laid direct ground temp 15 °C, g = 1.2 K.m/W, depth 0.8 m	Amp	536	610	692	776
(2) Drawn into ducts ground temp 15 °C, g = 1.2 K.m/W, depth 0.8 m	Amp	505	683	641	716
(3) Installed in air ambient air temperature 25 °C	Amp	707	826	958	1103
Maximum continuous conductor temperature	°C	90	90	90	90
Maximum short circuit conductor temperature	°C	250	250	250	250
Short circuit ratings -1.0 second duration					
(1) Conductor	kA	37.6	47	59.2	75.2
(2) Copper wire screen	kA	4.5	4.5	4.5	4.5

The above information is based on single core cables installed in trefoil formation, with screens solidly bonded

6350/11000 Volt, Single Core, Paper Insulated, Lead Covered Cables
Stranded Copper Conductor, to Specification BS6480 part 1 (Table 18)

	Nominal area of conductor	mm ²	500	630
1	Shape of Conductor		Circular	Circular
2	Minimum thickness of insulation between conductor and sheath	mm	2.8	2.8
3	Nominal thickness of sheath	mm	1.7	1.8
4	Nominal diameter over sheath	mm	39.8	44
5	Sheath material		Alloy 'E'	Alloy 'B'
6	Radial thickness of extruded PVC oversheath	mm	1.6	1.7
7	Nominal external diameter of completed cable	mm	43.3	47.7
8	Nominal weight per metre of completed cable	kg	7.5	9.3
9	Minimum radius of bend round which cable can be laid	mm	650	750
10	Nominal internal diameter of ducts	mm	100	100
11	Maximum d.c. resistance of conductor per metre of cable at 20°C	Ω	36.6	28.3
12*	Maximum a.c. resistance of conductor per metre of cable at maximum conductor temperature (70°C)	μΩ	47.8	38.9
13*	Equivalent star reactance per metre of cable at 50 Hz	μΩ	87	84.5
14	Maximum capacitance per metre of cable	pF	1210	1360
15	Maximum charging current per conductor per metre of cable at normal voltage & frequency	mA	2.42	2.72
16φ	Maximum continuous current carrying capacity per conductor			
	(a) Laid direct, ground temperature 15°C and g = 1.2°C m/W	A	660	740
	(b) Drawn into ducts, ground temperature 15°C and g = 1.2°C m/W	A	500	550
	(c) Laid in air, ambient temperatures 25°C	A	840	960
17	Maximum conductor temperature			
	(a) Laid direct in ground	°C	70	70
	(b) Drawn into ducts	°C	50	50
	(c) Laid in air	°C	70	70
18	Sheath loss per metre of three phase circuit at normal frequency and at maximum current rating			
	(a) Laid direct in ground	W	2.8	4.1
	(b) Drawn into ducts	W	9.3	11.8
	(c) Laid in air	W	4.6	6.9

*Cables laid in trefoil arrangement φ Cable sheaths solid bonded

11,000 VOLTS 3-CORE BELTED CABLE (TABLE 13, B.S. 480—Part 1.)

1	Sectional area of conductor	sq in	0.0225	0.04	0.06	0.1	0.15	0.2	0.25	0.3	0.4	0.5
	Shape of conductor		<i>Circular</i>	<i>Shaped</i>	<i>Shaped</i>	<i>Shaped</i>	<i>Shaped</i>	<i>Shaped</i>	<i>Shaped</i>	<i>Shaped</i>	<i>Shaped</i>	<i>Shaped</i>
2	Minimum thickness of insulation between conductors	in	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
3	Minimum thickness of insulation between any conductor and sheath		0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
4	Minimum, thickness of sheath	in	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.1	0.11
5	Nominal diameter over sheath	in	1.12	1.16	1.26	1.44	1.59	1.74	1.86	2	2.19	2.37
6	Sheath material (as specified in B.S. 801)		Lead Alloy "E" Alloy "B"									
7	Armour:											
	(a) No. (approx.) and diameter of armour wires	No./in	47/.080	49/.080	41/.104	46/.104	50/.104	54/.104	57/.104	61/.104	66/.104	57/.128
	{b} Thickness of each layer of steel tape	in	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
8	Nominal external diameter of completed cable:											
	(a) Type P ₂ CH	in	1.32	1.36	1.46	1.64	1.79	1.94	2.06	2.20	2.39	2.57
	{b} Type P ₂ CHWH ₂	in	1.64	1.68	1.83	2.01	2.16	2.31	2.43	2.57	2.76	2.99
	(c) Type P ₂ CHTH ₂	in	1.62	1.66	1.80	1.98	2.13	2.28	2.40	2.54	2.73	2.91
	{d} Type CHW(FR)	in	1.40	1.44	1.59	1.77	1.92	2.07	2.19	2.33	2.52	2.75
9	Nominal weight per yard of completed cable:											
	(a) Type P ₂ CH	lb	5.5	7.0	8.0	11.0	14.0	17.0	20.0	24.0	29.5	35.5
	(b) Type P ₂ CHWH ₂	lb	9.0	10.5	13.0	17.0	20.0	24.0	27.0	31.0	37.5	45.0
	(c) Type P ₂ CHTH ₂	lb	8.0	9.5	11.5	15.0	18.0	22.0	25.0	29.0	35.0	41.5
	{d} Type CHW/(FR)	lb	8.5	10.0	12.0	16.0	19.0	23.0	26.0	30.0	36.5	44.5
10	Minimum radius of bend round which cable can be laid	mm	550	550	550	610	690	690	770	770	840	950
11	Nominal internal diameter of pipes or ducts	mm	100	100	100	100	100	100	100	125	125	125
12	Maximum D.C. resistance of conductor per 1,000 yards of cable at 20°C	Ω	1.149	0.6422	0.4238	0.2519	0.1721	0.1295	0.1031	0.08408	0.06256	0.05101
13	Maximum A.C. resistance of conductor per 1,000 yards of cable at maximum conductor temperature	Ω	1.35	0.76	0.5	0.3	0.2	0.16	0.13	0.1	0.076	0.064
14	Equivalent star reactance per 1,000 yards of cable at 50Hz	Ω	0.104	0.093	0.088	0.082	0.077	0.075	0.073	0.071	0.070	0.068
15	Maximum equivalent star capacitance per 1,000 yards of cable	μF	0.22	0.26	0.30	0.37	0.43	0.49	0.53	0.56	0.65	0.70
16	Maximum charging current per conductor 1,000 yards of cable at normal voltage and frequency	amps	0.44	0.52	0.60	0.74	0.86	0.98	1.06	1.12	1.30	1.40
*17	Maximum continuous carrying capacity per conductor when laid direct in the ground one three-phase circuit per trench:											
	(a) g = 120°C./watt/cm	amps	85	120	145	205	250	290	335	370	430	475
	(b) g = 90°C./watt/cm	amps	92	130	160	220	270	320	370	410	475	530
*18	Maximum continuous current carrying capacity per conductor;											
	(a) Drawn into pipes or ducts, ground temperature 15°C. and g = 120°C./watt/cm	amps	75	105	125	175	215	285	295	330	380	420
	(b) Drawn into pipes or ducts, ground temperature 15°C. and g = 90°C./watt/cm	amps	78	110	136	185	230	270	315	350	405	450
	(c) Laid on racks or in air, ambient temperature 25°C.	amps	79	115	140	200	250	295	345	390	465	530
*19	Maximum conductor temperature:											
	(a) Laid direct in ground	°C	←————— 65 —————→									
	(b) Drawn into pipes or ducts	°C	←————— 65 —————→									
	(c) Laid on racks or in air	°C	←————— 65 —————→									
20	Sheath loss per 1,000 yards of three-phase circuit at normal working voltage and frequency and at maximum current rating:											
	(a) Laid direct in ground [Current as in Item 17]	kW	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	0.8	1.1
	(b) Drawn into ducts [Current as in Item 18 (a)]	kW	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	0.8
	(c) In air [Current as in Item 18 (b)]	kW	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.7	1.0	1.3

*NOTE.—The figures given in Items 17, 18 and 19 (b) apply to armoured cables only. The assumed maximum conductor temperature for unarmoured cables drawn into ducts [Item 19 (b)] is 50°C

11,000 VOLTS 3-CORE SCREENED CABLE (TABLE 13, B.S. 480—Part 1.)

1	Sectional area of conductor	sq. in.	0.0225	0.04	0.06	0.1	0.15	0.2	0.25	0.3	0.4	0.5
	Shape of conductor		Circular	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped
2	Minimum thickness of insulation between conductor and screen	in	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
3	Type of screen round individual cores		Metal tape or metallised paper									
4	Minimum thickness of sheath	in	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.11	0.11
5	Nominal diameter over sheath	in	1.2	1.21	1.31	1.5	1.65	1.8	1.91	2.05	2.27	2.42
6	Sheath material (as specified in B.S. 801)		Lead, Alloy"E", Alloy"B"									
7	Armour:											
	(a) No. (approx.) and diameter of armour wires.	No./in	50/.080	50/.080	42/.104	47/.104	51/.104	55/.104	58/.104	62/.104	55/.128	59/.128
	(b) Thickness of each layer of steel tape		0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
8	Nominal external diameter of completed cable:											
	(a) Type P ₂ CH	in	1.40	1.41	1.51	1.70	1.85	2.00	2.11	2.25	2.47	2.62
	(b') Type P ₂ CHWH ₂	in	1.72	1.73	1.88	2.07	2.22	2.37	2.48	2.62	2.89	3.04
	(c) Type P ₂ CHTH ₂	in	1.70	1.71	1.85	2.04	2.19	2.34	2.45	2.59	2.81	2.96
	{d} Type CHW(FR)	in	1.48	1.49	1.64	1.83	1.98	2.13	2.24	2.38	2.65	2.80
9	Nominal weight per yard of completed cable:											
	(a) Type P ₂ CH	lb	6.5	7.5	9.0	12.0	14.5	18.0	21.0	25.0	31.5	36.5
	(b) Type P ₂ CHWH ₂	lb	10.0	11.0	13.5	17.0	20.5	25.0	28.0	32.0	40.5	46.0
	(c) Type P ₂ CHTH ₂	lb	9.5	10.0	12.0	16.0	19.5	23.0	26.0	30.0	37.0	42.0
	{d} Type CHW(FR)	lb	9.5	10.5	12.5	16.5	20.0	24.0	27.0	31.0	39.5	45.0
10	Minimum radius of bend round which cable can be laid	mm	540	540	610	610	690	770	770	840	920	920
11	Nominal internal diameter of pipes or ducts	mm	100	100	100	100	100	100	100	125	125	125
12	Maximum D.C. resistance of conductor per 1,000 yards of cable at 20°C	Ω	1.149	0.6422	0.4238	0.2519	0.1721	0.1295	0.1031	0.08408	0.06256	0.05101
13	Maximum A.C. resistance of conductor per 1,000 yards of cable at maximum conductor temperature	Ω	1.37	0.77	0.51	0.3	0.21	0.16	0.13	0.11	0.077	0.065
14	Reactance per core per 1,000 yards of three-phase circuit at 50Hz per second	Ω	0.113	0.1	0.094	0.088	0.083	0.08	0.076	0.076	0.072	0.071
15	Maximum capacitance per core per 1,000 yards of cable	μF	0.24	0.29	0.34	0.41	0.48	0.54	0.59	0.64	0.73	0.8
16	Maximum charging current per conductor per 1,000 yards of cable at normal voltage and frequency	amps	0.48	0.58	0.68	0.82	0.96	1.08	1.18	1.28	1.46	1.6
*17	Maximum continuous current carrying capacity per conductor when laid direct in the ground. One three-phase circuit per trench;											
	(a) g = 120°C./watt/cm	amps	93	130	165	215	265	315	355	395	460	500
	(b) g = 90°C./watt/cm	amps	100	140	180	240	295	350	390	435	510	560
*18	Maximum continuous current carrying capacity per conductor:											
	(a) Drawn into pipes or ducts, ground temperature 15°C. and g = 120°C./watt/cm	amps	81	105	135	190	230	265	305	340	400	440
	(b) Drawn into pipes or ducts, ground temperature 15°C. and g = 90°C./watt/cm	amps	84	110	145	200	245	285	325	360	425	470
	(c) Laid on racks or in air, ambient temperature 25°C.	amps	90	125	160	220	275	330	380	435	510	570
*19	Maximum conductor temperature;											
	(a) Laid direct in ground	°C	←-----70----->									
	(b) Drawn into pipes or ducts	°C	←-----70----->									
	(c) Laid on racks or in air	°C	←-----70----->									
20	Sheath loss per 1,000 yards of three-phase circuit at normal working voltage and frequency and at maximum current rating:											
	(a) Laid direct in ground [Current as in Item 17]	kW	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.7	1.1	1.3
	(b) Drawn into ducts [Current as in Item 18 (a)]	kW	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7	1.0
	(c) In air [Current as in Item 18 (b)]	kW	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	0.8	1.3	1.7

*NOTE.—The figures given in Items 17, 18 and 19 (b) apply to armoured cables only. The assumed maximum conductor temperature for unarmoured cables drawn into ducts [Item 19 (b)] is 50°C.

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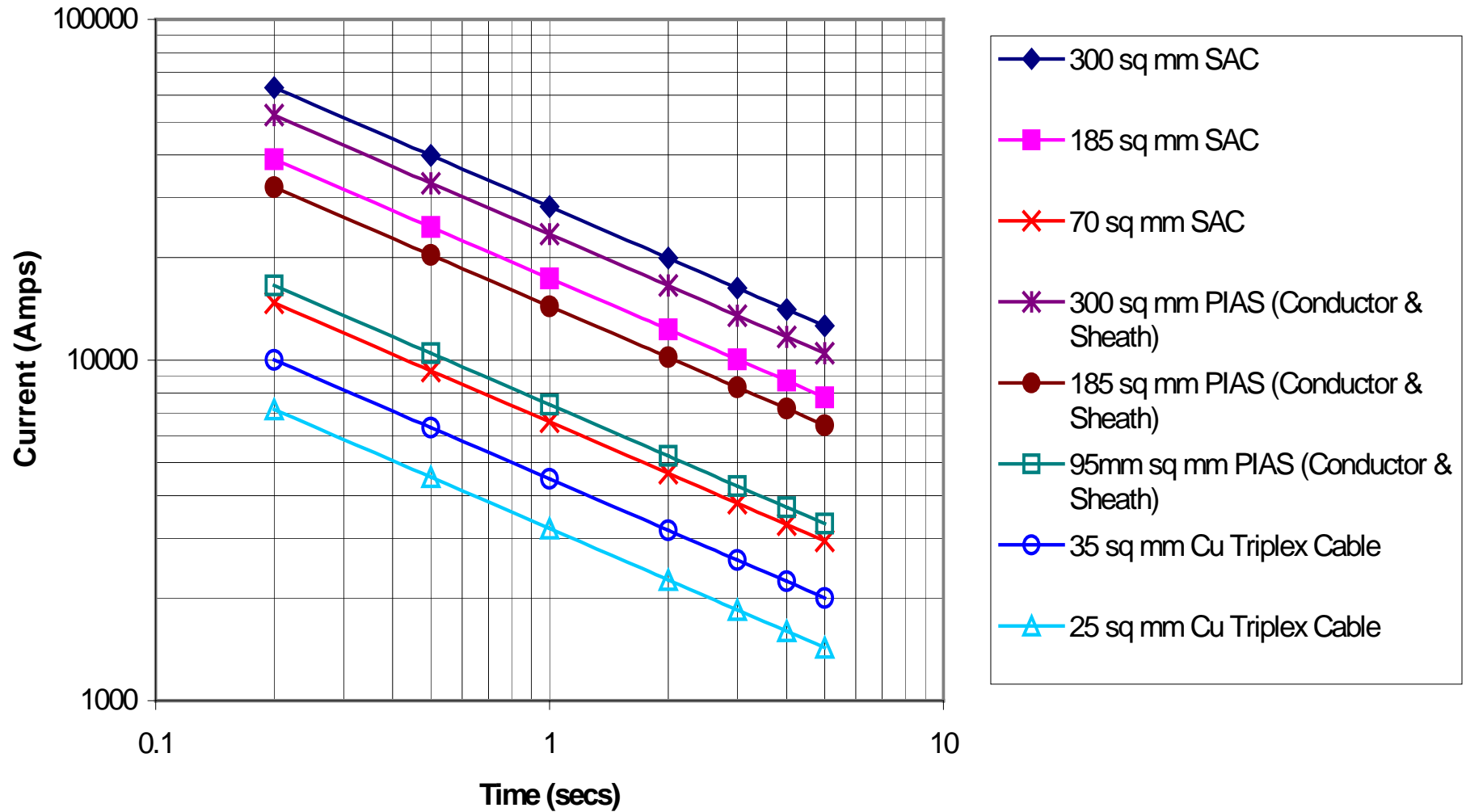
11,000 VOLTS 3-CORE BELTED CABLE WITH ALUMINIUM CONDUCTORS
(Table 13, B.S. 480—Part 1.)

1	Sectional area of conductor Shape of conductor	sq in	0.0225	0.04	0.06	0.10	0.15	0.20	0.25	0.30	0.40	0.50
			Circular	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped	Shaped
2	Minimum thickness of insulation between conductors	in	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
3	Minimum thickness of insulation between any conductor and sheath	in	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
4	Minimum thickness of sheath	in	0.060	0.070	0.070	0.080	0.080	0.090	0.090	0.100	0.100	0.110
5	Nominal diameter over sheath	in	1.12	1.16	1.26	1.44	1.59	1.74	1.86	2.00	2.19	2.37
6	Sheath material (as specified in B.S. 801)		Lead Alloy "E" Alloy "B"									
7	Armour:											
	(a) No. (approx.) and diameter of armour wires	No./in	47/.080	49/.080	41/.104	46/.104	50/.104	54/.104	57/.104	61/.104	66/.104	57/.128
	{b} Thickness of each layer of steel tape	in	0.030	0.030	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
8	Nominal external diameter of completed cable:											
	(a) Type P ₂ CH	in	1.32	1.36	1.46	1.64	1.79	1.94	2.06	2.20	2.39	2.57
	{b} Type P ₂ CHWH ₂	in	1.64	1.68	1.83	2.01	2.16	2.31	2.43	2.57	2.76	2.99
	(c) Type P ₂ CHTH ₂	in	1.62	1.66	1.80	1.98	2.13	2.28	2.40	2.54	2.73	2.91
	{d} Type CHW(FR)	in	1.40	1.44	1.59	1.77	1.92	2.07	2.19	2.33	2.52	2.75
9	Nominal weight per yard of completed cable:											
	(a) Type P ₂ CH	lb	5.0	6.0	6.5	8.5	10.5	12.0	14.0	16.5	19.0	23.0
	(b) Type P ₂ CHWH ₂	lb	8.5	9.5	11.5	14.5	16.5	19.0	21.0	23.5	27.0	32.5
	(c) Type P ₂ CHTH ₂	lb	7.5	8.5	10.0	12.5	14.5	17.0	19.0	21.5	24.5	29.0
	{d} Type CHW(FR)	lb	8.0	9.0	10.5	13.5	15.5	18.0	20.0	22.5	26.0	32.0
10	Minimum radius of bend round which cable can be laid	mm	550	550	550	610	690	690	770	770	840	950
11	Nominal internal diameter of pipes or ducts	mm	100	100	100	100	100	100	100	125	125	125
12	Maximum D.C. resistance of conductor per 1,000 yards of cable at 20°C	Ω	1.900	1.062	0.7015	0.4171	0.2848	0.2143	0.1707	0.1391	0.1035	0.08442
13	Maximum A.C. resistance of conductor per 1,000 yards of cable at maximum conductor temperature	Ω	2.24	1.25	0.83	0.49	0.34	0.26	0.21	0.17	0.13	0.10
14	Equivalent star reactance per 1,000 yards of cable at 50Hz	Ω	0.104	0.093	0.088	0.082	0.077	0.075	0.073	0.071	0.070	0.068
15	Maximum equivalent star capacitance per 1,000 yards of cable	μF	0.22	0.26	0.30	0.37	0.43	0.49	0.53	0.56	0.65	0.70
16	Maximum charging current per conductor 1,000 yards of cable at normal voltage and frequency	amps	0.44	0.52	0.60	0.74	0.86	0.98	1.06	1.12	1.30	1.40
17	Maximum continuous carrying capacity per conductor when laid direct in the ground one three-phase circuit per trench:											
	(a) g = 120°C./watt/cm	amps	66	94	115	160	195	225	260	290	340	375
	(b) g = 90°C./watt/cm	amps	72	100	125	170	210	250	290	325	375	420
18	Maximum continuous current carrying capacity per conductor;											
	(a) Drawn into pipes or ducts, ground temperature 15°C. and g = 120°C./watt/cm	amps	59	82	98	135	170	200	230	260	300	330
	(b) Drawn into pipes or ducts, ground temperature 15°C. and g = 90°C./watt/cm	amps	61	86	105	145	180	210	245	275	320	355
	(c) Laid on racks or in air, ambient temperature 25°C.	amps	62	90	110	155	195	230	270	310	365	420
19	Maximum conductor temperature:											
	(a) Laid direct in ground	°C	←————— 65 —————→									
	(b) Drawn into pipes or ducts*	°C	←————— 65 —————→									
	(c) Laid on racks or in air	°C	←————— 65 —————→									
20	Sheath loss per 1,000 yards of three-phase circuit at normal working voltage and frequency and at maximum current rating:											
	(a) Laid direct in ground [Current as in Item 17(a)]	kW	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7
	(b) Drawn into ducts [Current as in Item 18 (a)]	kW	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
	(c) In air [Current as in Item 18 (c)]	kW	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	0.6	0.8

•NOTE.—The assumed maximum conductor temperature for unarmoured cables drawn into ducts [Item 19 (A)] is 50°C. (122°F.).

Short Circuit Ratings for Cables							SECTION 2	
							SUB-SECTION 2.2.9	
	Time (sec)	0.2	0.5	1	2	3	4	5
	300 sq mm SAC	63057	39881	28200	19940	16281	14100	12611
	185 sq mm SAC	38885	24593	17390	12297	10040	8695	7777
	70 sq mm SAC	14713	9306	6580	4653	3799	3290	2943
	300 sq mm PIAS (Conductor & Sheath)	52324	33093	23400	16546	13510	11700	10465
	185 sq mm PIAS (Conductor & Sheath)	32199	20365	14400	10182	8314	7200	6440
	95mm sq mm PIAS (Conductor & Sheath)	16547	10465	7400	5233	4272	3700	3309
	35 sq mm Cu Triplex Cable	10018	6336	4480	3168	2587	2240	2004
	25 sq mm Cu Triplex Cable	7155	4525	3200	2263	1848	1600	1431

Short Circuit Ratings for 11kV cables



SCHEDULE OF TECHNICAL PARTICULARS

CABLE

SUB-SECTION

New Cables

Single Core 33kV XLPE insulated Copper Wire Screened, Stranded Copper Conductors. 2.3.1

Superseded Cables

Single Core 19/33kV Paper Insulated, Lead Covered Solid Cables, Stranded Aluminium Conductor. 2.3.2

Single Core 19/33kV Paper Insulated, Lead Covered Solid Cables, Stranded Copper Conductor. 2.3.3

Single Core 19/33kV Paper Insulated, Lead Covered Solid Cables, Stranded Copper Conductor (with shaped conductors). 2.3.4

Three Core 19/33kV Paper Insulated, Corrugated Aluminium Sheath, Oil Filled Cables, Copper & Aluminium Conductors. 2.3.5

Three Core, 33kV, Mass Impregnated, Screened, Shaped or Oval Conductors, Armoured Cable. 2.3.6

Three Core, 33kV, Mass Impregnated, Screened, Shaped or Oval Conductors, Armoured Cable 2.3.7

Three Core 33kV Mass Impregnated, Screened S.L. Circular Conductor, Cable. *(This information is missing at present)*. 2.3.8

Three Core 33kV Mass Impregnated, Screened S.L. Circular Conductor, Cable. 2.3.9

Three Core, 33kV, Compacted Oval Conductor, Corrugated Aluminium Sheath, Oil Filled Cable. 2.3.10

Three Core, 33kV, Compacted Circular Conductor, Lead Alloy Sheathed, Oil Filled Cable. 2.3.11

Three Core, 33kV, |Compacted Oval Conductor, Lead Alloy Sheathed, Oil Filled Cable. 2.3.12

STANDARD CABLES

33kV CABLES

All 33kV cables shall be as detailed in the appropriate section and schedule and the Transmission Planning Manual.

Cables shall be installed as detailed in this Code of Practice Section 3 – Technical Requirements for Cable Laying.

Single Core (Solid) X.L.P.E. Insulated

33kV Network Extensions and Alterations

Stranded copper conductors, cross-linked polyethylene (XLPE) extruded insulation, longitudinal moisture sealing (LW), medium density polyethylene (MDPE) sheathed overall, single core 33kV, generally to specification BS6622: 1999.

Two sizes will be used: -

Size	Use
150mm ² Stranded Copper 1 core	24 MVA 33kV Circuits
400mm ² Stranded Copper 1 core	40 MVA 33kV Circuits

33kV Transformer Tails.

Stranded copper conductors, cross-linked polyethylene (XLPE) extruded insulation, longitudinal moisture sealing (LW), medium density polyethylene (MDPE) sheathed overall, single core 33kV, generally to specification BS6622: 1999.

Three sizes will be used: -

Size	Use
150mm ² Stranded Copper 1 core	12/24 MVA 33kV Transformer Tails (1 per ph)
400mm ² Stranded Copper 1 core	20/40 MVA 33kV Transformer Tails (1 per ph)
500mm ² Stranded Copper 1 core <i>(These will be to special order)</i>	90/117 MVA 33kV Transformer Tails (2 per ph)

Single Core 33kV X.L.P.E. Insulated, Copper Wire Screened Solid Cables, Stranded Copper Conductors, Generally to BS 7870 4-10:1999.

	Nominal Area of Conductor	mm ²	150	240	300	400	500
1	Conductor material		Stranded Copper				
	Nominal conductor diameter	mm	14.8	19.0	21.3	24.4	27.4
2	Approximate thickness of conductor screen	mm	0.7	0.7	0.7	0.7	0.7
3	Minimum average thickness of insulation	mm	8.0	8.0	8.0	8.0	8.0
4	Minimum thickness of insulation at any point	mm	7.1	7.1	7.1	7.1	7.1
5	Approximate thickness of insulation screen	mm	1.0	1.0	1.0	1.0	1.0
6	Approximate thickness of semi-conducting tape (where applied)	mm	0.3	0.3	0.3	0.3	0.3
7	Copper wire screen	mm ²	35	35	35	35	35
	Screen area						
	Nominal wire diameter	mm	1.04	1.04	1.04	1.04	1.04
	Number of wires		42	42	42	42	42
	Maximum conductor resistance	Ω/km	0.542	0.542	0.542	0.542	0.542
8	Approximate thickness of binder tape (where applied)	mm	0.2	0.2	0.2	0.2	0.2
9	Minimum average thickness of oversheath	mm	2.2	2.3	2.4	2.5	2.6
10	Minimum thickness of oversheath at any point	mm	1.77	1.85	1.94	2.02	2.11
11	Approximate overall diameter of finished cable (D)	mm	43.0	47.5	50.0	53.3	56.5
12	Approximate weight per metre of finished cable	kg	2.7	3.7	4.3	5.2	6.3
13	Maximum DC resistance of conductor at 20°C	Ω/km	0.124	0.0754	0.0601	0.0470	0.0366
14	AC resistance of conductor at 90°C						
	In trefoil formation	Ω/km	0.1589	0.0976	0.0785	0.0624	0.0500
	Flat with 2D between cable centres	Ω/km	0.1587	0.0971	0.0779	0.0616	0.0488
15	Reactance of cable at 50Hz						
	In trefoil formation	Ω/km	0.128	0.118	0.114	0.110	0.106
	Flat with 2D between cable centres	Ω/km	0.186	0.176	0.172	0.168	0.164
16	Capacitance of cable per km	µF	0.20	0.24	0.26	0.29	0.31
	Minimum installation radius						
	During pulling in	mm	900	950	1000	1100	1200
	Adjacent to joints and terminations	mm	650	750	750	800	850
17	Nominal internal diameter of ducts	mm	100	100	100	100	100
18	Maximum short circuit conductor temperature	°C	250	250	250	250	250
19	Maximum continuous conductor temperature	°C	90	90	90	90	90

	Nominal Area of Conductor	mm²	150	240	300	400	500
20	Maximum continuous current carrying capacity: Laid direct, ground temperature 15 ⁰ C, g = 1.2Km/W, depth 0.8m						
	(a) In trefoil						
	- solidly bonded	A	405	528	594	672	758
	- single pt. bonded	A	409	536	604	687	778
	(b) Flat with 2D between centres						
	- solidly bonded	A	412	527	586	655	729
	- single pt. bonded	A	431	567	640	732	836
	Drawn into ducts, ground temperature 15 ⁰ C, g = 1.2Km/W, depth 0.8m						
	(a) In trefoil						
	- solidly bonded	A	392	500	557	625	698
	- single pt. bonded	A	415	544	614	700	796
	(b) Flat with ducts touching						
- solidly bonded	A	385	490	544	608	676	
- single pt. bonded	A	411	538	606	691	784	
Laid in air at 25 ⁰ C trefoil formation							
- solidly bonded	A	489	657	750	865	994	
- single pt. bonded	A	493	665	761	881	1016	
21	Short circuit rating*						
	- Copper wire screen (1 sec)**	kA	4.5	4.5	4.5	4.5	4.5
	- Conductor (1 sec)	kA	21.4	34.3	42.9	57.2	71.5

* Short circuit ratings are based on (i) an initial conductor temperature of 90°C and a final temperature of 250°C and (ii) an initial screen temperature of 80°C and a final temperature of 200°C.

** Copper wire screen short circuit rating is based on a through fault.

CAUTIONARY NOTE: The conductor temperatures and associated current ratings quoted in items 21.1 and 21.2, do not make any allowance for the possibility of “drying-out” of the surrounding soil

‡Cyclic ratings taken as 114% x continuous ratings

19000/33000 Volt Single Core, Paper Insulated, Lead Covered Solid Cables, Stranded Conductor to BS6480 Part 1 (Table 26)

Nominal area of Conductor		mm²	300	800
1	Conductor Material Shape of Conductor		Aluminium Circular	
2.	Minimum thickness of insulation between conductor and screen	mm	6.8	6.8
3.	Type of screen		metalised paper or non ferrous metal tape	
4.	Nominal thickness of sheath	mm	1.8	2.2
5.	Nominal diameter oversheath	mm	41.7	57.4
6.	Sheath material		Lead Alloy	
7.	Radial thickness of extruded PVC oversheath	mm	1.7	2.0
8.	Nominal external diameter of completed cable	mm	45.4	61.8
9.	Nominal weight per metre of completed cable	kg	5.3	8.9
10.	Minimum radius of bend round which cable can be laid	mm	960	1300
11.	Nominal internal diameter of ducts	mm	100	100
12.	Maximum d.c resistance of conductor per metre of cable at 20°C	μΩ	97.6	36.7
13.	*Maximum a.c resistance of conductor per metre of cable at maximum temperature (65°C)	μΩ	116.5	47.0
14.	*Equivalent star reactance per metre of cable at 50 Hz.	μΩ	106	91.5
15.	Maximum capacitance per metre of cable	pF	470	700
16.	Maximum charging current per conductor per metre of cable at nominal voltage and frequency.	mA	2.82	4.20
17.	*φ Maximum continuous current capacity per conductor			
	(a) Laid direct, ground temperature 15°C & g = 1.2°C m/a	A	395	650
	(b) Drawn into ducts, ground temperature 15°C & g = 1.2°C m/a	A	320	495
	(c) Laid in air	A	465	830
18.	Maximum conductor temperature			
	(a) Laid Direct in ground	°C	65	65
	(b) Drawn into ducts	°C	50	50
	(c) Laid in air	°C	65	65
19.	Maximum dielectric loss per metre of three-phase circuit when laid direct in ground at normal working voltage and frequency and at maximum conductor temperature	W	1.60	2.38
20.	(1) Mass-impregnated non-draining			
	(a) At 9.5kv		0.005	0.005
	(b) Maximum difference in power factor between 9.5kv and 24kv		0.003	0.003
	24kv and 38kv		0.006	0.006
21.	Sheath loss per metre of 3 phase circuit at normal frequency and at maximum current rating			
	(a) Laid direct in ground	W	1.2	5.0
	(b) Drawn into ducts	W	4.1	11.0
	(c) Laid in air	W	1.6	8.3

* Cables laid in trefoil formation - φ Cable sheaths solid bonded

19000/33000 Volt Single Core, Paper Insulated, Lead Covered Solid Cables, Stranded Conductor to BS6480 Part 1 (Table 26)

Nominal area of Conductor		mm ²	185	400	500	630
1.	Conductor Material Shape of Conductor		Copper Circular			
2.	Minimum thickness of insulation between conductor and screen	mm	1.7	1.9	6.8	6.8
3.	Type of screen		metalised paper or non ferrous metal tape			
4.	Nominal thickness of sheath	mm	36.4	44.8	2.0	2.1
5.	Nominal diameter oversheath	mm	6.8	6.8	48.4	53.0
6.	Sheath material		Lead Alloy			
7.	Radial thickness of extruded PVC oversheath	mm	1.5	1.8	1.8	1.9
8.	Nominal external diameter of completed cable	mm	39.7	48.8	52.8	57.1
9.	Nominal weight per metre of completed cable	kg	4.8	8.5	9.7	12.0
10.	Minimum radius of bend round which cable can be laid	mm	840	1030	1200	1200
11.	Nominal internal diameter of ducts	mm	100	100	100	100
12.	Maximum d.c resistance of conductor per metre of cable at 20°C	µΩ	97.2	46.1	36.6	28.3
13.	*Maximum a.c resistance of conductor per metre of cable at maximum temperature (65°C)	µΩ	115.5	56.9	46.4	37.6
14.	*Equivalent star reactance per metre of cable at 50 Hz.	µΩ	114	103.5	97.5	97.0
15.	Maximum capacitance per metre of cable	pF	385	520	520	630
16.	Maximum charging current per conductor per metre of cable at nominal voltage and frequency.	mA	2.31	3.12	3.42	3.78
17.	*φ Maximum continuous current capacity per conductor					
	(a) Laid direct, ground temperature 15°C & g = 1.2°C m/a	A	385	570	670	710
	(b) Drawn into ducts, ground temperature 15°C & g = 1.2°C m/a	A	315	445	490	540
	(c) Laid in air	A	440	690	780	890
18.	Maximum conductor temperature					
	(a) Laid Direct in ground	°C	65	65	65	65
	(b) Drawn into ducts	°C	50	50	50	50
	(c) Laid in air	°C	65	65	65	65
19.	Maximum dielectric loss per metre of three-phase circuit when laid direct in ground at normal working voltage and frequency and at maximum conductor temperature	W	1.31	1.77	1.77	2.15
20.	(1) Mass-impregnated non-draining					
	(a) At 9.5kv		0.005	0.005	0.005	0.004
	(b) Maximum difference in power factor between 9.5kv and 24kv		0.003	0.003	0.005	0.005
	24kv and 38kv		0.006	0.006	0.006	0.001
21.	Sheath loss per metre of 3 phase circuit at normal frequency and at maximum current rating					
	(a) Laid direct in ground	W	0.0	2.7	2.7	5.3
	(b) Drawn into ducts	W	3.8	8.2	8.2	12.8
	(c) Laid in air	W	1.2	4.1	4.1	8.5

* Cables laid in trefoil formation - φ Cable sheaths solid bonded

19000/33000 Volt Three Core, Paper Insulated, Lead Covered Solid Cables Stranded Conductors to BS6480 Part 1 (Table 27)

Nominal area of conductor		mm ²	185	300
1	Conductor Material Shape of Conductor		Copper Shaped	
2	Minimum thickness of insulation between conductor and screen	mm	6.8	6.8
3	Type of screen round individual cores		Metalised Paper or non-ferrous metal tape	
4	Nominal thickness of sheath	mm	2.7	2.9
5	Nominal diameter over sheath	mm	70.3	79.6
6	Sheath material		Lead, Alloy E, Alloy B	
7	Armour Approximate number and diameter of armour wires	No/mm	67/3.15	75/3.15
8	Nominal external diameter of completed cable Type P ₂ B WH ₂	mm	83.6	92.9
9	Nominal weight per metre of completed cable Type P ₂ B WH ₂	kg	21	21.5
10	Minimum radius of bend round which cable can be laid	mm	1510	1670
11	Nominal internal diameter of ducts	mm	150	150
12	Maximum d.c. resistance of conductor per meter of cable at 20°C	μΩ	99.1	100
13	*Maximum a.c. resistance of conductor per metre of cable at maximum conductor temperature	μΩ	117.7	120
14	*Equivalent star reactance per metre of cable at 50 Hz	μΩ	110	94
15	Maximum capacitance per metre of cable	pF	395	480
16	Maximum changing current per conductor per metre of cable at normal voltage and frequency	mA	2.37	2.88
17	*ΦMaximum continuous current carrying capacity per conductor			
	(a) Laid direct, ground temp. 15°C and g = 1.2°C m/W	A	360	370
	(b) Drawn into ducts, ground temperature 15°C and g = 1.2°C m/W	A	315	325
	(c) Laid in air, ambient temperature 25°C	A	385	405
18	Maximum conductor temperature			
	(a) Laid direct in ground	°C	65	65
	(b) Drawn into ducts	°C	65	65
	(c) Laid in air	°C	65	65
19	Maximum dielectric loss per metre of three-phase circuit when laid direct in ground at normal working voltage and frequency and at maximum conductor temperature	W	1.77	2.15
20	(1) Mass-impregnated non-draining			
	(a) at 9.5kV		0.005	0.004
	(b) Maximum difference in power factor between 9.5kV and 24kV		0.005	0.005
	24kV and 38kV.		0.006	0.001
21	Sheath loss per metre of 3 phase circuit at normal frequency and at maximum current rating			
	(a) Laid direct in ground	W	2.7	5.3
	(b) Drawn into ducts	W	8.2	12.8
	(c) Laid in air	W	4.1	8.5

*Cables laid in trefoil arrangement - ΦCable sheaths solidly bonded

19000/33000 Volt Three Core, Paper Insulated, Corrugated Aluminium Sheathed Oil Filled Cables, Stranded Conductors to EATS 09-3

	Sectional area of conductor	mm²	400	630
1	Minimum radial thickness of insulation between conductor screen and dielectric screen	mm	3.3	3.3
	Conductor Material		Cu	Al
2	Impregnant		Low Viscosity Oil	
	2.1 Type			
	2.2 Viscosity at: 20°C	cP	13	
	50°C	cP	5	
	90°C	cP	2	
3	Minimum radial thickness of aluminium sheath	mm	1.3	1.5
4	Nominal diameter over aluminium sheath	mm	73	85
5	Minimum average thickness of extruded PVC oversheath (Qx)	mm	3.3	3.6
6	Nominal overall diameter of completed cable	mm	81	95
7	Nominal weight per metre of completed cable:			
	7.1 Copper Conductors	Kg	15.5	
	7.2 Aluminium Conductors	Kg		1.0
8	Maximum a.c resistance of conductor per metre of cable at 90°C			
	8.1 Copper conductors	μΩ	63	
	8.2 Aluminium conductors	μΩ		64
9	Equivalent star reactance per metre of three-phase circuit at 50Hz		79	75
10	Nominal electrostatic capacitance per core per metre of cable	pF	840	1050
11	Nominal charging current per conductor per metre of cable as nominal voltage	mA	5.0	6.3
12.	Nominal dielectric loss of cable per m of three-phase circuitry when laid direct in the ground at nominal voltage, normal frequency and operating oil pressure at maximum conductor temperature	W	0.69	0.86
13	Maximum continuous current-carrying capacity per conductor when laid direct in the ground with 0.9m to top of cable at a ground temperature of 15° c, 'g' = 1.2° c m/W (Assumed maximum conductor temperature 90° C).			
	13.1 One circuit			
	Copper conductors	A	600	
	Aluminium conductors	A		610
	13.2 Two circuits HORIZONTAL at 0.45m centres			
	Copper conductors	A	530	
	Aluminium conductors	A		530
14.	Maximum continuous current-carrying capacity per conductor when drawn into pipe in the ground with 0.9m to top of pipe at a ground temperature of 15°C, 'g' = 1.2°C m/w (Assumed maximum conductor temperature 90°C)			
	14.1 One circuit			
	Copper conductors	A	530	
	Aluminium conductors	A		545
	14.2. Two circuits HORIZONTAL at 0.45m centres			
	Copper conductors	A	480	
	Aluminium conductors	A		485
15.	Maximum continuous current-carrying capacity per conductor when laid on racks in air at ambient temperature of 25°C (Assumed maximum conductor temperature 90°C)			
	15.1 One three-phase circuit			
	Copper conductors	A	735	
	Aluminium conductors	A		775

	Sectional area of conductor	mm²	400	630
16.	Sheath loss of cable per metre of three-phase circuit at nominal voltage, normal frequency and operating oil pressure at maximum current rating:			
	16.1 Laid direct in the ground with current per conductor as stated in item 13.1			
	Copper conductors	W	7.9	
	Aluminium conductors	W		10.1
	16.2 Drawn into duct cluster with current per conductor as stated in item 14.1			
	Copper conductors	W	6.2	11.7
	Aluminium conductors	W	4.0	8.0
	16.3 Laid in racks in air with current per conductor as stated in item 15			
	Copper conductors	W	11.9	24.0
	Aluminium conductors	W	7.6	
17.	Sheath short-circuit current-carrying capacity for one second, cable fully loaded before short-circuit maximum sheath temperature 250°C	kA	29.0	39.5
18.	Minimum radius of bend round which cable can be laid:			
	18.1 Laid direct or in air	m	1.6	1.9
	18.2 in ducts	m	2.4	2.9
	18.3 With cable placed in position adjacent to joints and terminals			
	(i) Without former	m	1.2	1.5
	(ii) With former	m	1.0	1.2
19.	Nominal internal diameter of pipes or ducts	mm	125	150
20	Oil content per metre	Litres	1.59	2.06

33kV Mass Impregnated 3-Core Screened, Shaped or Oval Conductors, Armoured
Cable to B.S.480, Part 1; 1954 (Table 15)

1	Sectional area of Conductor	sq.in	0.10	0.15	0.20	0.25	0.30	0.40	0.50
2	Minimum thickness of insulation between conductor and screen	in	0.315	0.300	0.300	0.280	0.280	0.280	0.280
3	Type of screen		Metal Tape or Metallised Paper						
4	Minimum thickness of sheath	in	0.11	0.12	0.12	0.12	0.13	0.14	0.14
5	Nominal diameter over sheath	in	2.47	2.58	2.72	2.75	2.90	3.12	3.28
6	Sheath material (as specified in B.S.801)		Lead, Alloy, "E", Alloy "B"						
7	Approximate number and diameter of armour wires	No/in	60/.128	62/.128	65/.128	66/.128	66/.128	74/.128	77/.128
8	Nominal external diameter of cable								
	(a) P ₂ CHWH ₂ Finish	in	3.09	3.20	3.34	3.37	3.52	3.74	3.90
	(b) CHW (FR) Finish	in	2.85	2.96	3.10	3.13	3.28	3.50	3.66
9	Nominal weight per yard of cable								
	(a) P ₂ CHWH ₂ Finish	lbs	33.5	38.0	41.5	44.0	49.5	58.0	64.0
	(b) CHW (FR) Finish	lbs	33.0	37.0	41.0	43.5	48.5	57.0	63.0
10	Minimum radius of bend round which cable can be laid								
	(a) Direct or in air	mm	1600	1600	1750	1750	1825	1900	1975
	(b) In ducts	mm	2350	2430	2600	2600	2660	2900	2970
11	Nominal internal diameter of pipes or ducts	mm	125	125	125	125	150	150	150
12	Maximum D.C resistance of conductor per 1,000 yards of cable at 20°C	Ω	0.2519	0.1721	0.1295	0.1031	0.08408	0.06256	0.05404
13	Approximate A.C resistance of conductor per 1,000 yards of cable at 60°C	Ω	0.30	0.20	0.15	0.12	0.10	0.075	0.062
14	Reactance per core per 1,000 yards of three-phase circuit at 50 cycles	Ω	0.113	0.104	0.100	0.096	0.092	0.088	0.086
15	Maximum electrostatic capacitance per core per 1,000 yards of cable	μF	0.23	0.27	0.30	0.34	0.37	0.41	0.45
16	Maximum charging current per conductor per 1,000 yards of cable at normal voltage and frequency	A	1.38	1.62	1.80	2.01	2.22	2.46	2.70
17	Maximum continuous current carrying capacity per conductor when laid direct in the ground with 42in to top of cable ground temperature 15°C (50°F)								
	(a) One 3-phase circuit per trench	A	205	250	290	330	365	420	460
	g = 120°C /watt/cm – (b) Two 3-phase circuits per trench in horizontal formation and 18in centres	A	185	225	260	295	330	380	415
	(c) One 3-phase circuit per trench	A	220	270	315	360	400	465	510
	g = 90°C /watt/cm (d) Two 3-phase circuits per trench in horizontal formation and 18in centres	A	200	245	285	325	360	420	460

1	Sectional area of Conductor	sq.in	0.10	0.15	0.20	0.25	0.30	0.40	0.50
18	Maximum continuous current carrying capacity per conductor (a) When drawn into pipes or ducts, ground temperature 15°C and g = 120°C/watt/cm (b) When drawn into pipes or ducts, ground temperature 15°C and g = 90°C/watt/cm (c) When laid on racks in air at ambient temperature 25°C	A	180	225	260	205	325	380	420
		A	190	235	275	310	345	405	445
		A	215	265	315	360	410	485	540
19	Assumed maximum conductor temperature (a) Laid direct in the ground (b) Drawn into pipes or ducts (c) Laid on racks in air	°C	----- 65 ----->						
		°C	----- 65 ----->						
		°C	----- 65 ----->						
20	Maximum dielectric loss of three-phase circuit per 1,000 yards when laid direct in the ground at normal working voltage and frequency and at maximum conductor temperature (see item 17(a))	kW	0.48	0.56	0.62	0.70	0.76	0.84	0.92
21	Maximum power factor of charging KVA of cable at normal working voltage and frequency and a conductor temperature of:- (a) 15°C (b) 30°C (c) 40°C (d) 50°C (e) 60°C (f) 65°C		----- 0.0040 ----->						
			----- 0.0035 ----->						
			----- 0.0036 ----->						
			----- 0.0040 ----->						
			----- 0.0050 ----->						
			----- 0.0060 ----->						
22	Maximum power factor of charging KVA of cable at normal frequency and a conductor temperature of 15°C (a) 9.5 kV (b) 19.0 kV (c) 28.5 kV (d) 38.0 kV		----- 0.0038 ----->						
			----- 0.0040 ----->						
			----- 0.0042 ----->						
			----- 0.0044 ----->						
23	Calculated sheath loss of three-phase circuit per 1,000 yards at normal working voltage, frequency and at maximum current rating based on "g" = 120°C/watt/cm (a) Laid direct in the ground with current per conductor as specified in item 17(a) (b) Drawing into ducts with current per conductor as specified in item 18(a) (c) In air with current per conductor as specified in item 18(c)	kW	<0.5	<0.5	<0.5	0.6	0.9	1.4	1.8
		kW	<0.5	<0.5	<0.5	0.5	0.6	1.0	1.3
		kW	<0.5	<0.5	0.6	0.7	1.1	1.7	2.3

33KV Mass Impregnated 3-Core Screened, Shaped or Oval Conductors, Armoured Cable
(Table 15, B.S.480, Part 1, 1954)

1	Sectional area of Conductor	sq.in	0.10	0.15	0.20	0.25	0.30	0.40	0.50
2	Minimum thickness of insulation between conductor and screen	in	0.315	0.300	0.300	0.280	0.280	0.280	0.280
3	Type of screen		Metal Tape or Metallised Paper						
4	Minimum thickness of sheath	in	0.11	0.12	0.12	0.12	0.13	0.14	0.14
5	Nominal diameter over sheath	in	2.47	2.58	2.72	2.75	2.90	3.12	3.28
6	Sheath material (as specified in B.S.801)		Lead, Alloy, "E", Alloy "B"						
7	Approximate number and diameter of armour wires	No/in	60/.128	62/.128	65/.128	66/.128	66/.128	74/.128	77/.128
8	Nominal external diameter of cable								
	(a) P ₂ CHWH ₂ Finish	in	3.09	3.20	3.34	3.37	3.52	3.74	3.90
	(b) CHW (FR) Finish	in	2.85	2.96	3.10	3.13	3.28	3.50	3.66
9	Nominal weight per yard of cable								
	(a) P ₂ CHWH ₂ Finish	lbs	33.5	38.0	41.5	44.0	49.5	57.5	63.5
	(b) CHW (FR) Finish	lbs	33.0	37.0	41.0	43.5	49.0	57.0	63.0
10	Minimum radius of bend round which cable can be laid								
	(a) Direct or in air	ft	5½	5½	5¾	5¾	6	6¼	6½
	(b) In ducts	ft	7¾	8	8½	8½	8¾	9½	9¾
11	Nominal internal diameter of pipes or ducts	in	5	5	5	5	6	6	6
12	Maximum D.C resistance of conductor per 1,000 yards of cable at 20°C	Ω	0.2519	0.1721	0.1295	0.1031	0.08408	0.06256	0.06101
13	Approximate A.C resistance of conductor per 1,000 yards of cable at 60°C	Ω	0.30	0.20	0.15	0.12	0.10	0.075	0.062
14	Reactance per core per 1,000 yards of three-phase circuit at 50 cycles	Ω	0.113	0.104	0.100	0.096	0.092	0.088	0.086
15	Maximum electrostatic capacitance per core per 1,000 yards of cable	μF	0.23	0.27	0.30	0.34	0.37	0.41	0.45
16	Maximum charging current per conductor per 1,000 yards of cable at normal voltage and frequency	A	1.38	1.62	1.80	2.04	2.22	2.46	2.70
17	Maximum continuous current carrying capacity per conductor when laid direct in the ground with 42in to top of cable ground temperature 15°C (50°F)								
	(a) One 3-phase circuit per trench	A	205	250	290	330	365	420	460
	(b) Two 3-phase circuits per trench in horizontal formation and 18in centres	A	185	225	260	295	330	380	415
	(c) One 3-phase circuit per trench	A	220	270	315	360	400	465	510
	(d) Two 3-phase circuits per trench in horizontal formation and 18in centres	A	200	245	285	325	360	420	460

1	Sectional area of Conductor	sq.in	0.10	0.15	0.20	0.25	0.30	0.40	0.50
18	Maximum continuous current carrying capacity per conductor (a) When drawn into pipes or ducts, ground temperature 15°C (59°F) and g=120°C/watt/cm (b) When drawn into pipes or ducts, ground temperature 15°C (59°F) and g=90°C/watt/cm (c) When laid on racks in air at ambient temperature 25°C (77°F)	A	180	225	260	205	325	380	420
		A	190	235	275	310	345	405	445
		A	215	265	315	360	410	485	540
19	Assumed maximum conductor temperature (a) Laid direct in the ground (b) Drawn into pipes or ducts (c) Laid on racks in air	°C	-----65----->						
		°C	-----65----->						
		°C	-----65----->						
20	Maximum dielectric loss of three-phase circuit per 1,000 yards when laid direct in the ground at normal working voltage and frequency and at maximum conductor temperature (see item 17(a))	kW	0.74	0.88	0.97	1.10	1.20	1.33	1.46
21	Maximum power factor of charging KVA of cable at normal working voltage and frequency and a conductor temperature of (a) 15°C (b) 30°C (c) 40°C (d) 50°C (e) 60°C (f) 65°C		-----0.0070----->						
			-----0.0045----->						
			-----0.0045----->						
			-----0.0060----->						
			-----0.0080----->						
			-----0.0095----->						
22	Maximum power factor of charging KVA of cable at normal frequency and a conductor temperature of 15°C (a) 9.5 kV (b) 19.0 kV (c) 28.5 kV (d) 38.0 kV		-----0.0070----->						
			-----0.0070----->						
			-----0.0072----->						
			-----0.0075----->						
23	Calculated sheath loss of three-phase circuit per 1,000 yards at normal working voltage, frequency and at maximum current rating based on "g" = 120°C/watt/cm (a) Laid direct in the ground with current per conductor as specified in item 17(a) (b) Drawing into ducts with current per conductor as specified in item 18(a) (c) In air with current per conductor as specified in item 18(c)	kW	<0.5	<0.5	<0.5	0.6	0.9	1.4	1.8
		kW	<0.5	<0.5	<0.5	0.5	0.6	1.0	1.3
		kW	<0.5	<0.5	0.6	0.7	1.1	1.7	2.3

**33KV Mass Impregnated 3-Core Screened, S.L. Circular Conductors
B.S.480, Part 1, 1954 (Table 15)**

1	Sectional area of Conductor	sq.in	0.10	0.15	0.20	0.25	0.30	0.40	0.50
2	Diameter of conductor	in	0.305	0.480	0.530	0.620	0.085	0.789	0.875
3	Minimum thickness of insulation between conductor and screen	in	0.315	0.300	0.300	0.280	0.280	0.280	0.280
4	Type of screen		Metal Tape or Metallised Paper						
5	Minimum thickness of sheath	in	0.07	0.07	0.07	0.07	0.08	0.08	0.09
6	Nominal diameter over sheath	in	1.23	1.28	1.35	1.38	1.47	1.57	1.68
7	Sheath material (as specified in B.S 801)		Lead, Alloy "E" Alloy "B"						
8	Approximate number and diameter of armour wires	No/in	65/.128	68/.128	71/.128	72/.128	76/.128	81/.128	86/.128
9	Nominal external diameter of cable								
	(a) PCH ₂ WH ₂ Finish	in	3.38	3.49	3.64	3.70	3.90	4.11	4.35
10	Nominal weight per yard of cable								
	(a) PCH ₂ WH ₂ Finish	lbs	37.0	40.5	44.5	47.5	54.0	62.0	71.0
11	Minimum radius of bend round which cable can be laid								
	(a) Direct or in air	mm	1676	1676	1753	1753	1830	1910	1990
	(b) In ducts	mm	2370	2450	2600	2600	2700	2900	2900
12	Nominal internal diameter of pipes or ducts	mm	125	150	150	150	150	150	150
13	Maximum D.C resistance of conductor per 1,000 yards of cable at 20°C	Ω	0.2519	0.1721	0.1205	0.1031	0.08408	0.06256	0.05101
14	Approximate A.C resistance of conductor per 1,000 yards of cable at 60°C	Ω	0.30	0.20	0.15	0.12	0.10	0.075	0.062
15	Reactance per core per 1,000 yards of three-phase circuit at 50 cycles	Ω	0.127	0.117	0.112	0.106	0.103	0.099	0.096
16	Maximum electrostatic capacitance per core per 1,000 yards of cable	μF	0.22	0.26	0.28	0.32	0.35	0.39	0.43
17	Maximum charging current per conductor per 1,000 yards of cable at normal voltage and frequency	A	1.32	1.56	1.68	1.92	2.10	2.34	2.58
18	Maximum continuous current carrying capacity per conductor when laid direct in the ground with 1070mm to top of cable ground temperature 15°C.								
	g=120°C C/watt/cm								
	(a) One 3-phase circuit per trench	A	210	250	295	330	370	425	465
	(b) Two 3-phase circuits per trench in horizontal formation and 18in centres	A	190	225	265	295	335	380	420
	g=90°C C/watt/cm								
	(c) One 3-phase circuit per trench	A	230	270	320	360	405	470	210
	(d) Two 3-phase circuits per trench in horizontal formation and 18in centres	A	205	245	290	325	365	425	470

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.9**

1	Sectional area of Conductor	sq.in	0.10	0.15	0.20	0.25	0.30	0.40	0.50
19	Maximum continuous current carrying capacity per conductor (a) When drawn into pipes or ducts, ground temperature 15°C and g=120°C/watt/cm (b) When drawn into pipes or ducts, ground temperature 15°C and g=90°C/watt/cm (c) When laid on racks in air at ambient temperature 25°C	A A A	185 195 225	225 235 275	265 280 325	295 315 375	330 350 420	375 405 500	415 445 550
20	Assumed maximum conductor temperature (a) Laid direct in the ground (b) Drawn into pipes or ducts (c) Laid on racks in air	°C °C °C	<-----65----->						
21	Maximum dielectric loss of three-phase circuit per 1,000 yards when laid direct in the ground at normal working voltage and frequency and at maximum conductor temperature (see item 18(a))	kW	0.46	0.53	0.58	0.66	0.72	0.80	0.80
22	Maximum power factor of charging KVA of cable at normal working voltage and frequency and a conductor temperature of:- (a) 15°C (b) 30°C (c) 40°C (d) 50°C (e) 60°C (f) 65°C		<-----0.0040-----> <-----0.0035-----> <-----0.0036-----> <-----0.0040-----> <-----0.0050-----> <-----0.0060----->						
23	Maximum power factor of charging KVA of cable at normal frequency and a conductor temperature of 15°C (a) 9.5 kV (b) 19.0 kV (c) 28.5 kV (d) 38.0 kV		<-----0.0038-----> <-----0.0040-----> <-----0.0044-----> <-----0.0048----->						
24	Calculated sheath loss of three-phase circuit per 1,000 yards at normal working voltage, frequency and at maximum current rating based on "g" = 120°C/watt/cm (a) Laid direct in the ground with current per conductor as specified in item 17(a) (b) Drawing into ducts with current per conductor as specified in item 18(a) (c) In air with current per conductor as specified in item 18(c)	kW kW kW	<0.5 <0.5 <0.5	<0.5 <0.5 0.5	0.6 <0.5 0.7	0.7 0.5 0.9	1.1 0.8 1.4	1.5 1.1 2.1	2.2 1.5 3.1

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.10**

3-Core Compacted Oval Conductor Corrugated Aluminium Sheathed 33 kV Oil Filled Cable (BEBS C4: 1966)

	Sectional area of conductor	sq.in	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60
1	Minimum radial thickness of insulation between conductor and screen	in	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
2	Type of impregnant		<-----Low Viscosity Mineral Oil----->								
	Viscosity 20°C	Centipoise	<-----13----->								
	Viscosity 50°C	Centipoise	<-----5----->								
	Viscosity 85°C	Centipoise	<-----2----->								
3	Minimum radial thickness of aluminium sheath	in	0.043	0.046	0.046	0.049	0.049	0.052	0.052	0.055	0.055
4	Nominal diameter over aluminium sheath	in	1.97	2.13	2.26	2.38	2.49	2.59	2.65	2.76	2.88
5	Nominal composition of aluminium sheath		Material VIB as specified in B.S 1474 or SIB as specified in B.S 1470								
6	Reinforcement		<-----None----->								
7	Protective outer coverings										
	7.1 Minimum average thickness Extruded PVC(Q)	in	0.11	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13
8	Nominal overall diameter of completed cable										
	8.1 Extruded PVC (Q)	in	2.23	2.42	2.55	2.67	2.78	2.90	2.96	3.07	3.19
9	Nominal weight per yard of completed cable										
	9.1 Copper conductors	lb	12	15	18	20	22	25	27	29	32
	9.2 Aluminium conductors	lb	8	9	10	11	12	13	14	15	16
10	Maximum D.C resistance of conductor per 1,000 yards of cable at 20°C (68°F)										
	10.1 Copper conductors	Ω	0.1295	0.1031	0.08407	0.0711	0.06256	0.05633	0.05101	0.04684	0.04194
	10.2 Aluminium conductors	Ω	0.2123	0.1691	0.1377	0.1166	0.1025	0.09234	0.08360	0.07679	0.06876
11	Maximum A.C resistance of conductor per 1,000 yards of cable at 85°C (185°F)										
	11.1 Copper conductors	lb	0.163	0.131	0.107	0.091	0.081	0.073	0.067	0.062	0.056
	11.2 Aluminium conductors	lb	0.27	0.125	0.175	0.15	0.135	0.12	0.11	0.10	0.09
12	Equivalent star reactance per 1,000 yards of three-phase circuit at 50 cycles/sec	Ω	0.079	0.077	0.075	0.073	0.072	0.071	0.070	0.069	0.068
13	Maximum electrostatic capacitance per core per 1,00 yards of cable	μF	0.46	0.50	0.55	0.58	0.62	0.65	0.68	0.71	0.74
14	Maximum charging current per conductor per 1,000 yards of cable at nominal voltage	A	2.8	3.0	3.3	3.5	3.7	3.9	4.1	4.3	4.4

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.10**

	Sectional area of conductor	sq.in	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60
15	Maximum power factor of charging KVA of cable when laid direct in the ground at nominal voltage, normal frequency and operating oil pressure, at a conductor temperature of 20°C 30°C 45°C 65°C 85°C		<div style="display: flex; justify-content: space-between;"> <-----0.0028-----> </div> <div style="display: flex; justify-content: space-between;"> <-----0.0026-----> </div> <div style="display: flex; justify-content: space-between;"> <-----0.0025-----> </div> <div style="display: flex; justify-content: space-between;"> <-----0.0023-----> </div> <div style="display: flex; justify-content: space-between;"> <-----0.0024-----> </div>								
16	Maximum dielectric loss of cable per 1,000 yards of three-phase circuit when laid direct in the ground at nominal voltage, normal frequency and operating oil pressure at maximum conductor temperature	kW	0.38	0.41	0.45	0.48	0.51	0.53	0.56	0.58	0.61
17	Maximum power factor of charging KVA of cable at normal frequency and operating oil pressure at a conductor temperature of 20°C 50 per cent, nominal voltage Nominal voltage 150 per cent, nominal voltage 200 per cent, nominal voltage		<div style="display: flex; justify-content: space-between;"> <-----0.0028-----> </div> <div style="display: flex; justify-content: space-between;"> <-----0.0028-----> </div> <div style="display: flex; justify-content: space-between;"> <-----0.0031-----> </div> <div style="display: flex; justify-content: space-between;"> <-----0.0034-----> </div>								
18	Maximum change in power factor between nominal voltage and 200 per cent, nominal voltage at 20°C		<div style="display: flex; justify-content: space-between;"> <-----0.0006-----> </div>								
19	Maximum continuous current carrying capacity per conductor when laid direct in the ground with 42 in to top of uppermost cable at a ground temperature of 15°C g = 120°C cm/watt one circuit										
	Cu conductors	A	340	390	430	470	495	525	550	575	600
	Al conductors	A	270	310	340	370	390	415	435	435	475
	Two circuits horizontal at 18 in centres										
	Cu conductors	A	300	345	375	410	430	460	480	500	520
	Al conductors	A	235	270	295	325	340	365	380	395	410
	Three circuits horizontal at 18 in centres										
	Cu conductors	A	275	310	340	370	390	410	430	445	465
	Al conductors	A	215	245	265	290	305	325	340	350	370

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.10**

	Sectional area of conductor	sq.in	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60
	Three circuits tier at 18 in centres										
	Cu conductors	A	260	295	320	355	370	390	410	425	445
	Al conductors	A	205	235	255	280	290	310	325	355	350
	Four circuits horizontal at 18 in centres										
	Cu conductors	A	260	295	320	355	365	390	405	420	440
	Al conductors	A	205	235	255	280	290	310	320	335	350
	four circuits tier at 18 in centres										
	Cu conductors	A	245	275	300	330	345	365	380	395	410
	Al conductors	A	190	220	235	260	270	290	300	310	325
	g = 90°C cm/watt										
	One circuit										
	Cu conductors	A	380	435	475	520	550	580	610	645	670
	Al conductors	A	300	345	375	410	435	460	480	510	530
	Two circuits horizontal at 18 in centres										
	Cu conductors	A	340	385	420	460	480	505	535	565	585
	Al conductors	A	265	305	335	360	385	405	420	450	460
	Three circuits horizontal at 18 in centres										
	Cu conductors	A	310	350	380	415	435	455	485	510	525
	Al conductors	A	245	275	300	325	345	365	380	405	415
	Three circuits tier at 18 in centres										
	Cu conductors	A	295	335	360	395	415	435	460	490	500
	Al conductors	A	230	265	290	310	330	345	365	385	395
	Four circuits horizontal at 18 in centres										
	Cu conductors	A	290	330	360	395	415	435	460	485	495
	Al conductors	A	230	260	285	310	330	345	360	385	390
	Four circuits tier at 18 in centres										
	Cu conductors	A	275	310	340	370	390	410	430	455	465
	Al conductors	A	215	245	270	290	310	325	340	360	365
	Assumed maximum conductor temperature	°C	← 85 →								
20	Maximum continuous current carrying per conductor when drawn into pipes in the ground with 42 in to top of uppermost pipe at a ground temperature of 15°C										
	g = 120°C cm/watt										
	One circuit										
	Cu conductors	A	290	325	360	395	425	450	470	490	515
	Al conductors	A	230	255	285	310	335	355	370	390	410

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.10**

Sectional area of conductor	sq.in	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60
Two circuits horizontal at 18 in centres										
Cu conductors	A	265	295	325	355	380	400	420	440	460
Al conductors	A	210	235	255	280	300	320	330	345	360
Three circuits horizontal at 18 in centres										
Cu conductors	A	240	270	300	325	350	370	385	400	415
Al conductors	A	195	215	235	260	275	290	305	315	330
Three circuits tier at 18 in centres										
Cu conductors	A	230	260	285	310	335	335	365	380	400
Al conductors	A	185	205	225	245	265	280	290	300	315
Four circuits horizontal at 18 in centres										
Cu conductors	A	230	260	285	310	335	355	365	380	395
Al conductors	A	185	205	225	245	265	280	290	300	315
Four circuits tier at 18 in centres										
Cu conductors	A	220	245	265	290	315	330	340	355	370
Al conductors	A	175	190	210	230	250	265	270	280	295
g = 90°C cm/watt										
One circuit										
Cu conductors	A	310	350	385	425	455	485	510	530	555
Al conductors	A	245	275	305	335	360	385	405	420	440
Two circuits horizontal at 18 in centres										
Cu conductors	A	285	320	350	385	410	435	460	475	500
Al conductors	A	225	255	275	305	325	345	360	375	390
Three circuits horizontal at 18 in centres										
Cu conductors	A	265	295	325	360	385	405	425	440	460
Al conductors	A	210	235	255	280	305	320	335	350	360
Three circuit tier at 18 in centres										
Cu conductors	A	255	290	310	345	365	390	405	425	440
Al conductors	A	205	225	245	275	290	305	320	335	345
Four circuits horizontal at 18 in centres										
Cu conductors	A	255	290	310	345	365	385	405	420	440
Al conductors	A	205	225	245	275	290	305	320	335	345
Four circuits tier at 18 in centres										
Cu conductors	A	245	275	295	325	345	365	380	395	410
Al conductors	A	195	215	230	255	275	290	305	315	325
Assumed maximum temperature	°C	<-----85----->								

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.10**

	Sectional area of conductor	sq.in	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60
21	Maximum continuous current carrying capacity per conductor when laid on racks in air at ambient temperature of 25°C One three-phase circuit										
	Cu conductors	A	380	440	490	540	590	625	655	690	730
	Al conductors	A	300	350	390	430	465	495	515	545	575
	Assumed maximum conductor temperature	°C	←-----85-----→								
22	Sheath loss of cable per 1,000 yards of three-phase circuit at nominal voltage, normal frequency and operating oil pressure, at maximum current rating										
	Laid direct in the ground with current per conductor as stated on item 19.1.1										
	Cu conductors	kW	1.3	1.9	2.5	3.2	3.8	4.4	5.2	5.8	6.7
	Al conductors	kW	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.2
	Drawn into duct cluster with current per conductor as stated in item 20.1.1										
	Cu conductors	kW	1.0	1.3	1.8	2.2	2.7	3.3	3.7	4.2	5.0
	Al conductors	kW	0.6	0.8	1.1	1.4	1.7	2.1	2.3	2.6	3.1
	Laid on racks in air with current per conductor as stated in item 21.1										
	Cu conductors	kW	1.6	2.4	3.2	4.2	5.5	6.5	7.5	8.5	10.0
	Al conductors	kW	1.0	1.5	2.0	2.6	3.4	4.1	4.7	5.3	6.2
23	Sheath short circuit current carrying capacity for one second, cable fully loaded before short circuit, maximum sheath temperature 250°C	kA	16.3	18.7	19.9	22.3	23.2	25.6	26.3	28.7	30.0
24	Minimum radius of bend round which cable can be laid										
	24.1 Laid direct or in air	ft	3¾	4	4¼	4½	4¾	5	5	5.25	5.5
	24.2 In ducts	ft	5¾	6	6½	6¾	7	7.25	7.5	7.75	8
25	Nominal internal diameter of pipes or ducts	in	4	4	5	5	5	5	5	5	5

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.10**

	Sectional area of conductor	sq.in	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60
26	Oil pressure										
	26.1 Minimum operating pressure										
	Cable and joints		<-----2.5----->								
	Sealing ends		<-----2.5----->								
	Pressure tanks										
	1 Atmos	p.s.i.g	<-----2.5----->								
	1½ Atmos	p.s.i.g	<-----10.0----->								
	2 Atmos	p.s.i.g	<-----17.0----->								
	2¼ Atmos	p.s.i.g	<-----21.0----->								
	2½ Atmos	p.s.i.g	<-----25.0----->								
	3 Atmos	p.s.i.g	<-----32.0----->								
	26.2 Maximum operating pressure										
	Static conditions	p.s.i.g	<-----76----->								
	Cable and joints	p.s.i.g	<-----76----->								
	Sealing ends	p.s.i.g	<-----43----->								
	Pressure tanks										
	1 Atmos	p.s.i.g	<-----64----->								
	1½ Atmos	p.s.i.g	<-----76----->								
	2 Atmos	p.s.i.g	<-----76----->								
	2¼ Atmos	p.s.i.g	<-----76----->								
	2½ Atmos	p.s.i.g	<-----76----->								
	3 Atmos	p.s.i.g	<-----76----->								
	Transient conditions										
	Cable and joints	p.s.i.g	<-----115----->								
	Sealing ends	p.s.i.g	<-----115----->								
27	Oil content per unit length	Litre/km	855	955	1070	1160	1275	1295	1375	1500	1585

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.11**

Sectional Area of Conductor		sq in	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	
21	Three circuits Tier at 18 in centres											
	Cu conductors	A	300	340	375	410	430	455	480	500	525	
	A1 conductors	A	235	270	295	325	340	360	380	395	415	
	Four circuits Horizontal at 18 in centres											
	Cu conductors	A	300	340	375	410	430	455	480	495	525	
	A1 conductors	A	235	270	295	325	335	360	380	395	415	
	Four circuits Tier at 18 in centres											
	Cu conductors	A	280	320	345	385	400	425	450	465	490	
	A1 conductors	A	220	255	275	305	315	335	355	370	390	
	Assumed maximum conductor temperature	°C	← 85 →									
	Maximum continuous current carrying capacity per conductor when drawn into pipes in the ground with 42 in to top of uppermost pipe at a ground temperature of 15°C g = 120°C cm/watt											
	One circuit Φ											
	Cu conductors	A	300	340	380	415	440	470	490	510	540	
	A1 conductors	A	235	270	300	330	350	370	390	405	425	
	Two circuits Horizontal at 18 in centres											
	Cu conductors	A	270	310	340	370	395	420	440	455	480	
	A1 conductors	A	215	240	270	295	315	330	350	360	375	
	Three circuits Horizontal at 18 in centres											
	Cu conductors	A	250	285	310	340	360	385	400	415	440	
	A1 conductors	A	195	225	245	270	285	305	315	325	345	
	Three Circuits Tier at 18 in centres											
Cu conductors	A	240	270	300	325	345	365	380	395	420		
A1 conductors	A	190	215	240	260	275	290	300	315	330		
Four circuits Horizontal at 18 in centres												
Cu conductors	A	240	270	300	325	345	365	380	395	420		
A1 conductors	A	190	215	235	260	275	290	300	310	330		
Four circuits Tier at 18 in centres												
Cu conductors	A	230	255	280	305	325	345	360	370	395		
A1 conductors	A	180	200	225	245	255	270	285	295	305		

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.11**

	Sectional Area of Conductor	sq in	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60
	g = 90°C cm/watt										
	One circuit										
	Cu conductors	A	320	365	405	445	470	510	530	550	585
	A1 conductors	A	250	290	320	350	370	405	420	435	465
	Two circuits Horizontal at 18 in centres										
	Cu conductors	A	295	335	370	405	425	465	480	500	530
	A1 conductors	A	230	265	290	320	335	370	380	395	420
	Three circuits Horizontal at 18 in centres										
	Cu conductors	A	275	310	345	375	395	430	440	460	485
	A1 conductors	A	215	250	270	295	310	340	350	360	385
	Three Circuits Tier at 18 in centres										
	Cu conductors	A	265	300	330	360	380	410	420	440	465
	A1 conductors	A	210	240	260	285	300	325	335	350	370
	Four circuits Horizontal at 18 in centres										
	Cu conductors	A	265	300	330	360	380	410	420	440	460
	A1 conductors	A	210	240	260	285	295	325	335	350	370
	Four circuits Tier at 18 in centres										
	Cu conductors	A	250	285	310	340	360	390	400	415	440
	A1 conductors	A	195	230	245	270	280	310	320	330	350
	Assumed maximum conductor temperature	°C	← 85 →								
22	Maximum continuous current carrying capacity per conductor when laid on racks in air at ambient temperature of 25°C										
	One three-phase circuit δ										
	Cu conductors	A	390	450	510	570	610	655	690	730	780
	A1 conductors	A	310	355	405	450	480	520	545	575	615
	Assumed maximum conductor temperature	°C	← 85 →								
23	Sheath loss (including reinforcement) of cable per 1,000 yards of three-phase circuit at nominal voltage, normal frequency and operating oil pressure, at maximum current rating										
	Laid direct in the ground with current per conductor as stated in item *										
	Cu conductors	kW	0.4	0.5	0.7	0.9	1.2	1.4	1.5	1.8	2.1
	A1 conductors	kW	0.2	0.3	0.5	0.6	0.7	0.9	1.0	1.2	1.3

3-Core Compacted Oval Conductor Lead Alloy Sheathed 33kV Oil Filled Cable to BEBS-C4 1966

	SECTIONAL AREA OF CONDUCTOR	sq.in	0.20	0.25	0.30	0.35	0.40
1	Minimum radial thickness of insulation between conductor and screen	in	<-----0.13----->				
2	Type of impregnant Viscosity 20°C 50°C 85°C	Centipoise Centipoise Centipoise	<-----Low Viscosity Mineral Oil-----> <-----13-----> <-----5-----> <-----2----->				
3	Minimum radial thickness of lead alloy sheath	in	0.085	0.085	0.090	0.090	0.090
4	Nominal diameter over lead alloy sheath	in	1.78	1.91	2.05	2.16	2.24
5	Nominal composition of lead alloy sheath Alloy Tin Cadmium Antimony Lead	 per cent per cent per cent	<-----¼B or ½C-----> <-----0.2-----> <-----0.075-----> <-----0.55-----> <-----remainder remainder----->				
6	Reinforcement						
	6.1 Material		<-----1% Tin Bronze----->				
	6.2 0.10% proof stress	p.s.i	<-----52,000----->				
	6.3 Nominal thickness	mils	<-----4----->				
	6.4 Number of layers		<-----1----->				
	6.5 Maximum working stress	p.s.i	<-----26,000----->				
7	Protective outer coverings						
	7.1 Nominal thickness QR2QH2	in	0.20	0.20	0.20	0.20	0.20
	7.2 Minimum average thickness Extruded PVC (QX)	in	0.11	0.11	0.12	0.12	0.12
8	Nominal overall diameter of completed cable						
	8.1 QR2QH2	in	2.21	2.34	2.48	2.59	2.67
	8.2 Extruded PVC (QX)	in	2.05	2.18	2.35	2.46	2.54
9	Nominal weight per yard of completed cable						
	9.1 Copper conductors	lb	19	22	25	28	31
	9.2 Aluminium conductors	lb	14	16	17	19	21
10	Maximum D.C resistance of conductor per 1,000 yards of cable at 20°C (68°F)						
	10.1 Copper conductors	ohm	0.1295	0.1031	0.08407	0.0711	0.06256
	10.2 Aluminum conductors	ohm	0.2123	0.1691	0.1377	0.1166	0.1025

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.12**

11	Maximum A.C resistance of conductor per 1,000 yards of cable at 85°C (185°F) 11.1 Copper conductor 11.2 Aluminum conductors	ohm ohm	0.163 0.27	0.131 0.215	0.107 0.175	0.091 0.15	0.081 0.135
12	Equivalent star reactance per 1,000 yards of three-phase circuit at 50 cycles/sec	ohm	0.079	0.077	0.075	0.073	0.072
13	Maximum electrostatic capacitance per core per 1,000 yards of cable	mfd	0.1295	0.1031	0.08407	0.0711	0.06256
14	Maximum charging current per conductor per 1,000 yards of cable at nominal voltage	amp	2.8	3.0	3.3	3.5	3.7
15	Maximum power factor of charging KVA of cable when laid direct in the ground at nominal voltage, normal frequency and operating oil pressure, at a conductor temperature of 20°C 30°C 45°C 65°C 85°C		<-----0.0028-----> <-----0.0026-----> <-----0.0025-----> <-----0.0023-----> <-----0.0024----->				
16	Maximum dielectric loss of cable per 1,000 yards of three-phase circuit when laid direct in the ground at nominal voltage, normal frequency and operating oil pressure at maximum conductor temperature	kw	0.38	0.41	0.45	0.48	0.51
17	Maximum power factor of charging KVA of cable at normal frequency and operating oil pressure at a conductor temperature of 20°C (68°F) 50 per cent, nominal voltage Nominal voltage 150 per cent, nominal voltage 200 per cent, nominal voltage		<-----0.0028-----> <-----0.0028-----> <-----0.0031-----> <-----0.0034----->				
18	Maximum change in power factor between nominal voltage and 200 per cent, nominal voltage at 20°C		<-----0.0006----->				
19	Maximum continuous current carrying capacity per conductor when laid direct in the ground with 42 in to top of uppermost cable at a ground temperature of 15°C						

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.12**

19.1	g = 120°C cm/watt						
	19.1.1 One circuit						
	Cu conductors	amp	340	390	435	475	505
	A1 conductors	amp	270	310	345	375	400
	19.1.2 Two circuits Horizontal at 18 in centres						
	Cu conductors	amp	300	345	385	420	445
	A1 conductors	amp	240	270	305	330	350
	19.1.3 Three circuits Horizontal at 18 in centres						
	Cu conductors	amp	275	310	345	380	400
	A1 conductors	amp	215	245	275	300	315
	19.1.4 Three circuits Tier at 18 in centres						
	Cu conductors	amp	260	300	330	360	380
	A1 conductors	amp	205	235	260	285	300
	19.1.5 Four circuits Horizontal at 18 in centres						
	Cu conductors	amp	260	295	330	360	380
	A1 conductors	amp	205	235	260	285	300
	19.1.6 Four circuits Tier at 18 in centres						
	Cu conductors	amp	245	280	310	335	355
	A1 conductors	amp	190	220	245	265	280
19.2	g = 90°C cm/watt						
	19.2.1 One circuit						
	Cu conductors	amp	380	435	485	530	560
	A1 conductors	amp	300	345	385	420	445
	19.2.2 Two circuits Horizontal at 18 in centres						
	Cu conductors	amp	340	385	430	470	495
	A1 conductors	amp	265	305	340	370	395
	19.2.3 Three circuits Horizontal at 18 in centres						
	Cu conductors	amp	310	350	390	425	445
	A1 conductors	amp	245	280	310	335	355
	19.2.4 Three circuits Tier at 18 in centres						
	Cu conductors	amp	295	335	375	405	425
	A1 conductors	amp	230	265	295	320	340
	19.2.5 Four circuits Horizontal at 18 in centres						
	Cu conductors	amp	295	335	375	405	425
	A1 conductors	amp	230	265	295	320	335
	19.2.6 Four circuits Tier at 18 in centres						

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.12**

	Cu conductors	amp	275	315	350	380	400
	A1 conductors	amp	215	250	275	300	315
19.3	Assumed maximum conductor temperature	°C	←-----85-----→				
20	Maximum continuous current carrying capacity per conductor when drawn into pipes in the ground with 42 in to top of uppermost pipe at a ground temperature of 15°C						
20.1	g = 120°C cm/watt						
	20.1.1 One circuit						
	Cu conductors	amp	290	230	365	400	435
	A1 conductors	amp	230	260	290	315	345
	20.1.2 Two circuits Horizontal at 18 in centres						
	Cu conductors	amp	265	300	330	360	390
	A1 conductors	amp	210	240	265	285	310
	20.1.3 Three circuits Horizontal at 18 in centres						
	Cu conductors	amp	245	275	305	330	360
	A1 conductors	amp	195	220	240	265	280
	20.1.4 Three circuits Tier at 18 in centres						
	Cu conductors	amp	235	265	295	315	345
	A1 conductors	amp	185	210	230	250	270
	20.1.5 Four circuits Horizontal at 18 in centres						
	Cu conductors	amp	235	265	295	315	345
	A1 conductors	amp	185	210	230	250	270
	20.1.6 Four circuits Tier at 18 in centres						
	Cu conductors	amp	220	250	275	295	320
	A1 conductors	amp	175	200	220	235	255
20.2	g = 90°C cm/watt						
	20.2.1 One circuit						
	Cu conductors	amp	310	355	390	430	465
	A1 conductors	amp	245	280	310	340	370
	20.2.2 Two circuits Horizontal at 18 in centres						
	Cu conductors	amp	285	325	355	395	420
	A1 conductors	amp	225	260	280	310	330
	20.2.3 Three circuits Horizontal at 18 in centres						
	Cu conductors	amp	265	305	335	360	390
	A1 conductors	amp	210	240	260	285	310

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.12**

	20.2.4 Three circuits Tier at 18 in centres							
	Cu conductors	amp	255	295	320	345	375	
	A1 conductors	amp	205	230	255	275	300	
	20.2.5 Four circuits Horizontal at 18 in centres							
	Cu conductors	amp	255	290	320	345	375	
	A1 conductors	amp	205	230	255	275	295	
	20.2.6 Four circuits Tier at 18 in centres							
	Cu conductors	amp	245	275	305	330	355	
	A1 conductors	amp	195	220	240	255	280	
	20.3 Assumed maximum conductor temperature	°C	<-----85----->					
21	Maximum continuous current carrying capacity per conductor when laid on racks in air at ambient temperature of 25°C (77°F)							
	21.1 One three-phase circuit							
	Cu conductors	amp	385	435	500	550	600	
	A1 conductors	amp	305	345	395	435	475	
	21.2 Assumed maximum conductor temperature	°C	<-----85----->					
22	Sheath loss (including reinforcement) of cable per 1,000 yards of three-phase circuit at nominal voltage, normal frequency and operating oil pressure, at maximum current rating							
	22.1 Laid direct in the ground with current per conductor as stated in item 20.1.1							
	Cu conductors	kw	0.3	0.5	0.7	0.9	1.0	
	A1 conductors	kw	0.2	0.3	0.4	0.5	0.6	
	22.2 Drawn into duct cluster with current per conductor as stated in item 21.1.1							
	Cu conductors	kw	0.2	0.3	0.5	0.6	0.8	
	A1 conductors	kw	0.1	0.2	0.3	0.4	0.5	
	22.3 Laid on racks in air with current per conductor as stated in item 22.1							
	Cu conductors	kw	0.4	0.6	0.9	1.2	1.4	
	A1 conductors	kw	0.3	0.4	0.6	0.8	0.9	

23	Sheath short circuit current carrying capacity for one second, cable fully loaded before short circuit maximum sheath temperature 250°C	kilo-amp	8.8	9.4	10.6	11.2	11.6
24	Minimum radius of bend round which cable can be laid						
25	24.1 Laid direct or in air	ft	3¾	4	4½	4½	4½
	24.2 In ducts	ft	5½	6	6¼	6½	6¾
	Nominal internal diameter of pipes or ducts	in	4	4	4	5	5
26	Oil pressure						
	26.1 Minimum operating pressure						
	Cable and joints	p.s.i.g	<-----2.5----->				
	Sealing ends	p.s.i.g	<-----2.5----->				
	Pressure tanks 1 Atoms	p.s.i.g	<-----2.5----->				
	1½ Atoms	p.s.i.g	<-----10.0----->				
	2 Atoms	p.s.i.g	<-----17.0----->				
	2¼ Atoms	p.s.i.g	<-----21.0----->				
	2½ Atoms	p.s.i.g	<-----25.0----->				
	3 Atoms	p.s.i.g	<-----32.0----->				
	26.2 Maximum operating pressure						
	Static conditions						
	Cable and joints	p.s.i.g	<-----76----->				
	Sealing ends	p.s.i.g	<-----76----->				
	Pressure tanks 1 Atoms	p.s.i.g	<-----43----->				
1½ Atoms	p.s.i.g	<-----64----->					
2 Atoms	p.s.i.g	<-----76----->					
2¼ Atoms	p.s.i.g	<-----76----->					
2½ Atoms	p.s.i.g	<-----76----->					
3 Atoms	p.s.i.g	<-----76----->					
Transient conditions							
Cable and joints	p.s.i.g	<-----115----->					
Sealing ends	p.s.i.g	<-----115----->					
27	Oil content per unit length	litres per km	630	705	795	860	930

SUB-SECTION 2.3
ISSUE A

SCHEDULE 7
(BEBS-C4 1966)

SCHEDULE OF TECHNICAL PARTICULARS

SECTION 2.3.2.7

	SECTIONAL AREA OF CONDUCTOR	sq.in	0.45	0.50	0.50	0.60
1	Minimum radial thickness of insulation between conductor and screen	in	<-----0.13----->			
2	Type of impregnant Viscosity 20°C 50°C 85°C	Centipoise Centipoise Centipoise	<----Low Viscosity Mineral Oil-----> <-----13-----> <-----5-----> <-----2----->			
3	Minimum radial thickness of lead alloy sheath	in	0.095	0.095	0.095	0.100
4	Nominal diameter over lead alloy sheath	in	2.33	2.42	2.48	2.58
5	Nominal composition of lead alloy sheath Alloy Tin Cadmium Antimony Lead	 per cent per cent per cent	<-----1/4B or 1/2C-----> <-----0.2-----> <-----0.075-----> <-----0.55-----> <-----remainder remainder----->			
6	Reinforcement 6.1 Material 6.2 0.10% proof stress 6.3 Nominal thickness 6.4 Number of layers 6.5 Maximum working stress	 p.s.i mils p.s.i	<-----1% Tin Bronze-----> <-----52,000-----> <-----4-----> <-----1-----> <-----26,000----->			
7	Protective outer coverings 7.1 Nominal thickness QR2QH2 7.2 Minimum average thickness Extruded PVC (QX)	in in	0.20 0.12	0.20 0.12	0.23 0.13	0.23 0.13
8	Nominal overall diameter of completed cable 8.1 QR2QH2 8.2 Extruded PVC (QX)	 in in	 2.76 2.63	 2.85 2.72	 2.97 2.80	 3.07 2.90
9	Nominal weight per yard of completed cable 9.1 Copper conductors 9.2 Aluminium conductors	 lb lb	 33 22	 36 23	 38 24	 43 27

10	Maximum D.C resistance of conductor per 1,000 yards of cable at 20°C (68°F) 10.1 Copper conductors 10.2 Aluminium conductors	ohm ohm	0.05633 0.09234	0.05100 0.08360	0.04684 0.07679	0.04194 0.06876
11	Maximum A.C resistance of conductor per 1,000 yards of cable at 85°C (185°F) 11.1 Copper conductor 11.2 Aluminium conductors	ohm ohm	0.073 0.12	0.067 0.11	0.062 0.10	0.056 0.090
12	Equivalent star reactance per 1,000 yards of three-phase circuit at 50 cycles/sec	ohm	0.071	0.070	0.069	0.068
13	Maximum electrostatic capacitance per core per 1,000 yards of cable	mfd	0.65	0.68	0.71	0.7.4
14	Maximum changing current per conductor per 1,000 yards of cable at nominal voltage	amp	3.9	4.1	4.3	4.4
15	Maximum power factor of charging KVA of cale when laid direct in the ground at nominal voltage, normal frequency and operating oil pressure, at a conductor temperature of 20°C 30°C 45°C 65°C 85°C		<-----0.0028-----> <-----0.0026-----> <-----0.0025-----> <-----0.0023-----> <-----0.0024----->			
16	Maximum dielectric loss of cable per 1,000 yards of three-phase circuit when laid direct in the ground at nominal voltage, normal frequency and operating oil pressure at maximum conductor temperature	kw	0.53	0.56	0.58	0.61
17	Maximum power factor of charging KVA of cable at normal frequency and operating oil pressure at a conductor temperature of 20°C (68°F) 50 per cent, nominal voltage Nominal voltage 150 per cent, nominal voltage 200 per cent, nominal voltage		<-----0.0028-----> <-----0.0028-----> <-----0.0031-----> <-----0.0034----->			
18	Maximum change in power factor between nominal voltage and 200 per cent, nominal voltage at 20°C		<-----0.0006----->			

19	Maximum continuous current carrying capacity per conductor when laid direct in the ground with 42 in to top of uppermost cable at a ground temperature of 15°C					
19.1	g = 120°C cm/watt					
	19.1.1 One circuit					
	Cu conductors	amp	535	560	585	615
	Al conductors	amp	425	445	465	485
	19.1.2 Two circuits Horizontal at 18 in centres					
	Cu conductors	amp	465	490	510	535
	Al conductors	amp	375	390	405	425
	19.1.3 Three circuits Horizontal at 18 in centres					
	Cu conductors	amp	420	440	460	480
	Al conductors	amp	335	350	365	380
	19.1.4 Three circuits Tier at 18 in centres					
	Cu conductors	amp	400	420	435	460
	Al conductors	amp	320	335	350	360
	19.1.5 Four circuits Horizontal at 18 in centres					
	Cu conductors	amp	400	415	435	455
	Al conductors	amp	320	330	345	360
	19.1.6 Four circuits Tier at 18 in centres					
	Cu conductors	amp	375	390	405	425
	Al conductors	amp	295	310	325	335
19.2	g = 90°C cm/watt					
	19.2.1 One circuit					
	Cu conductors	amp	595	620	655	690
	Al conductors	amp	470	490	515	545
	19.2.2 Two circuits Horizontal at 18 in centres					
	Cu conductors	amp	520	545	575	605
	Al conductors	amp	415	430	455	480
	19.2.3 Three circuits Horizontal at 18 in centres					
	Cu conductors	amp	470	495	520	545
	Al conductors	amp	375	390	410	430
	19.2.4 Three circuits Tier at 18 in centres					
	Cu conductors	amp	450	470	495	520
	Al conductors	amp	355	375	390	410
	19.2.5 Four circuits Horizontal at 18					

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.12**

	in centres					
	Cu conductors	amp	445	465	490	515
	A1 conductors	amp	355	370	390	405
	19.2.6 Four circuits Tier at 18 in centres					
	Cu conductors	amp	420	440	460	485
	A1 conductors	amp	330	350	360	380
	19.3 Assumed maximum conductor temperature	°C	←-----85----->			
20	Maximum continuous current carrying capacity per conductor when drawn into pipes in the ground with 42 in to top of uppermost pipe at a ground temperature of 15°C					
20.1	g = 120°C cm/watt					
	20.1.1 One circuit					
	Cu conductors	amp	460	480	505	530
	A1 conductors	amp	365	380	400	420
	20.1.2 Two circuits Horizontal at 18 in centres					
	Cu conductors	amp	410	435	455	475
	A1 conductors	amp	325	340	355	375
	20.1.3 Three circuits Horizontal at 18 in centres					
	Cu conductors	amp	380	395	415	430
	A1 conductors	amp	295	310	325	345
	20.1.4 Three circuits Tier at 18 in centres					
	Cu conductors	amp	365	375	395	410
	A1 conductors	amp	285	295	310	330
	20.1.5 Four circuits Horizontal at 18 in centres					
	Cu conductors	amp	365	375	390	410
	A1 conductors	amp	285	295	310	330
	20.1.6 Four circuits Tier at 18 in centres					
	Cu conductors	amp	340	260	370	390
	A1 conductors	amp	270	280	290	305
20.2	g = 90°C cm/watt					
	20.2.1 One circuit					
	Cu conductors	amp	495	520	545	575
	A1 conductors	amp	390	410	430	455
	20.2.2 Two circuits Horizontal at 18 in centres					
	Cu conductors	amp	450	470	495	520

TECHNICAL SCHEDULE

**SECTION 2.3
SUB-SECTION 2.3.12**

	20.2.3 Three circuits Horizontal at 18 in centres	A1 conductors amp	350	370	390	410
		Cu conductors amp	415	435	455	475
	20.2.4 Three circuits Tier at 18 in centres	A1 conductors amp	330	345	360	375
		Cu conductors amp	400	420	440	460
	20.2.5 Four circuits Horizontal at 18 in centres	A1 conductors amp	315	330	345	360
		Cu conductors amp	400	420	435	460
		A1 conductors amp	315	330	345	360
	20.2.6 Four circuits Tier at 18 in centres					
		Cu conductors amp	375	395	410	435
		A1 conductors amp	295	310	325	345
	20.3 Assumed maximum conductor temperature	°C	<-----85----->			
21	Maximum continuous current carrying capacity per conductor when laid o racks in air at ambient temperature of 25°C (77°F)					
	21.1 One three-phase circuit					
		Cu conductors amp	635	670	705	745
		A1 conductors amp	500	530	555	590
	21.2 Assumed maximum conductor temperature	°C	<-----85----->			
22	Sheath loss (including reinforcement) of cable per 1,000 yards of three-phase circuit at nominal voltage, normal frequency and operating oil pressure, at maximum current rating					
	22.1 Laid direct in the ground with current per conductor as stated in item 20.1.1					
		Cu conductors kw	1.2	1.4	1.6	1.9
		A1 conductors kw	0.7	0.9	1.0	1.2
	22.2 Drawn into duct cluster with current per conductor as stated in item 21.1.1					
		Cu conductors kw	0.9	1.0	1.2	1.4
		A1 conductors kw	0.5	0.6	0.8	0.9
	22.3 Laid on racks in air with current per conductor as stated in item 22.1					

	Cu conductors Al conductors	kw kw	1.7 1.1	2.0 1.3	2.3 1.4	2.8 1.8
23	Sheath short circuit current carrying capacity for one second, cable fully loaded before short circuit maximum sheath temperature 250°C	kilo-amp	12.7	13.2	13.5	14.9
24	Minimum radius of bend round which cable can be laid					
25	24.1 Laid direct or in air	ft	4¾	4¾	5	5½
	24.2 In ducts	ft	7	7¼	7½	7¾
	Nominal internal diameter of pipes or ducts	in	5	5	5	5
26	Oil pressure					
	26.1 Minimum operating pressure					
	Cable and joints	p.s.i.g	<-----2.5----->			
	Sealing ends	p.s.i.g	<-----2.5----->			
	Pressure tanks 1 Atoms	p.s.i.g	<-----2.5----->			
	1½ Atoms	p.s.i.g	<-----10.0----->			
	2 Atoms	p.s.i.g	<-----17.0----->			
	2¼ Atoms	p.s.i.g	<-----21.0----->			
	2½ Atoms	p.s.i.g	<-----25.0----->			
	3 Atoms	p.s.i.g	<-----32.0----->			
	26.2 Maximum operating pressure					
	Static conditions					
	Cable and joints	p.s.i.g	<-----76----->			
	Sealing ends	p.s.i.g	<-----76----->			
	Pressure tanks 1 Atoms	p.s.i.g	<-----43----->			
1½ Atoms	p.s.i.g	<-----64----->				
2 Atoms	p.s.i.g	<-----76----->				
2¼ Atoms	p.s.i.g	<-----76----->				
2½ Atoms	p.s.i.g	<-----76----->				
3 Atoms	p.s.i.g	<-----76----->				
Transient conditions						
Cable and joints	p.s.i.g	<-----115----->				
Sealing ends	p.s.i.g	<-----115----->				
27	Oil content per unit length	litres per km	975	1030	1085	1160

2.4 INDEX OF STANDARD CABLE AND SPECIFICATION

SECTION 2.4.1 132KV CABLES

<u>SECTION</u>	<u>DESCRIPTION OF CABLE</u>	<u>SPECIFICATION</u>
2.4.2	400mm ² segmental copper conductor single core 12mm central oil duct, carbon paper screen, insulation designed for 12MV/m maximum working, carbon paper interlocked with metalised paper dielectric screen, corrugated aluminium sheath, PVC sheathes overall 132KV oil filled cable.	ESI - 09.4 Schedule 1
2.4.3	400mm ² compacted circular copper conductor single core, carbon paper conductor screen, insulation designed for 12MV/m maximum working stress, carbon paper interlocked with aluminium tape dielectric screen, loose corrugated aluminium sheath PVC sheathed overall 132KV oil filled cable.	ESI - 09-4 Schedule 2
2.4.4	1000mm ² segmental copper conductor single core, central oil duct, segmental conductor, carbon paper conductor screen, insulation designed for 11MV/m maximum working stress, carbon paper interlock with metalised paper dielectric screen, corrugated aluminium sheath PVC sheathed overall 132kV oil filled cable.	ESI - 09-4 Schedule 3
2.4.5	400mm ² compacted circular copper conductor single core, extruded semi-conducting screen, XLPE insulated of 20.0mm minimum average thickness, extruded semi-conducting insulation screen, corrugated aluminium sheath PVC sheathed overall 132kV solid cable.	ESI to be issued Schedule 4
2.4.6	400mm ² compacted circular copper conductor, three core, carbon paper conductor screen, insulation designed for 12MV/m maximum working stress, carbon paper interlocked with aluminium tape dielectric screen, corrugated sheath, PVC sheathed overall 132kV oil filled cable.	ESI 09-4 Schedule 2

CABLES AND ACCESSORIES MANUAL

SECTION 2.4 STANDARD CABLES

132KV CABLES

All 132kv cables shall be as detailed in the appropriate section and schedule and the Transmission Planning Manual. Cable shall be installed as detailed in Code of Practice No.16 - Cable Laying.

SINGLE CORE (OIL-FILLED)

PAPER INSULATED, CORRUGATED ALUMINIUM SHEATHED

- 2.4.2 400mm²segmental copper conductor in accordance with section 2.4.1 and Schedule 1. Suitable for 135MVA rated circuits with feeders at 600mm centres between groups of trefoil cables.
- 2.4.3 400mm² compacted circular copper conductor in accordance with section 2.4.1 and Schedule 2. Suitable for 132MVA rated circuits as 'tails' into sealing ends on three core cables.
- 2.4.4 1000mm²0 segmental copper conductor in accordance with section 2.4.1 and Schedule 3. Suitable for 270MVA rated circuits with feeders at 4 metre centres between inner phases of cable groups laid in flat formation.

SINGLE CORE (SOLID)

X.L.P.E. INSULATED, CORRUGATED ALUMINIUM SHEATHED

- 2.4.5 400mm² compacted circular copper conductors in accordance with section 2.4.1 and Schedule 4. Suitable for 135MVA rated circuits with feeders at 600mm centres between groups of trefoil.

THREE CORE (OIL-FILLED)

PAPER INSULATED, CORRUGATED ALUMINIUM SHEATHED

- 2.4.6 400mm² compacted circular conductor in accordance with section 2.4.1 and Schedule 2. Suitable for 135MVA rated circuits with feeders at 600mm centres between cables.

EAST MIDLANDS ELECTRICITY BOARD
CABLES AND ACCESSORIES MANUAL

2.4 SIZES OF IMPERIAL NON-STANDARD CABLES AND SPECIFICATION

INDEX

SECTION 2.4.1.0 132KV CABLES

SECTION	DESCRIPTION OF CABLE	SPECIFICATION
2.4.1.1	<p><u>SINGLE CORE</u> (8mm C.O.D) <u>STRANDED COPPER CONDUCTOR</u></p> <p>Annular conductor formed of segmental copper strips and layer(s) of rolled copper wires, impregnated paper insulation and screened. Lead alloy sheathed, impregnated cotton taped reinforced with tin bronze tapes and anti-corrosion serving overall. Feeder laid in trefoil at 450mm centres.</p>	BEBS C4 (1966) (SCHEDULE 1)
2.4.1.2	<p><u>SINGLE CORE</u> (12mm C.O.D) <u>STRANDED COPPER CONDUCTOR</u></p> <p>Annular conductor formed of segmental copper strips and layer(s) of rolled copper wires, impregnated paper insulation and screened. Lead alloy sheathed, impregnated cotton taped reinforced with tin bronze tapes and anti-corrosion serving overall. Feeder laid in trefoil at 450mm centres.</p>	BEBS C4 (1966) (SCHEDULE 2)
2.4.1.3	<p><u>THREE CORE</u> <u>STRANDED COPPER CONDUCTOR</u> <u>(CIRCULAR)</u></p> <p>Compact copper conductor, carbon loaded paper screen, impregnated paper insulated and screened, laid up with paper fillings and spiral oil ducting each interstice. Lapped with copper threaded tape, lead alloy sheathed, impregnated cotton taped, reinforced with tin bronze, anti-corrosion serving overall.</p> <p>Feeders laid at 450mm centres.</p>	BEBS C4 (1966) (SCHEDULE 3)

UNDER REVIEW

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SCHEDULE 1

(BEBS-C4:)

SCHEDULE OF TECHNICAL PARTICULARS

SECTION 2.4.1.1

132KV SINGLE CORE 8mm C.O.D. LEAD SHEATHED OIL FILLED CABLE

1	SECTIONAL AREA OF CONDUCTOR		0.10 sq.in	0.15 sq.in	0.20 sq.in	0.25 sq.in
2	Minimum thickness of insulation	in	0.460	0.435	0.435	0.420
3	Minimum Sheath thickness	in	0.080	0.085	0.085	0.085
4	Diameter oversheath	in	1.70	1.72	1.72	1.74
5	Diameter completed cable	in	2.14	2.16	2.16	2.18
6	Weight per yard	lb	13.0	14.0	14.0	15.0
7	Max DC resistant at 20°C per 1000 yds. of cable	ohms	0.2494	0.4663	0.1255	0.1006
8	Max 50 C/S AC resistance at 85°C per 1000 yds. of cable	ohms	0.313	0.209	0.158	0.126
9	Star reactance at 50 C/S per 1000 yds. of cable	ohms	0.134	0.127	0.127	0.124
10	Maximum capacitance to neutral per 100 yds. of cable	F	0.18	0.20	0.20	0.22
11	Maximum charging current at 50 C/S per 1000 yds. of cable	amps	4.3	4.8	4.8	5.3
12	Max stress at conductor	kV/cm	<-----110----->			
13	Max continuous carrying capacity per conductor laid direct in ground.	amps	250	310	355	400
14	Drawn into pipes or ducts	amps	240	295	340	380
15	Laid on racks or cleats in air	amps	315	400	470	530
16	Sheath loss per 1000 yds. of three phase circuit					
	(a) Laid direct	kW	59.6	61.5	61.1	62.3
	(b) Drawn into ducts	kW	56.3	57.7	58.8	59.7
	(c) In air	kW	94.4	102.0	106.9	109.0

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SCHEDULE 1

(BEBS-C4:)

SCHEDULE OF TECHNICAL PARTICULARS

SECTION 2.4.1.1

132KV SINGLE CORE 8mm C.O.D. LEAD SHEATHED OIL FILLED CABLE

1	SECTIONAL AREA OF CONDUCTOR		0.30 sq.in	0.35 sq.in	0.40 sq.in	0.45 sq.in
2	Minimum thickness of insulation	in	0.405	0.395	0.385	0.380
3	Minimum Sheath thickness	in	0.085	0.085	0.080	0.085
4	Diameter oversheath	in	1.77	1.80	1.83	1.86
5	Diameter completed cable	in	2.21	2.24	2.27	2.30
6	Weight per yard	lb	16.0	17.0	17.5	18.0
7	Max DC resistant at 20°C per 1000 yds. of cable	ohms	0.08241	0.07224	0.06195	0.05538
8	Max 50 C/S AC resistance at 85°C per 1000 yds. of cable	ohms	0.104	0.091	0.078	0.070
9	Star reactance at 50 C/S per 1000 yds. of cable	ohms	0.119	0.116	0.114	0.1111
10	Maximum capacitance to neutral per 100 yds. of cable	F	0.24	0.25	0.27	0.28
11	Maximum charging current at 50 C/S per 1000 yds. of cable	amps	5.8	6.0	6.5	6.7
12	Max stress at conductor	kV/cm	<-----110----->			
13	Max continuous carrying capacity per conductor laid direct in ground.	amps	445	475	515	545
14	Drawn into pipes or ducts	amps	420	445	480	505
15	Laid on racks or cleats in air	amps	600	645	710	755
16	Sheath loss per 1000 yds. of three phase circuit					
	(a) Laid direct	kW	64.0	64.2	65.1	65.9
	(b) Drawn into ducts	kW	61.1	61.3	62.8	62.8
	(c) In air	kW	115.9	118.0	125.9	125.9

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(BEBS-C4:)

SCHEDULE OF TECHNICAL PARTICULARS

SECTION 2.4.1.1

132KV SINGLE CORE 8mm C.O.D. LEAD SHEATHED OIL FILLED CABLE

1	SECTIONAL AREA OF CONDUCTOR		0.50 sq.in	0.55 sq.in	0.60 sq.in	0.65 sq.in
2	Minimum thickness of insulation	in	0.370	0.365	0.360	0.360
3	Minimum Sheath thickness	in	0.085	0.085	0.085	0.085
4	Diameter oversheath	in	1.88	1.91	1.94	1.99
5	Diameter completed cable	in	2.32	2.35	2.38	2.43
6	Weight per yard	lb	19.0	19.5	20.5	22.0
7	Max DC resistant at 20°C per 1000 yds. of cable	ohms	0.05006	0.04520	0.04128	0.03795
8	Max 50 C/S AC resistance at 85°C per 1000 yds. of cable	ohms	0.064	0.059	0.054	0.050
9	Star reactance at 50 C/S per 1000 yds. of cable	ohms	0.109	0.107	0.105	0.103
10	Maximum capacitance to neutral per 100 yds. of cable	F	0.30	0.31	0.32	0.33
11	Maximum charging current at 50 C/S per 1000 yds. of cable	amps	7.2	7.4	7.7	7.9
12	Max stress at conductor	kV/cm	<-----110----->			
13	Max continuous carrying capacity per conductor laid direct in ground.	amps	570	600	625	650
14	Drawn into pipes or ducts	amps	525	550	575	595
15	Laid on racks or cleats in air	amps	795	845	890	930
16	Sheath loss per 1000 yds. of three phase circuit					
	(a) Laid direct	kW	66.1	67.9	68.2	68.8
	(b) Drawn into ducts	kW	62.8	64.3	66.3	68.8
	(c) In air	kW	128.1	134.2	137.7	140.3

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SCHEDULE 1

(BEBS-C4:)

SCHEDULE OF TECHNICAL PARTICULARS

SECTION 2.4.1.1

132KV SINGLE CORE 8mm C.O.D. LEAD SHEATHED OIL FILLED CABLE

1	SECTIONAL AREA OF CONDUCTOR		0.75 sq.in	0.85 sq.in	1.0 sq.in
2	Minimum thickness of insulation	in	0.355	0.345	0.340
3	Minimum Sheath thickness	in	0.090	0.090	0.090
4	Diameter oversheath	in	2.04	2.10	2.20
5	Diameter completed cable	in	2.48	2.54	2.64
6	Weight per yard	lb	23.0	25.0	28.0
7	Max DC resistant at 20°C per 1000 yds. of cable	ohms	0.03406	0.02921	0.02410
8	Max 50 C/S AC resistance at 85°C per 1000 yds. of cable	ohms	0.045	0.040	0.034
9	Star reactance at 50 C/S per 1000 yds. of cable	ohms	0.102	0.099	0.096
10	Maximum capacitance to neutral per 100 yds. of cable	F	0.35	0.38	0.41
11	Maximum charging current at 50 C/S per 1000 yds. of cable	amps	8.4	9.1	9.8
12	Max stress at conductor	kV/cm	<-----110----->		
13	Max continuous carrying capacity per conductor laid direct in ground.	amps	680	725	785
14	Drawn into pipes or ducts	amps	620	660	710
15	Laid on racks or cleats in air	amps	985	1065	1180
16	Sheath loss per 1000 yds. of three phase circuit				
	(a) Laid direct	kW	68.3	70.0	71.6
	(b) Drawn into ducts	kW	66.6	68.9	71.3
	(c) In air	kW	142.8	150.4	161.0

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SCHEDULE OF TECHNICAL PARTICULARS

SECTION 2.4.1.1

132KV SINGLE CORE 8mm C.O.D. LEAD SHEATHED OIL FILLED CABLE

1	SECTIONAL AREA OF CONDUCTOR		0.10 sq.in	0.15 sq.in	0.20 sq.in	0.25 sq.in
2	Minimum thickness of insulation	in	0.460	0.435	0.435	0.420
3	Minimum Sheath thickness	in	0.080	0.085	0.085	0.085
4	Diameter oversheath	in	1.70	1.72	1.72	1.74
5	Diameter completed cable	in	2.14	2.16	2.16	2.18
6	Weight per yard	lb	13.0	14.0	14.0	15.0
7	Max DC resistant at 20°C per 1000 yds. of cable	ohms	0.2494	0.4663	0.1255	0.1006
8	Max 50 C/S AC resistance at 85°C per 1000 yds. of cable	ohms	0.313	0.209	0.158	0.126
9	Star reactance at 50 C/S per 1000 yds. of cable	ohms	0.134	0.127	0.127	0.124
10	Maximum capacitance to neutral per 100 yds. of cable	F	0.18	0.20	0.20	0.22
11	Maximum charging current at 50 C/S per 1000 yds. of cable	amps	4.3	4.8	4.8	5.3
12	Max stress at conductor	kV/cm	<-----110----->			
13	Max continuous carrying capacity per conductor laid direct in ground.	amps	250	310	355	400
14	Drawn into pipes or ducts	amps	240	295	340	380
15	Laid on racks or cleats in air	amps	315	400	470	530
16	Sheath loss per 1000 yds. of three phase circuit					
	(a) Laid direct	kW	59.6	61.5	61.1	62.3
	(b) Drawn into ducts	kW	56.3	57.7	58.8	59.7
	(c) In air	kW	94.4	102.0	106.9	109.0

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SCHEDULE 1

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SCHEDULE OF TECHNICAL PARTICULARS

SECTION 2.4.1.1

132KV SINGLE CORE 8mm C.O.D. LEAD SHEATHED OIL FILLED CABLE

1	SECTIONAL AREA OF CONDUCTOR		0.30 sq.in	0.35 sq.in	0.40 sq.in	0.45 sq.in
2	Minimum thickness of insulation	in	0.405	0.395	0.385	0.380
3	Minimum Sheath thickness	in	0.085	0.085	0.080	0.085
4	Diameter oversheath	in	1.77	1.80	1.83	1.86
5	Diameter completed cable	in	2.21	2.24	2.27	2.30
6	Weight per yard	lb	16.0	17.0	17.5	18.0
7	Max DC resistant at 20°C per 1000 yds. of cable	ohms	0.08241	0.07224	0.06195	0.05538
8	Max 50 C/S AC resistance at 85°C per 1000 yds. of cable	ohms	0.104	0.091	0.078	0.070
9	Star reactance at 50 C/S per 1000 yds. of cable	ohms	0.119	0.116	0.114	0.1111
10	Maximum capacitance to neutral per 100 yds. of cable	F	0.24	0.25	0.27	0.28
11	Maximum charging current at 50 C/S per 1000 yds. of cable	amps	5.8	6.0	6.5	6.7
12	Max stress at conductor	kV/cm	<-----110----->			
13	Max continuous carrying capacity per conductor laid direct in ground.	amps	445	475	515	545
14	Drawn into pipes or ducts	amps	420	445	480	505
15	Laid on racks or cleats in air	amps	600	645	710	755
16	Sheath loss per 1000 yds. of three phase circuit					
	(a) Laid direct	kW	64.0	64.2	65.1	65.9
	(b) Drawn into ducts	kW	61.1	61.3	62.8	62.8
	(c) In air	kW	115.9	118.0	125.9	125.9

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(BEBS-C4:)

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SECTION 2.4.1.1

132KV SINGLE CORE 8mm C.O.D. LEAD SHEATHED OIL FILLED CABLE

1	SECTIONAL AREA OF CONDUCTOR		0.50 sq.in	0.55 sq.in	0.60 sq.in	0.65 sq.in
2	Minimum thickness of insulation	in	0.370	0.365	0.360	0.360
3	Minimum Sheath thickness	in	0.085	0.085	0.085	0.085
4	Diameter oversheath	in	1.88	1.91	1.94	1.99
5	Diameter completed cable	in	2.32	2.35	2.38	2.43
6	Weight per yard	lb	19.0	19.5	20.5	22.0
7	Max DC resistant at 20°C per 1000 yds. of cable	ohms	0.05006	0.04520	0.04128	0.03795
8	Max 50 C/S AC resistance at 85°C per 1000 yds. of cable	ohms	0.064	0.059	0.054	0.050
9	Star reactance at 50 C/S per 1000 yds. of cable	ohms	0.109	0.107	0.105	0.103
10	Maximum capacitance to neutral per 100 yds. of cable	F	0.30	0.31	0.32	0.33
11	Maximum charging current at 50 C/S per 1000 yds. of cable	amps	7.2	7.4	7.7	7.9
12	Max stress at conductor	kV/cm	<-----110----->			
13	Max continuous carrying capacity per conductor laid direct in ground.	amps	570	600	625	650
14	Drawn into pipes or ducts	amps	525	550	575	595
15	Laid on racks or cleats in air	amps	795	845	890	930
16	Sheath loss per 1000 yds. of three phase circuit					
	(a) Laid direct	kW	66.1	67.9	68.2	68.8
	(b) Drawn into ducts	kW	62.8	64.3	66.3	68.8
	(c) In air	kW	128.1	134.2	137.7	140.3

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SCHEDULE 1

(BEBS-C4:)

SCHEDULE OF TECHNICAL PARTICULARS

SECTION 2.4.1.1

132KV SINGLE CORE 8mm C.O.D. LEAD SHEATHED OIL FILLED CABLE

1	SECTIONAL AREA OF CONDUCTOR		0.75 sq.in	0.85 sq.in	1.0 sq.in
2	Minimum thickness of insulation	in	0.355	0.345	0.340
3	Minimum Sheath thickness	in	0.090	0.090	0.090
4	Diameter oversheath	in	2.04	2.10	2.20
5	Diameter completed cable	in	2.48	2.54	2.64
6	Weight per yard	lb	23.0	25.0	28.0
7	Max DC resistant at 20°C per 1000 yds. of cable	ohms	0.03406	0.02921	0.02410
8	Max 50 C/S AC resistance at 85°C per 1000 yds. of cable	ohms	0.045	0.040	0.034
9	Star reactance at 50 C/S per 1000 yds. of cable	ohms	0.102	0.099	0.096
10	Maximum capacitance to neutral per 100 yds. of cable	F	0.35	0.38	0.41
11	Maximum charging current at 50 C/S per 1000 yds. of cable	amps	8.4	9.1	9.8
12	Max stress at conductor	kV/cm	<-----110----->		
13	Max continuous carrying capacity per conductor laid direct in ground.	amps	680	725	785
14	Drawn into pipes or ducts	amps	620	660	710
15	Laid on racks or cleats in air	amps	985	1065	1180
16	Sheath loss per 1000 yds. of three phase circuit				
	(a) Laid direct	kW	68.3	70.0	71.6
	(b) Drawn into ducts	kW	66.6	68.9	71.3
	(c) In air	kW	142.8	150.4	161.0

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SCHEDULE 1
(BEBS-C4: 1959)
SCHEDULE OF TECHNICAL PARTICULARS
SECTION 2.4.1.3
132KV THREE CORE LEAD SHEATHED OIL FILLED CABLE

1	SECTIONAL AREA OF CONDUCTOR		0.10 sq.in	0.15 sq.in	0.20 sq.in	0.25 sq.in
2	Minimum thickness of insulation	in	0.545	0.480	0.465	0.435
3	Minimum Sheath thickness	in	0.120	0.115	0.115	0.120
4	Diameter oversheath	in	3.66	3.56	3.56	3.58
5	Diameter completed cable	in	4.26	4.16	4.16	4.18
6	Weight per yard	lb	44.5	44.5	46.5	49.0
7	Max DC resistant at 20°C per 1000 yds. of cable	ohms	0.2519	0.1721	0.1295	0.1031
8	Max 50 C/S AC resistance at 85°C per 1000 yds. of cable	ohms	0.316	0.216	0.163	0.130
9	Star reactance at 50 C/S per 1000 yds. of cable	ohms	0.135	0.121	0.117	0.111
10	Maximum capacitance to neutral per 100 yds. of cable	F	0.14	0.17	0.18	0.20
11	Maximum charging current at 50 C/S per 1000 yds. of cable	amps	3.4	4.1	4.3	4.8
12	Max stress at conductor	kV/cm	<-----110----->			
13	Max continuous carrying capacity per conductor laid direct in ground.	amps	225	280	325	370
14	Drawn into pipes or ducts	amps	210	255	295	330
15	Laid on racks or cleats in air	amps	255	320	380	435
16	Sheath loss per 1000 yds. of three phase circuit					
	(a) Laid direct	kW	50.7	54.3	55.8	58.3
	(b) Drawn into ducts	kW	44.4	45.4	46.4	46.9
	(c) In air	kW	64.6	70.2	75.3	79.5

SCHEDULE 1(BEBS-C4: 1959)SCHEDULE OF TECHNICAL PARTICULARSSECTION 2.4.1.3132KV THREE CORE LEAD SHEATHED OIL FILLED CABLE

1	SECTIONAL AREA OF CONDUCTOR		0.30 sq.in	0.35 sq.in	0.40 sq.in
2	Minimum thickness of insulation	in	0.415	0.405	0.395
3	Minimum Sheath thickness	in	0.120	0.120	0.120
4	Diameter oversheath	in	3.63	3.71	3.78
5	Diameter completed cable	in	4.23	4.31	4.38
6	Weight per yard	lb	51.5	54.0	57.0
7	Max DC resistant at 20°C per 1000 yds. of cable	ohms	0.08408	0.07110	0.06256
8	Max 50 C/S AC resistance at 85°C per 1000 yds. of cable	ohms	0.107	0.091	0.080
9	Star reactance at 50 C/S per 1000 yds. of cable	ohms	0.106	0.102	0.099
10	Maximum capacitance to neutral per 100 yds. of cable	F	0.22	0.24	0.25
11	Maximum charging current at 50 C/S per 1000 yds. of cable	amps	5.3	5.7	6.0
12	Max stress at conductor	kV/cm	←-----110----->		
13	Max continuous carrying capacity per conductor laid direct in ground.	amps	410	445	475
14	Drawn into pipes or ducts	amps	365	400	430
15	Laid on racks or cleats in air	amps	485	530	570
16	Sheath loss per 1000 yds. of three phase circuit				
	(a) Laid direct	kW	59.7	60.6	61.3
	(b) Drawn into ducts	kW	47.9	49.6	50.9
	(c) In air	kW	82.3	84.6	86.8

SECTION 2
SUB-SECTION 2.4
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SCHEDULE 1
(BEBS-C4: 1959)
SCHEDULE OF TECHNICAL PARTICULARS
SECTION 2.4.1.3
132KV THREE CORE LEAD SHEATHED OIL FILLED CABLE

1	SECTIONAL AREA OF CONDUCTOR		0.45 sq.in	0.50 sq.in	0.55 sq.in	0.60 sq.in
2	Minimum thickness of insulation	in	0.385	0.380	0.375	0.365
3	Minimum Sheath thickness	in	0.120	0.125	0.125	0.125
4	Diameter oversheath	in	3.82	3.90	3.96	4.02
5	Diameter completed cable	in	4.42	4.50	4.56	4.62
6	Weight per yard	lb	60.0	62.5	64.5	67.5
7	Max DC resistant at 20°C per 1000 yds. of cable	ohms	0.05633	0.05101	0.04684	0.04195
8	Max 50 C/S AC resistance at 85°C per 1000 yds. of cable	ohms	0.073	0.067	0.062	0.056
9	Star reactance at 50 C/S per 1000 yds. of cable	ohms	0.097	0.095	0.093	0.091
10	Maximum capacitance to neutral per 100 yds. of cable	F	0.27	0.28	0.29	0.31
11	Maximum charging current at 50 C/S per 1000 yds. of cable	amps	6.5	6.7	7.0	7.4
12	Max stress at conductor	kV/cm	<-----110----->			
13	Max continuous carrying capacity per conductor laid direct in ground.	amps	500	525	545	575
14	Drawn into pipes or ducts	amps	455	475	490	515
15	Laid on racks or cleats in air	amps	605	640	665	705
16	Sheath loss per 1000 yds. of three phase circuit					
	(a) Laid direct	kW	62.7	64.1	64.6	65.8
	(b) Drawn into ducts	kW	52.5	53.2	53.0	53.7
	(c) In air	kW	90.0	93.4	94.3	96.9

SCHEDULE 1
(E.S.I. 09-4)
DETAILS OF TECHNICAL PARTICULARS
SECTION 2.4.2

SECTION 2
SUB-SECTION 2.4
ISSUE A

132,000 VOLT SINGLE CORE C.O.D. PAPER INSULATED, CORRUGATED
ALUMINIUM SHEATHED OIL FILLED CABLE.

ITEM			
1	Voltage between phases of three-phase circuit	kV	132
2	Number of cores		1
3	Nominal cross sectional area of conductor(s)	mm ²	400
4	Conductor details: 4.1 Material 4.2 Design type [†] 4.3 Overall dimensions	mm	copper 5 25.4
5	Oil ducts: 5.1 Material 5.2 Nominal internal diameter	mm	copper 12.0
6	Conductor screen: 6.1 Material 6.2 Diameter over conductor screen	mm	Carbon paper 26.6
7	Maximum dielectric stress at the conductor screen (assumed smooth)	MV/m	12.0
8	Minimum radial thickness of insulation between conductor screen and core screen.	mm	8.1
9	Insulation paper: 9.1 Type 9.2 Nominal thickness	μm	Specially chemically treated woodpulp. 105, 135, 200
10	Core screen: 10.1 Material 10.2 Nominal thickness	μm	Carbon paper interlocked with metallised paper 380

[†] The key for the Conductor design Type numbers is given in Clause 4.1. of ESI standard 09-4

SECTION 2
SUB-SECTION 2.4
ISSUE A

ITEM			
11.	Impregnant: 11.1 Type 11.2 Viscosity at: 20°C 50°C 90°C 11.3 Drop Point (Gas filled cable only)	cp cP cP °C	Alkyl Benzene 13 5 2 -
12.	Binder over laid-up cores: 12.1 Material 12.2 Nominal thickness	mm	- -
13.	Diaphragm Sheath 13.1 Composition 13.2 Minimum radial thickness Pressure retaining sheath: 13.3 Composition 13.4 Minimum radial thickness	mm mm	- - Aluminium Material EIB to BS 1474 (1969) 1.15
14.	Number and nominal dimensions of flutes (fluted sheaths only)	-/mm	-
15.	Nominal diameter over sheath	mm	54.1
16.	Control tapes over diaphragm sheath: 16.1 Material 16.2 Nominal thickness 16.3 Nominal width 16.4 Number of tapes per layer 16.5 Number of layers	mm mm	- - - - -
17.	Bedding under reinforcement: 17.1 Material 17.2 Nominal thickness	mm	- -

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ITEM			
18	Reinforcement:		
	18.1 Material		-
	18.2 0.10% proof stress	N/mm ²	-
	18.3 Nominal thickness	mm	-
	18.4 Nominal width	mm	-
	18.5 Number of tapes per layer		-
	18.6 Number of layers		-
	18.7 Maximum working stress	N/mm ²	-
19	Protective outer coverings:		
	19.1 Material		PVC
	19.2 Minimum average thickness	mm	3.0
20	Nominal overall dimension(s) of completed cable.	mm	61.3
21	Skid wires (for pipe-line cables)		
	21.1 Material		-
	21.2 Dimensions	mm	-
	21.3 Number		-
	21.4 Nominal lay length	mm	-
22	Nominal weight per metre of completed cable(excluding pipe for pipe-line cable)	kg	6.8
23	Pipe for pipe-line cable:		
	23.1 Overall diameter	mm	-
	23.2 Thickness	mm	-
	23.3 Nominal weight per metre	kg	-
24	Minimum radius of bend round which cable can be laid:		
	24.1 Laid direct or in air		1.9
	24.2 In ducts	m	2.2
	24.3 With cables placed in position adjacent to joints and terminals		
	(i) Without former	m	1.3
	(ii) With former	m	1.0
25	Nominal internal diameter of pipes or ducts for self-contained cable	mm	100
26	Maximum d.c resistance of conductor per metre of cable at 20°C	μΩ	46.1

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SUB-SECTION 2.4
ISSUE A

ITEM			
27	Maximum a.c resistance of conductor per metre of cable at 90°C	$\mu\Omega$	60.0
28	Equivalent star reactance per metre of three phase circuit at 50 Hz	$\mu\Omega$	110
29	Maximum electrostatic capacitance per core per metre of cable	$\mu\Omega$	410
30	Maximum charging current per conductor per metre of cable at nominal voltage	$\mu\Omega$	9.8
31	Current carrying capacity (see also Item 41)	A	W 640 S 530
32	Maximum dielectric loss angle of charging VA of cable when laid direct in the ground at nominal voltage, normal frequency and operating oil/gas pressure, at a conductor temperature of: 20°C 90°C		0.0028 0.0024
33	Maximum dielectric loss of cable per metre of three-phase circuit when laid direct in the ground at nominal voltage, normal frequency and operating oil/gas pressure at maximum conductor temperature	W	5.4
34	Maximum dielectric loss angle of charging VA of cable at normal frequency and at following oil/gas pressure, at a conductor temperature of 20°C 34.1 At factory test oil pressure (as specified in Schedule F) Nominal Voltage 200% nominal voltage 34.2 At factory test gas pressure (as specified in Schedule F) 25% nominal voltage 50% nominal voltage		0.0028 0.0036

SECTION 2
SUB-SECTION 2.4
ISSUE A

ITEM			
35	Maximum change in dielectric loss angle between nominal voltage and 200% nominal voltage at 20°C		0.0008
36	Sheath loss (including reinforcement) of cable per metre of three-phase circuit at nominal voltage, normal frequency and operating oil/gas pressure, at current rating given in Item 31.	W	W 20.11 S 3.8
37	Conductor short circuit current carrying capacity for 1 second, cable loaded as in Item 31 before shore circuit, and final conductor temperature 160°C	kA	
38	Oil feed pipes: 38.1 Material 38.2 Dimensions 38.3 Protective covering	mm	Please refer to Table 8 of ESI 09-4
39	Gas feed pipes: 39.1 Material 39.2 Dimensions 39.3 Protective covering	mm	- - -
40	Oil content per metre	litres	0.94
41	Installation and operating conditions on which current carrying stated in Item 31 is based. 900mm to top of cables. The circuit consists of one trefoil of cable in a thermally independent trench with sheath bonded and earthed at both ends of the route. (W) Winter rating (S) Summer rating Maximum conductor temperature Ground ambient Thermal resistivities as follows:- Soil: Outside 50C isotherm Inside 50C isotherm Backfill: Inside 50C isotherm	°C °C °C- m/W °C- m/W °C- m/W	(W) (S) 90 90 10 15 1.05 1.20 1.05 3.00 1.05 2.70

SCHEDULE 2
(E.S.I 09-4)
DETAIL OF TECHNICAL PARTICULARS

SECTION 2
SUB-SECTION 2.4
ISSUE A

SECTIONS 2.4.3 AND 2.4.6
132,000 VOLT SINGLE/THREE CORE, PAPER INSULATED, CORRUGATED
ALUMINIUM SHEATHED OIL FILLED CABLE

ITEM			
1	Voltage between phases of three-phase circuit	kV	132
2	Number of cores		3 1
3	Nominal cross sectional area of conductors	mm	400
4	Conductor details: 4.1 Material 4.2 Design type [†] 4.3 Overall dimensions	mm	Copper 3 23.2
5	Oil ducts: 5.1 Material 5.2 Nominal internal diameter	mm	Aluminium - 17.3 -
6	Conductor screen: 6.1 Material 6.2 Diameter over conductor screen	mm	Carbon paper 23,6
7	Maximum dielectric stress at the conductor screen (assumed smooth)	MV/M	11.5
8	Minimum radial thickness of insulation between conductor screen and core screen	mm	8.9
9	Insulation paper; 9.1 Type 9.2 Nominal thickness		Specially chemically treated wood pulp 105,135,200
10	Core screen; 10.1 Material 10.2 Nominal thickness		Carbon paper interlocked with al. tape 320
11	Impregnant: 11.1 Type 11.2 Viscosity at: 20°C 50°C 90°C 11.3 Drop Point (Gas filled cable only)	cP cP cP °C	Alkyl Benzene 13 5 2 -

[†] The key for the Conductor design Type numbers is given in Clause 4.1. of ESI standard 09-4

SECTION 2
SUB-SECTION 2.4
ISSUE A

ITEM				
12	Binder over laid-up cores: 12.1 Material		Copper woven fabric	-
	12.2 Nominal thickness	mm	tape 0.35	-
13	Diaphragm Sheath 13.1 Composition			
	13.2 Minimum radial thickness pressure retaining sheath:	mm		
	13.3 Composition		Aluminium, Material EIB to BS 1474 (1969)	
	13.4 Minimum radial thickness	mm	1.95	1.8
14	Number and nominal dimensions of flutes (fluted sheaths only)	-/mm		
15	Nominal diameter over sheath	mm	109.7	58.7
16	Control tapes over diaphragm sheath: 16.1 Material			-
	16.2 Nominal thickness	mm		-
	16.3 Nominal width	mm		-
	16.4 Number of tapes per layer			-
	16.5 Number of layers			-
17	Bedding under reinforcement: 17.1 Material			-
	17.2 Nominal thickness	mm		-
18	Reinforcement: 18.1 Material			-
	18.2 0.10% proof stress	N/mm		-
	18.3 Nominal thickness	mm		-
	18.4 Nominal width	mm		-
	18.5 Number of tapes per layer			-
	18.6 Number of layers			-
	18.7 Maximum working stress	N/mm		-
19	Protective outer covering: 19.1 Material		Extruded PVC	
	19.2 Minimum average thickness	mm	3.6	3.0

SECTION 2
SUB-SECTION 2.4
ISSUE A

ITEM				
20	Nominal overall dimensions of completed cable	mm	118.3	65.9
21	Skid wires (for pipe-line cables)			
21.1	Material		-	
21.2	Dimensions	mm	-	
21.3	Number		-	
21.4	Nominal lay length	mm	-	
22	Nominal weight per metre of completed cable (Excluding pipe for pipe-line cable)	kg	23.5	7.5
23	Pipe for pipe-line cable:			
23.1	Overall diameter	mm	-	
23.2	Thickness	mm	-	
23.3	Nominal weight per metre	kg	-	
24	Minimum radius of bend round which cable can be laid:			
24.1	Laid direct or in air		2.4	2.0
24.2	In ducts	m	3.6	2.4
24.3	With cables placed in position adjacent to joints and terminals			
	(i) Without former	m	1.8	1.4
	(ii) With former	m	1.8	1.4
25	Nominal internal diameter of pipes or ducts for self-contained cable	mm	230	125
26	Maximum d.c resistance of conductor per metre of cable at 20°C	$\mu\Omega$	47.0	
27	Maximum a.c resistance of conductor per metre of cable at 90°C	$\mu\Omega$	62.4	
28	Equivalent star reactance per metre of three phase circuit at 50 Hz	$\mu\Omega$	98.7	-
29	Maximum electrostatic capacitance per core per metre of cable	$\mu\Omega$	335	0
30	Maximum charging current per conductor per metre of cable at nominal voltage	$\mu\Omega$	8.0	7.9
31	Current carrying capacity (see also Item 41)	A	(W) 610 (S) 520	at least equal to rating of three core cable

SECTION 2

SUB-SECTION 2.4
ISSUE A

ITEM			
32	Maximum dielectric loss angle of charging VA of cable when laid direct in the ground at nominal voltage, normal frequency and operating oil/gas pressure, at a conductor temperature of: 20°C 90°C		0.0028 0.0024
33	Maximum dielectric loss of cable per metre of three-phase circuit when laid direct in the ground at nominal voltage, normal frequency and operating oil/gas pressure at maximum conductor temperature	W	4.4 4.3
34	Maximum dielectric loss angle of charging VA of cable at normal frequency and at following oil/gas pressure, at a conductor temperature of 20°C 34.1 At factory test oil pressure (as specified in Schedule F) Nominal Voltage 200% nominal voltage 34.2 At factory test gas pressure (as specified in Schedule F) 25% nominal voltage 50% nominal voltage		0.0028 0.0036 - -
35	Maximum change in dielectric loss angle between nominal voltage and 200% nominal voltage at 20°C		0.0008
36	Sheath loss (including reinforcement) of cable per metre of three-phase circuit at nominal voltage, normal frequency and operating oil/gas pressure, at current rating given in Item 31.	W	(W)12.9 - (S)9.3 -
37	Conductor short circuit current carrying capacity for 1 second, cable loaded as in Item 31 before shore circuit, and final conductor temperature 160°C	kA	39.0
38	Oil feed pipes: 38.1 Material 38.2 Dimensions 38.3 Protective covering	mm	Please refer to Table 8 of ESI 09-4

SECTION 2

SUB-SECTION 2.4
ISSUE A

ITEM				
39	Gas feed pipes: 39.1 Material 39.2 Dimensions 39.3 Protective covering	mm	-	-
40	Oil content per metre	litres	4.74	1.14
41	Installation and operating conditions on which current carrying stated in Item 31 is based. 900mm to top of cables thermally independent trench. (W) Winter rating (S) Summer rating Maximum conductor temperature Ground ambient Thermal resistivities as follows:- Soil: Outside 50°C isotherm Inside 50°C isotherm Backfill: Inside 50°C isotherm	°C °C °C-m/W °C-m/W °C-m/W	(W) 90 10 1.05 1.05 1.05	(S) 90 15 1.20 3.00 2.70

SCHEDULE 3
(E.S.I. 09.4)
DETAILS OF TECHNICAL PARTICULARS

SECTION 2
SUB-SECTION 2.4
ISSUE A

SECTION 2.4.4
132,000 VOLT SINGLE CORE C.O.D. PAPER INSULATED, CORRUGATED
ALUMINIUM SHEATHED OIL FILLED CABLE.

ITEM			
1	Voltage between phases of three-phase circuit	kV	132
2	Number of cores		1
3	Nominal cross sectional area of conductors(s)	mm ²	1000
4	Conductor details: 4.1 Material 4.2 Design type [†] 4.3 Overall dimensions	mm	Copper 5 38.0
5	Oil ducts: 5.1 Material 5.2 Nominal internal diameter	mm	Copper 12.0
6	Conductor screen: 6.1 Material 6.2 Diameter over conductor screen	mm	Carbon Paper 24.3
7	Maximum dielectric stress at the conductor screen (assumed smooth)	MV/m	12.0
8	Minimum radial thickness of insulation between conductor screen and core screen	mm	8.3
9	Insulation paper: 9.1 Type 9.2 Nominal thickness	μm	Specially chemically treated wood pulp 105, 135, 200
10	Core Screen: 10.1 Material 10.2 Nominal thickness	μm	Carbon paper interlocked with metallised paper. 380

[†] The key for the Conductor design Type numbers is given in Clause 4.1. of ESI standard 09-4

SECTION 2
SUB-SECTION 2.4
ISSUE A

ITEM			
11	Impregnant: 11.1 Type 11.2 Viscosity at: 20°C 50°C 90°C 11.3 Drop Point (Gas filled cable only)	 cP cP cP °C	Alkyl Benzene 13 5 2 -
12	Binder over laid-up cores: 12.1 Material 12.2 Nominal thickness	 mm	 - -
13	Diaphragm Sheath 13.1 Composition 13.2 Minimum radial thickness Pressure retaining sheath: 13.3 Composition 13.4 Minimum radial thickness	 mm mm	 - - Aluminium, Material EIB to BS. 1475 (1969) 1.35
14	Number and nominal dimensions of flutes (fluted sheaths only)	-/mm	-
15	Nominal diameter over sheath	mm	68.8
16	Control tapes over diaphragm sheath: 16.1 Material 16.2 Nominal thickness 16.3 Nominal width 16.4 Number of tapes per layer 16.5 Number of layers	 mm mm 	 - - - - -
17	Bedding under reinforcement: 17.1 Material 17.2 Nominal thickness	 mm	 - -
18	Reinforcement: 18.1 Material 18.2 0.10% Proof stress 18.3 Nominal thickness 18.4 Nominal width 18.5 Number of tapes per layer	 N/mm ² mm mm 	 - - - - -

SECTION 2
SUB-SECTION 2.4
ISSUE A

ITEM			
	18.6 Number of layers		-
	18.7 Maximum working stress	N/mm ²	-
19	Protective outer covering:		Extruded PVC
	19.1 Material		
	19.2 Minimum average thickness	mm	3.3
20	Nominal overall dimension(s) of completed cable.	mm	76.7
21	Skid wires (for pipe-line cables)		
	21.1 Material		-
	21.2 Dimensions	mm	-
	21.3 Number		-
	21.4 Nominal lay length	mm	-
22	Nominal weight per metre of completed cable (Excluding pipe for pipe-line cable)	kg	13.4
23	Pipe for pipe-line cable:		
	23.1 Overall diameter	mm	-
	23.2 Thickness	mm	-
	23.3 Nominal weight per metre	kg	-
24	Minimum radius of bend round which cable can be laid:		
	24.1 Laid direct or in air	m	2.3
	24.2 In ducts	m	2.7
	24.3 With cables placed in position adjacent to joints and terminals		
	(i) Without former	m	1.6
	(ii) With former	m	1.6
25	Nominal internal diameter of pipes or ducts for self-contained cable	mm	125
26	Maximum d.c resistance of conductor per m of cable at 20°C	μΩ	17.6
27	Maximum a.c resistance of conductor per m of cable at 90°C	μΩ	24.9
28	Equivalent star reactance per m of three phase circuit at 50 Hz	μΩ	175
29	Maximum electrostatic capacitance per core per m of cable	pF	550
30	Maximum charging current per conductor per m of cable at nominal voltage.	mA	13.2

SECTION 2
SUB-SECTION 2.4
ISSUE A

ITEM			
31	Current carrying capacity (see also item 41)	A	(W) 1240 (S) 1140
32	Maximum dielectric loss angle of charging VA of cable when laid direct in the ground at nominal voltage, normal frequency and operating oil/gas pressure, at a conductor temperature of: 20°C 90°C		0.0028 0.0024
33	Maximum dielectric loss of cable per m of three-phase circuit when laid direct in the ground at nominal voltage, normal frequency and operating oil/gas pressure at maximum conductor temperature.	W	7.2
34	Maximum dielectric loss angle of charging VA of cable at normal frequency and at following oil/gas pressure, at a conductor temperature of 20C 34.1 At factory test oil pressure (as specified in Schedule F) Nominal voltage 200% Nominal voltage 34.2 At factory test gas pressure (as specified in Schedule F) 25% Nominal voltage 50% Nominal voltage		0.0028 0.0036 - -
35	Maximum change in dielectric loss angle between nominal voltage and 200% nominal voltage at 20°C		0.0008
36	Sheath loss (including reinforcement) of cable per metre of three-phase circuit at nominal voltage, normal frequency and operating oil/gas pressure, at current rating given in Item 31.	W	W 2.8 S 2.4
37	Conductor short circuit current carrying capacity for 1 second, cable loaded as in Item 31 before shore circuit, and final conductor temperature 160°C	kA	103

SECTION 2
SUB-SECTION 2.4
ISSUE A

ITEM			
38	Oil feed pipes: 38.1 Material 38.2 Dimensions 38.3 Protective covering	mm	Please refer to Table 8 of ESI 09-4
39	Gas feed pipes: 39.1 Material 39.2 Dimensions 39.3 Protective covering	mm	- - -
40	Oil content per metre	litres	1.3
41	Installation and operating conditions on which current carrying stated in Item 31 is based. 900mm to top of cables. The circuit consists of three cables in horizontal formation at 200mm centres , with sheaths specially bonded, installed in cement-bound-sand. Thermally independent trench (W) Winter rating (S) Summer rating Maximum conductor temperature Ground ambient Environment thermal resistivity	 °C °C °C- m/W	 (W) (S) 90 90 10 15 1.05 1.20

SCHEDULE 4
DETAILS OF TECHNICAL PARTICULARS
SECTION 2.4.5
132,000 VOLT SINGLE CORE XLPE INSULATED CORRUGATED
ALUMINIUM SHEATHED SOLID CABLE

SECTION 2
SUB-SECTION 2.4
ISSUE A

ITEM			
1.	Voltage between phases of three phase circuit	kV	132
2.	Number of cores		1
3.	Nominal cross sectional area of conductor	mm ²	400
4.	Conductor details: 4.1 Material 4.2 Design 4.3 Overall diameter	mm	Copper 3 23.4
5.	Extruded Conductor Screen: 5.1 Material 5.2 Nominal Thickness (Minimum average) 5.3 Minimum Thickness	mm mm	Semi-Conducting XLPE 1.0 0.7
6	Maximum dielectric stress at nominal voltage 6.1 At conductor screen (assumed smooth) 6.2 At core screen	MV/m MV/m	6.2 2.4
7	Insulation: 7.1 Material 7.2 Minimum average thickness of insulation between conductor screen and core screen 7.3 Minimum thickness at a point	mm mm	XLPE 20.0 19.0
8.	Core screen: 8.1 Semi-conducting screen (a) Material (b) Thickness (minimum average) 8.2 Copper screen (a) Number and diameter of wires (b) Number and thickness of counter spiral tape 8.3 Protection tape	mm No./mm No./mm	Semi conducting XLPE 1.5 6 crepe carbon papers

SECTION 2
SUB-SECTION 2.4
ISSUE A

ITEM			
9.	Nominal diameter over metallic screen	mm	
10.	Impervious metallic sheath		Aluminium material to EIB 1474 (1969)
10.1	Material and type		
10.2	Minimum radial thickness	mm	1.6
11.	Nominal diameter over metallic sheath	mm	85.4
12.	Outer Covering		PVC
12.1	Material		
12.2	Minimum average thickness	mm	
12.3	Minimum at a point	mm	2.96
13.	Nominal overall diameter of completed cable	mm	94.0
14.	Nominal weight per metre of complete cable	kg	9.9
15.	Minimum radius of bend round which cable can be laid		
15.1	Laid direct or in air	m	2.9
15.2	In ducts	m	3.3
15.3	With cables place in position adjacent to joints and terminations	m	1.9
16.	Nominal internal diameter of pipes or ducts	mm	150
17.	Maximum d.c resistance of conductor per m of cable at 20°C	microhm	46.1
18.	Maximum a.c resistance of conductor per m of cable at 90°C	microhm	60.5
19.	Equivalent star reactance per m of three phase circuit at 50 Hz	microhm	72
20.	Maximum d.c resistance of metallic screen/sheath per m of cable at 20°C	microhm	75
21.	Maximum electrostatic capacity per core per metre of cable.	pF	150
22.	Maximum charging current per conductor per metre of cable at nominal voltage	mA	3.6
23.	Current carrying capacity (see also item 33)	A	(W) 650 (S) 550
24.	Maximum tangent of dielectric loss angle of cable when laid direct in the ground at nominal voltage, normal frequency at a conductor temperature of:		
	20°C		0.001
	90°C		0.002

THE EAST MIDLANDS ELECTRICITY BOARD

CABLES AND ACCESSORIES MANUAL

SECTION 2.5

2.5 **MULTICORE PILOT, UNDERGROUND AUXILIARY AND TELEPHONE CABLES.**

2.5.1 **Pilot and Telephone Cables**

See Section 6.3.4 of the Transmission Planning Manual.

The following sizes and types of pilot and telephone cable should generally Business Unit used in conjunction with distribution cables up to and including 33kv.

The cables should have plain annealed copper wire polythene insulated, polythene inner sheathed, steel wire armoured, P.V.C outer sheathed multipair cables for use where the induced voltage does not exceed 5kv in accordance with Table 2.8 of ESI 09.6 Issue 6.

With one mains cable the size of pilot should be 7 pair 1/0.9mm. The protection circuits are provided by paralleling pairs of conductors i.e. 3 pairs provide 3 protection conductors. The Orange/White, Orange/Blue and Orange/Grey pairs have been specially designed in manufacture to limit crosstalk and attenuation on carrier and audio working and these nominated pairs should not be used for protection purposes.

Generally with duplicate circuit mains cables two separate pilot cables of 7 pair 1/0.8mm should not be used. The Orange/White, Orange/Blue and Orange/Grey pairs should not be used for protection purposes.

2.5.2 **Auxiliary Multicore Cables**

Auxiliary multicore cables should have 7/0.67 plain annealed copper wire P.V.C insulated P.V.C bedding, steel wire armoured, P.V.C outer sheathed normal duty in accordance with Table 1 of ESI 09-6 Issue 6.

THE EAST MIDLANDS ELECTRICITY BOARD

CABLES AND ACCESSORIES MANUAL

SECTION 2.5.3

**DETAILS OF POLYTHENE INSULATED POLYTHENE INNER SHEATHED, S.W.A
 P.V.C OUTER SHEATHED MULTIPAIR CABLES FOR USE WHERE THE INDUCED
 VOLTAGE LEVEL DOES NOT EXCEED 5KV.**

		7 Pair	19 Pair
Conductor	mm	1/0.8	1/8
Radial Thickness of Insulation	mm	0.5	0.5
Nominal Diameter under Inner Polythene Sheath.	mm	7.9	16.0
Thickness of Inner Polythene Sheath	mm	0.8	0.8
Nominal Diameter over Inner Polythene Sheath.	mm	9.5	18.0
Size of Armour Wire	mm	0.9	1.6
Thickness of Outer P.V.C Sheath.	mm		
Nominal		1.4	1.7
Minimum		0.92	1.16
Nominal overall diameter	mm	14.1	24.8
Approximate weight per metre	kg	0.4	1.3

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CABLES AND ACCESSORIES MANUAL

SECTION 2.5.4

**DETAILS OF P.V.C. INSULATED POLYMER INNER SHEATHED, S.W.A P.V.C
OUTER SHEATHED MULTICORE CABLES.**

			7 Core	19 Core
Conductor		mm	7/0.67	7/0.67
Radial Thickness of Insulation	Min Ave	mm	0.7	0.7
	Minimum	mm	0.50	0.56
		mm	10.8	17.8
Nominal Diameter under Polymer Sheath				
Thickness of Inner Polymer Sheath	Nominal	mm	0.8	0.8
	Minimum	mm	0.58	0.58
		mm	12.4	19.8
Nominal Diameter over Inner Polymer Sheath				
Size of Armour Wire		mm	1.25	1.6
Thickness of PVC oversheath	Nominal	mm	1.50	1.70
	Minimum	mm	1.50	1.16
Nominal overall diameter		mm	18.0	26.8
Approximate weight per metre		kg	0.7	1.55

SECTION 2
SUB-SECTION 2.5
ISSUE B

THE EAST MIDLANDS ELECTRICITY BOARD

CABLES AND ACCESSORIES MANUAL

SECTION 2.5.3

**DETAILS OF POLYTHENE INSULATED POLYTHENE INNER SHEATHED, S.W.A
P.V.C OUTER SHEATHED MULTIPAIR CABLES FOR USE WHERE THE INDUCED
VOLTAGE LEVEL DOES NOT EXCEED 5KV.**

		7 Pair	19 Pair
Conductor	mm	1/0.8	1/8
Radial Thickness of Insulation	mm	0.5	0.5
Nominal Diameter under Inner Polythene Sheath.	mm	7.9	16.0
Thickness of Inner Polythene Sheath	mm	0.8	0.8
Nominal Diameter over Inner Polythene Sheath.	mm	9.5	18.0
Size of Armour Wire	mm	0.9	1.6
Thickness of Outer P.V.C Sheath.	mm		
Nominal		1.4	1.7
Minimum		0.92	1.16
Nominal overall diameter	mm	14.1	24.8
Approximate weight per metre	kg	0.4	1.3

SECTION 2
SUB-SECTION 2.5
ISSUE A

THE EAST MIDLANDS ELECTRICITY BOARD

CABLES AND ACCESSORIES MANUAL

SECTION 2.5.4

DETAILS OF P.V.C. INSULATED POLYMER INNER SHEATHED, S.W.A P.V.C
OUTER SHEATHED MULTICORE CABLES.

			7 Core	19 Core
Conductor		mm	7/0.67	7/0.67
Radial Thickness of Insulation	Min Ave	mm	0.7	0.7
	Minimum	mm	0.50	0.56
		mm	10.8	17.8
Nominal Diameter under Polymer Sheath				
Thickness of Inner Polymer Sheath	Nominal	mm	0.8	0.8
	Minimum	mm	0.58	0.58
		mm	12.4	19.8
Nominal Diameter over Inner Polymer Sheath				
Size of Armour Wire		mm	1.25	1.6
Thickness of PVC oversheath	Nominal	mm	1.50	1.70
	Minimum	mm	1.50	1.16
Nominal overall diameter		mm	18.0	26.8
Approximate weight per metre		kg	0.7	1.55

SECTION 2
SUB-SECTION 2.4
ISSUE A

ITEM				
25.	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	1.6	
26.	Maximum value of tangent of dielectric loss angle of cable at normal frequency at a conductor temperature of 20°C Up to 50% Nominal voltage at 100% Nominal voltage at 200% Nominal Voltage		0.001 0.001 0.002	
27.	Maximum change in tangent of dielectric loss angle between 50% nominal voltage and 200% nominal voltage at 20°C		0.001	
28.	Metallic core screen loss of cable per metre of three-phase circuit at nominal voltage, normal frequency at current rating given in Item 23.	W		
29.	Metallic sheath loss of cable per metre of three-phase circuit at nominal voltage normal frequency at current rating given in Item 23.	W	(W)	(S)
			28	20
30.	Conductor short circuit current carrying capacity for one second cable loaded as Item 23, before short circuit and final conductor temperature of 250°C	kA	56.0	
31.	Screen short circuit current carrying capacity for 1 second cable loaded as Item 23 before short circuit and final screen temperature 250°C	kA		
32.	Metallic sheath short circuit current carrying capacity for one second cable loaded as Item 23 before short circuit and final sheath temperature of 250°C	kA	40.5	
33.	Installation and operating conditions on which current carrying stated in Item 23 is based			
34.	900 mm to top of cables. The circuit consists of one trefoil of cable in a thermally independent trench, with sheath bonded and earthed at both ends of the route. (W) Winter rating (S) Summer rating Maximum conductor temperature Ground temperature Thermal Resistivities:- Soil: Outside 50°C isotherm Inside 50°C isotherm Backfill: Inside 50°C isotherm		(W)	(S)
		°C	90	90
		°C	10	15
			1.05	1.2
			1.05	3.00
			1.05	2.70

EQUIPMENT POLICY AND DEVELOPMENT DEPARTMENT
NETWORKS SECTION**CABLE PRESSURE TEST VOLTAGES (kV)****1. SOLID PAPER, OR PRESSURE ASSISTED (OIL) CABLES**

SYSTEM VOLTAGE	NEW INSTALLATIONS 15 MINS. D.C.		EXISTING INSTALLATIONS 15 MINS. D.C.	
	PHASE TO PHASE	PHASE TO EARTH	PHASE TO PHASE	PHASE TO EARTH
6.6kV	-	-	18	11
11kv	34	25	30	18
33kV	-	66	-	60
132kV	-	305	-	228

Notes:

- For insulated metallic sheaths, apply initial 10kV dc for 1 min.
(repeat test 5kV dc for 1 min.)
- On cross-bonded earth systems, temporary bond earths at joints/terminations and disconnect sheath voltage limiters (SVL)
- On very old or suspect cable systems D.C. test for 5 mins. to system voltage and leave on soak at AC system voltage for 24 hours before loading cable if practicable.

2. POLYMERIC CABLES (XLPE OR EPR)

SYSTEM VOLTAGE	NEW INSTALLATIONS 15 MINS. D.C.		EXISTING INSTALLATIONS 0-10 YEARS 10 MINS. D.C.		EXISTING INSTALLATIONS OVER 10 YEARS 5 MINS. D.C.	
	PHASE TO PHASE	PHASE TO EARTH	PHASE TO PHASE	PHASE TO EARTH	PHASE TO PHASE	PHASE TO EARTH
11kv	34	25	30	18	25	12
33kV		66		60		38
132kV		305		228		152

Notes:

- Voltage levels apply equally to single and three core cables.
- Values can apply for suspect oil-filled sealing ends.
(These must be individually inspected for loss of oil and tracking).
- On very old or suspect cable systems D.C. test for 5 mins. to system voltage and leave on soak at AC system voltage for 24 hours before loading cable if practicable.

Central Networks

A company of **e-on**

Cable Laying Technical Requirements

Version	Prepared by	Approved by	Issue Date
5.3	T Haggis	R Ferris	2 September 2005

Revision Log for Cable Laying Technical Requirements

Changes made in version 5.3

Date	Section	Notes about the change
2/09/2005	32.1	Paragraph re-worded "All Central Networks' cables installed in the public environment shall be laid in black rigid corrugated ducts complying with ENATS 12-24 together with warning tape or tiles. Cables may be laid without ducts inside substations."

Changes made in version 5

Date	Section	Notes about the change
18/02/2005	31.2	Reference included to PPG3 residential sites
	32.3	Requirements for spacing between ducts for blinding / consolidation explained.
	Appendix A & C	Appendix A changed to read 'Cables Laid Along Footpaths and PPG 3 Road/Footpaths' Appendix C changed to read 'Cables Laid Across and Along Roads'
10/11/2004	Section	Document modified to reflect adoption of ducting all cables Duct cable drawings added to appendices A,B,C Appendix H added showing spacing of 11kV transformer tails

Changes made in version 3

Date	Section	Notes about the change
13/11/2002	Section 3 Cable Installation	Paragraph 32.3 Amendments to requirements for ducts, tapes & tiles due to introduction of Electricity Safety, Quality and Continuity Regulations 2002. Appendices A,B & C Amendments to drawings showing changes as a result of Paragraph 32.3 Appendix D Changes to duct size for 70mm ² Triplex 11kV cable. Appendix G Contractors item codes removed (no longer needed).

24/11/2003	Section 3 – Cable Laying Technical Requirements.	Section 1 22.1 – specification added to 33kV tiles. Appendix G – joint hole dimensions & text amended.
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TECHNICAL REQUIREMENTS:

Cable Laying

1. Introduction

- 11.1 This document defines the technical results to be obtained by the *Service Provider* together with the constraints he must operate under.
- 11.2 The *Service Provider* shall decide to how to achieve these results and shall provide method statements as required under his Contract.
- 11.3 Central Networks may approve or reject the *Service Provider's* method statements in accordance with the provisions of the Contract.

2. Excavation

21 Signing & Guarding

- 21.1 Public highway
All Works carried out shall comply with:
 - 1. New Roads and Street Works Act 1991 "Safety at Street Works and Road Works" code of practice.
 - 2. "Chapter 8 of the Traffic Signs Manual" published by the Dept. of Transport.
- 21.2 Private land
All works carried out shall be protected to the same degree as 21.1 unless otherwise agreed by the landowner.
- 21.3 Agricultural land
In addition to 21.1 and 21.2 the *Service Provider* may use electric fencing to protect livestock from the Works provided that:
 - The *Service Provider* obtains permission from the owner of the livestock and the landowner or tenant.
 - The electric fencing displays warning signs at a minimum of every 2 meters.

21.4 Courtesy Boards

A the *Service Provider* shall provide and display a courtesy board at each Site showing:

- the *Service Provider's* name
- Central Networks' name and 24 hour telephone number
- an approved apology message on behalf of Central Networks.

22 Excavation

22.1 Prior to excavation the *Service Provider* shall consult the plans of all utilities plant and then confirm their position by use of suitable instruments.

22.2 Excavation shall be carried out in accordance with the "HAUC Specification for the Reinstatement of Opening in Highways" document section S3 and Guidance Document HS(G)47 "Avoiding Danger from Underground Services" issued by the Health and Safety Executive

22.3 Trench dimensions are not specified but shall be sufficient to allow the *Service Provider* to install the ducts and cables:

- at the depth and spacing specified
- within the bending radii specified
- within the pulling tensions specified
- without damage to the cable sheaths

23 Reinstatement

23.1 Reinstatement shall be carried out in accordance with the "HAUC Specification for the Reinstatement of Opening in Highways" document sections S5 to S10.

23.2 Previously excavated materials may be used as back-fill. It is the responsibility of the *Service Provider* to assure the suitability of the materials for re-use and this procedure shall be included in his method statement.

23.3 There shall be a minimum separation of 25mm between adjacent ducts and between ducts and the trench side to enable proper consolidation of blinding material around, under and between ducts. (except 33kV see section 32.2)

3. Cable Installation

31 Depth & Spacing

31.1 Appendices A,B & C show the final physical positions of cables and ducts to be achieved in relation to finished ground level. The *Service Provider* shall determine the size of excavation required to achieve the result.

31.2 On building sites the cable route shall be:

- Sites with footpaths or service strips: - in accordance with NJUG recommendations.
- Sites without footpaths or service strips: – along the combined road/footpath as agreed with the site developer. *These sites are designed according to HM Government Planning Policy Guidelines 3 (Known as PPG3)*

In both cases the cable laying details are according to Appendix A.

31.3 On existing highway the route shall be agreed between the *Service Provider* and the *Project Manager* to minimise the cost to Central Networks consistent with good engineering practice.

31.4 Primary substation transformer tails.
The ratings shown in table 3.3.1.F of the Network Design Manual depend on the cores being laid in the correct formation and spacing. Appendix G shows the standard installations.

32 Protection of cables

32.1 Clauses 14(2) & 14(3) of the Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR) require that underground cables shall be protected, marked or otherwise indicated so as to ensure, so far as is reasonably practicable, that any person excavating the land above the cable will be given sufficient warning of its presence.

The Department of Trade & Industry Guidance Document lists the following methods in order of preference:

- (i) Cable installed in a duct with marker tape above.

- (ii) Cable installed in a duct only.
- (iii) Cable laid direct and covered with a protective tile.
- (iv) Cable laid direct and covered with marker tape.
- (v) Some other method of mark or indication.

All Central Networks' cables installed in the public environment shall be laid in black rigid corrugated ducts complying with ENATS 12-24 together with warning tape or tiles. Cables may be laid without ducts inside substations.

Short sections may be laid direct only where ducts cannot be used such as sharp bend or at jointing positions. Warning tape or tiles shall be used in these situations.

Warning tape and tiles may be omitted where trenchless excavation is used. However, the cables must be ducted.

Yellow marker tape shall be used for LV Services, LV Mains and 11kV Mains and this shall be installed 240mm below the finished surface.

33kV cables shall have interlocking plastic tiles or tile-tape (to ENATS 12-23) laid 75mm above the cables/ducts on top of the blinding material.

See drawings in Appendices A,B & C

Laying cables direct without the protection of ducts, tape, tiles or tile-tape is expressly forbidden except within substations.

32.2 Blinding with fines

Short sections of laid direct cable - the trench bottom shall be cleared of all sharp objects before pulling in the cable. The *Service Provider* shall place a 25mm layer of blinding material on the trench bottom before pulling in. The installed cable shall be covered with a layer of blinding material which shall cover the cable to a depth of 75 mm.

Ducts – shall be consolidated into the blinding material ensuring that no voids exist under or

between ducts.

The LV & 11kV duct arrangements show a spacing of 25mm between ducts to enable the voids between ducts to be filled and consolidated with fine-fill.

The 33kV trefoil arrangement shows the three ducts touching. These ducts shall be fastened together with suitable plastic cable ties to prevent movement and be treated as a single duct for backfilling purposes. This is to ensure that the three single cores remain in trefoil formation at a controlled spacing which has been taken into account in the cable rating calculations.

(Note if the cores are separated too far the circulating currents in the screen wires increase and cause additional heating).

32.3 Blinding material

LV and 11kv direct laid cables shall be blinded with a fine-fill material consisting of:

- excavated earth or soil which contains no stones or flints.
- imported excavated materials that have been screened through a 3 mm diameter mesh.

or

- cable laying sand, i.e. stone free sand of a composition suitable for cable laying and which will resist migration. (Builders sand is expressly prohibited)

33kV direct laid cable shall be blinded with cable laying sand or other fine material as may be agreed with the *Project Manager*.

Duct for all voltages shall be blinded with a fine-fill material consisting of:

- excavated earth or soil which contains no stones or flints.
- imported excavated materials that have been screened through a 3 mm diameter mesh.

32.4 Ducts across or along roads

Ducts installed by open cut methods shall have the marker tape laid at a position below the road base construction directly above the ducts.

At road crossings the ends of the ducts shall extend 150mm into the footpath as measured from the footpath edge of the kerb.

- 32.5 Direction of road crossings.
When installing road crossing ducts the *Service Provider* should be aware of the bending radii and pulling tensions of the cable concerned. The *Project Manager* shall normally accept proposals to install a crossing at a slight diagonal across the road to ease bending and friction where necessary.
- 32.6 Ducts installed by trenchless methods
Ducts for HV cables shall be supplied by the *Service Provider* which shall be mechanically suitable for the installation method to be used. The ducts shall be coloured black or red and be embossed with the legend "Danger Electric Cable" in such a way that the marking shall not be damaged during the pulling in process.
- 32.7 The ducts sizes
Appendix D shows the size of duct required for each cable size.

33 Pulling in cables

- 33.1 Bending radii
The minimum bending radii of cables currently used by Central Networks are shown in appendix E. Where cable types not shown in appendix E are to be installed the *Project Manager* shall give guidance to the *Service Provider*.
- 33.2 Pulling in tensions
The maximum pulling in tensions are shown in appendix F.
Any winch used shall have a dynamometer fitted which shall be calibrated at the intervals shown in the *Service Provider's* method statement.
- 33.3 Manhandling
Where cables are to be manhandled, flaked or pulled in from moving vehicles the *Service Provider* shall show how this is to be done in his method statement.

In the case of flaking, the bending radii must not be less than twice the minimum shown in appendix E.

33.4 Sealing cut ends

Cables shall be sealed by means of a mastic lined heat shrink cable cap or cold shrink cap. Single core cables laid up in triplex formation shall have a separate cap applied to each core. The *Service Provider's* method statement shall detail the method of application which shall include the degreasing and abrading the cable sheaths.

33.5 Precautions during low temperatures

PVC SHEATHED CABLES

Where the ambient temperature of the Site is below zero degrees centigrade, precautions are necessary to prevent the PVC cable sheath from cracking.

The *Service Provider* shall arrange with for any drums to be used during sub zero conditions to be maintained above zero degrees centigrade for 24 hours before pulling in takes place.

The *Service Provider's* method statement shall show his proposed method of pre-warming cables that have to be laid at short notice or in an emergency.

The following cables are PVC sheathed:

- Hybrid Service Cable
- LV CNE Cable (Alpex & Wavecon)
- 11kV PICAS Cable

POLYETHYLENE SHEATHED CABLES

Polyethylene sheathed cables can be laid at temperatures down to 20^o C below zero.

The following cables are Polyethylene sheathed:

- 11 kV XPLE Triplex
- 33 kV XPLE Single Core

33.6 Single core cables

Single core cables shall be arranged in trefoil formation and bound with plastic cable ties every 1.2 metres.

Where cables are supplied already bundled in

**Not sure if it's
PVC or
Polyethylene ?**

Simple Test:

Cut off a piece of sheath and place it in water.

PVC sinks

Polyethylene floats
(so does XLPE)

triplex formation cable ties will not be required.

4. Earthing and Bonding of Single Core Cables

41 LV Cables

LV cables shall be earthed and bonded in accordance with the Earthing Manual - Section E6 - Protective Multiple Earthing

42 Three Core Cables

There are no special requirements for earthing and bonding three core cables.

43 Single Core Cables

11kV Triplex Cables

Triplex to triplex joints. The screens of each core shall be jointed through without bonding to the other phases.

Triplex to PICAS or PILSWA joints. The screens of each core shall be jointed to the cable sheath.

At terminations the screens from all three cores shall be connected together and connected to the HV earth. (i.e. Solid Bonding)

Transformer Singles (11kV/33kV, Primary/Grid S/S)

These may be laid in trefoil or flat formation.

In either case the screens shall be earthed at one end only to prevent de-rating due to circulating currents. (i.e. Single Point Bonding)

33kV Circuits

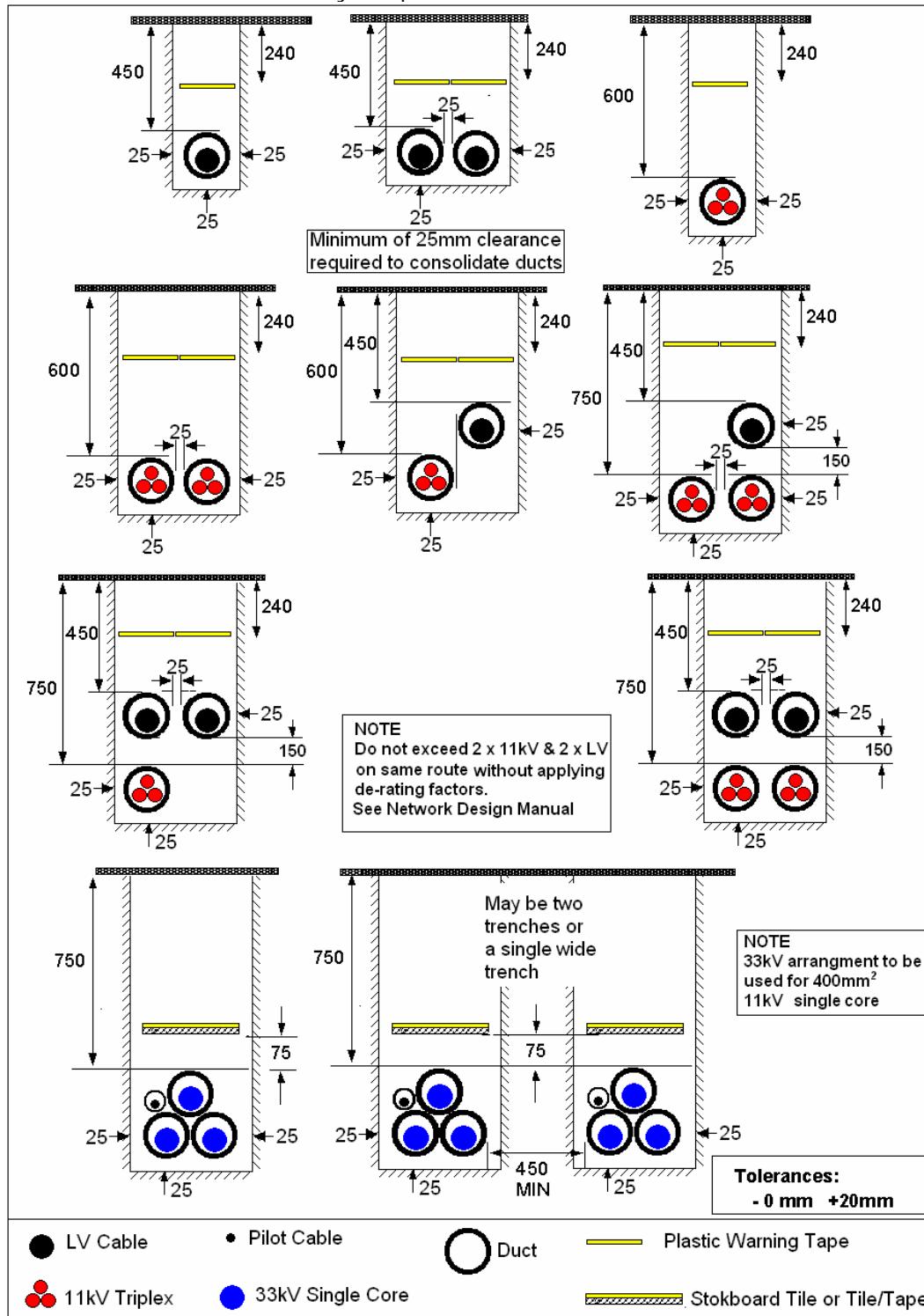
Cables laid in trefoil (direct or in ducts) shall be earthed at both ends. (Solid Bonding)

Cables laid in flat formation may be subject to de-rating due to screen wire circulating currents. Please refer to the Cables Engineer in Assets Management for guidance on Cross-Bonding the screens.

Appendix A

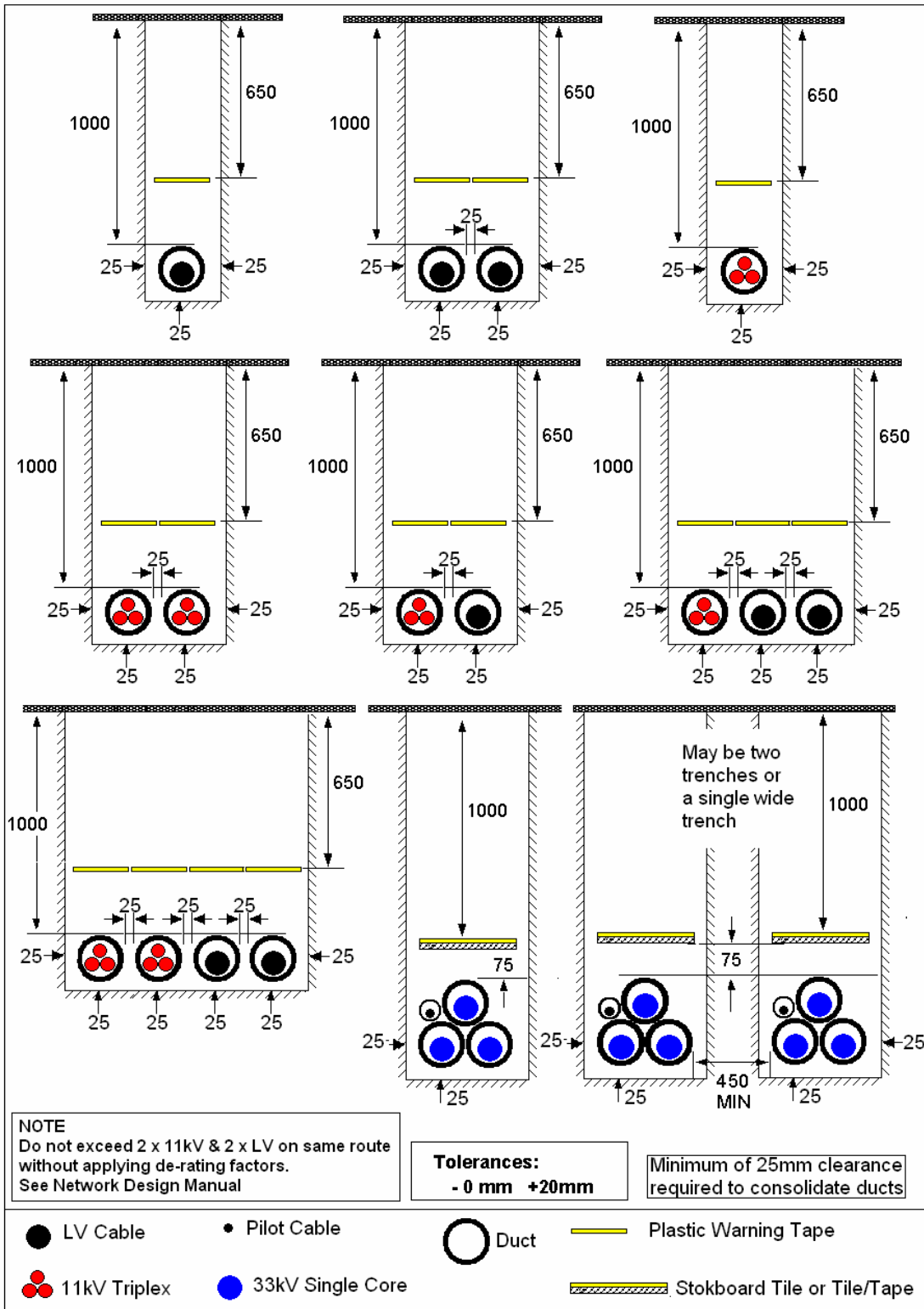
Cables Laid Along Footpaths and PPG 3 Road/Footpaths

Note – PPG3 sites are high density residential developments without footpaths or service strips. Vehicles and pedestrians use a combined roadway/footpath.



Appendix B

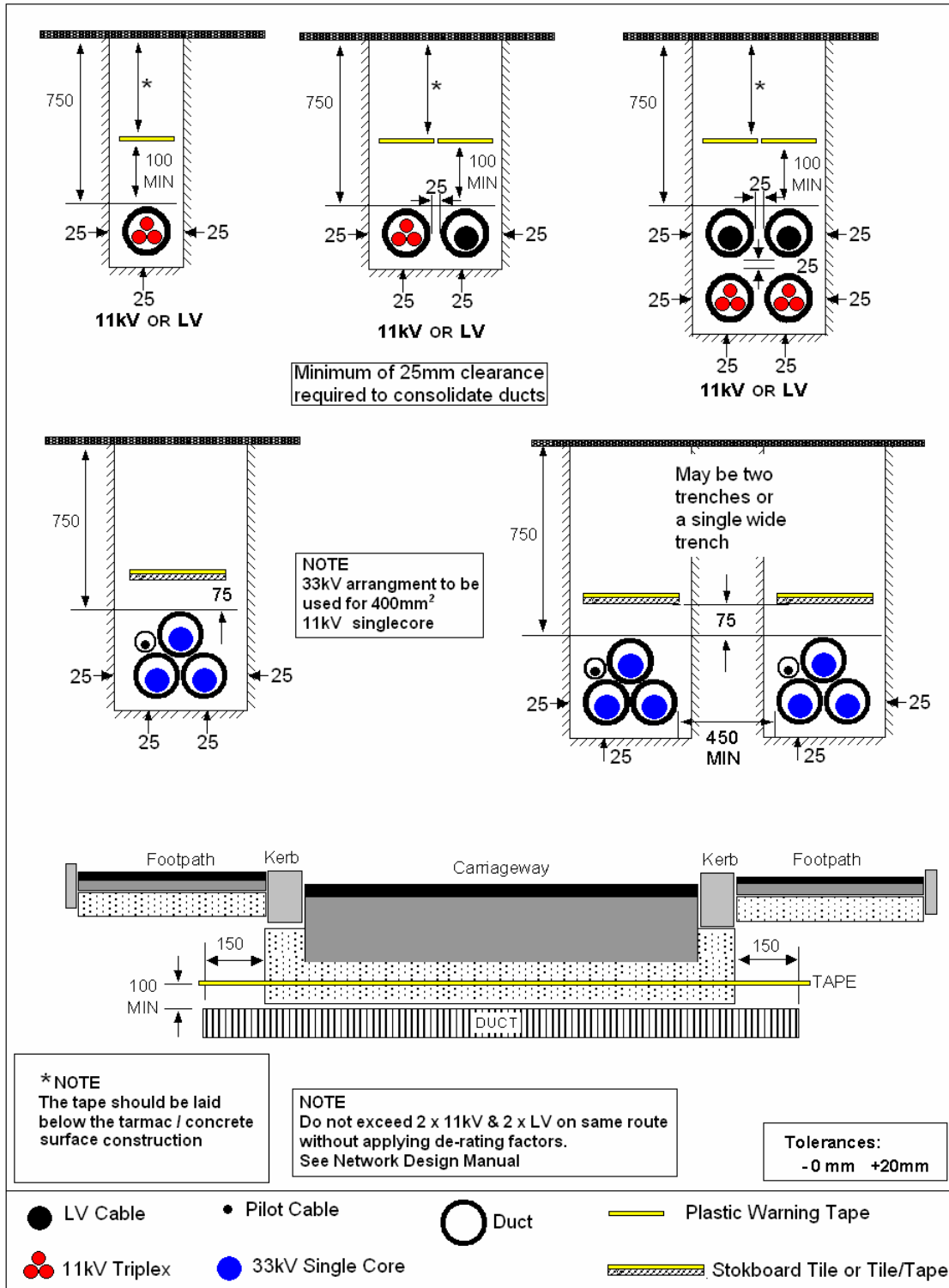
Cable Laid in Agricultural Land



Appendix C

Cables Laid Across and Along Roads

Note – Does not apply to PPG 3 sites in high density residential developments.
See Appendix A



Appendix D
Standard Duct Sizes

Cable Description	Cable Diameter (mm)	Duct Size (mm) (internal dia)
4 sq mm ² 1 core LV service	6.5	38
25 sq mm ² 1 core LV service	16.6	38
35 sq mm ² 1 core LV service	20.1	38
35 sq mm ² 3 core Wavecon CNE	30.5	50
95 sq mm ² 3 core Wavecon CNE	34.5	125
185 sq mm ² 3 core Wavecon CNE	46.9	125
300 sq mm ² 3 core Wavecon CNE	55.9	125
600 sq mm ² 1 core LV	38.0	125
95 sq mm ² 11 kV PICAS	49.2	125
185 sq mm ² 11 kV PICAS	60.7	125
300 sq mm ² 11 kV PICAS	72.5	125
70 sq mm ² 11 kV XLPE Triplex	3 x 26.9 = 58	125
95 sq mm ² 11 kV XLPE Triplex	3 x 28.6 = 62	125
150 sq mm ² 11 kV XLPE Triplex	3 x 31.7 = 68	125
185 sq mm ² 11 kV XLPE Triplex	3 x 33.1 = 72	125
300 sq mm ² 11 kV XLPE Triplex	3 x 38 = 82	125
300 sq mm ² Cu 11 kV XLPE Triplex	3 x 39 = 84	125
400 sq mm ² Cu 11 kV XLPE single core	41.7	3 x125
630 sq mm ² Cu 11 kV XLPE single core	49.5	3 x125
150 sq mm ² Cu. 33 kV XLPE single core	43	3 x125
240 sq mm ² Cu. 33 kV XLPE single core	47.5	3 x125
300 sq mm ² Cu. 33 kV XLPE single core	50	3 x125
400 sq mm ² Cu. 33 kV XLPE single core	53.3	3 x125

Appendix E

Minimum Bending Radii

Cable Description	Minimum radius of bend	
	on route (Metres)	at termination (Metres)
4 sq mm ² 1 core LV service	0.075	0.075
25 sq mm ² 1 core LV service	0.10	0.10
35 sq mm ² 1 core LV service	0.13	0.13
35 sq mm ² 3 core Wavecon CNE	0.45	0.45
95 sq mm ² 3 core Wavecon CNE	0.65	0.40
185 sq mm ² 3 core Wavecon CNE	0.85	0.54
300 sq mm ² 3 core Wavecon CNE	0.95	0.620
600 sq mm ² 1 core LV	0.85	0.85
95 sq mm ² 11 kV PICAS	0.60	0.58
185 sq mm ² 11 kV PICAS	0.75	0.60
300 sq mm ² 11 kV PICAS	0.90	0.70
70 sq mm ² 11 kV XLPE Triplex	0.55	0.425
95 sq mm ² 11 kV XLPE Triplex	0.575	0.45
150 sq mm ² 11 kV XLPE Triplex	0.65	0.50
185 sq mm ² 11 kV XLPE Triplex	0.70	0.55
300 sq mm ² 11 kV XLPE Triplex	0.80	0.60
150 sq mm ² Cu. 33kV 1 core XLPE (3 in trefoil)	0.90	0.65
240 sq mm ² Cu. 33kV 1 core XLPE (3 in trefoil)	0.95	0.75
300 sq mm ² Cu. 33kV 1 core XLPE (3 in trefoil)	1.00	0.75
400 sq mm ² Cu. 33kV 1 core XLPE (3 in trefoil)	1.10	0.80

Appendix F

Mechanical Pulling-in Tensions

Cable Type	Cable Size mm ²	Method to be used	Maximum Tension	
			kN	kgf
Wavecon CNE	95	Double eye stocking	3.0	305
Wavecon CNE	185	Double eye stocking	7.0	713
Wavecon CNE	300	Double eye stocking	7.0	713
11kv PICAS	95	Double eye stocking Double eye stocking & sheath pinned to cores	3.9 6.8	400 700
11kv PICAS	185	Double eye stocking Double eye stocking & sheath pinned to cores	6.3 11.7	650 1200
11kv PICAS	300	Double eye stocking Double eye stocking & sheath pinned to cores	9.8 19.6	1000 2000
11kV XLPE Triplex	70 Al	Double eye stocking on each core	6.1	630
11kV XLPE Triplex	95 Al	Double eye stocking on each core	8.4	855
11kV XLPE Triplex	150 Al	Double eye stocking on each core	13.2	1350
11kV XLPE Triplex	185 Al	Double eye stocking on each core	16.3	1665
11kV XLPE Triplex	300 Al	Double eye stocking on each core	19.6	2000
11kV XLPE Triplex	300 Cu	Double eye stocking on each core	19.6	2000
11kV XLPE Triplex	400 Cu	Double eye stocking on each core	19.6	2000
33kv XLPE single core	150	Double eye stocking on each core 1 core only 3 cores together	7.3 19.6	750 2000
33kv XLPE single core	240	Double eye stocking on each core 1 core only 3 cores together	11.7 19.6	1200 2000
33kv XLPE single core	300	Double eye stocking on each core 1 core only 3 cores together	14.7 19.6	1500 2000
33kv XLPE single core	400	Double eye stocking on each core 1 core only 3 cores together	19.6 19.6	2000 2000

Appendix G

Joint Hole Dimensions

These are suggested minimum joint hole dimensions. However, the actual dimensions must take into account all local site and ground conditions and be adequate to allow cable jointing to be carried out as required by the jointing specification.

Joint Type	Item *	Length (mm)	Width (mm)	Depth (mm)		
				Footpath, Building Sites & Unsurfaced	Agricultural	Carriageway
LV Mains-1 ph service joint and Service-service straight joint	H1	1000	800	650	1200	950
LV Mains-mains straight or breech joint	H2	1200	1000	650	1200	950
LV Mains stop end	H3	1000	800	650	1200	950
11kv straight	H4	1500	1000	900	1300	1050
11kv breech joint	H?	2000	1200	900	1300	1050
11kv stop end	H5	1200	1000	900	1300	1050
33 kv straight or trifurcating joint	H6	3000	1500	1000	1500	1300
Trial Hole to locate services	H7	Contractor to define dimensions				
Launch / reception pit for trenchless	H8	Contractor to define dimensions				





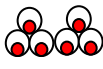
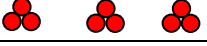
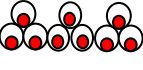
Depth Adjustment

The depths shown in the table assume standard cable laying depths according to appendices A, B & C. Where the actual cable depth differs, the service provider shall increase the depth to establish a clearance of 400 mm between the cable and the hole bottom.

Recommended minimum joint hole dimensions are given in Appendix G however the actual dimensions must take into account all local site and ground conditions and be adequate to allow cable jointing to be carried out as required by the jointing specification.

Appendix H

Transformer 11kV Tails

Formation	Size	Type	11kV	6.6kV
A In trefoil – 1 core per phase  R YB	400 mm ²	Cu Singles	6/12 MVA	
	630 mm ²	Cu Singles		
B Laid singly – 1 core per phase – 100mm spacing between cores  R Y B	400 mm ²	Cu Singles	6/12 MVA	
	630 mm ²	Cu Singles		
C Laid singly – 1 core per phase - ducts touching  R Y B	400 mm ²	Cu Singles	6/12 MVA	
	630 mm ²	Cu Singles		
D In trefoil – 2 cores per phase - 300mm spacing  R R YB YB	400 mm ²	Cu Singles	12/24 MVA	6/12 MVA
	630 mm ²	Cu Singles		
E Laid singly – 2 cores per phase - ducts touching  R R YB YB	400 mm ²	Cu Singles	12/24 MVA	6/12 MVA
	630 mm ²	Cu Singles		
F In trefoil – 3 cores per phase - 300mm spacing  R R R YB YB YB	400 mm ²	Cu Singles		
	630 mm ²	Cu Singles	20/40MVA	12/24 MVA
G Laid singly – 3 cores per phase - ducts touching  R R R YB YB YB	400 mm ²	Cu Singles		
	630 mm ²	Cu Singles	20/40MVA	12/24 MVA

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SECTION 4 L.V. LINK BOXES

INDEX

SUB-SECTION

TITLE

4.1	Installation of L.V. Link Boxes and Accessories
4.2	Link Box Selection Chart
4.3	Link Box Frame and Cover Selection Chart
4.4	List of Standard Link Boxes and Accessories

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4.1 INSTALLATION OF LV LINK BOXES AND ACCESSORIES

General

- 4.1.1 Instructions governing the installation of new and replacement link boxes shall be in accordance with instructions given in the Distribution Planning Manual or by the Chief System Design Engineer.

Generally the installation of a two-way link box is approved if used as an interconnector between substations, capable of carrying 331/3% of transformer capacity i.e. 370 amps for an 800kva transformer.

4.1.2 TWO-WAY LINK BOXES

When on the few occasions two-way boxes are to be connected to LV cables greater than 185mm then non-standard boxes will be required.

4.1.3 FOUR-WAY LINK BOXES

Where installations of four-way boxes are required then approval from the Chief System Design Engineer must be sought before the purchase or use of any four-way boxes except for emergency fault replacement.

Where a four-way box has faulted, then an emergency four-way link box stored at Hinckley Emergency Stores may be booked out.

4.1.4 FRAMES AND COVERS

Pit and Pavement frame and covers are available for the Board's standard two-way link box and two other sizes of pavement frame and cover are available for other boxes. Where pavement frame and covers are used it will be necessary to construct a brick built pit if one does not already exist.

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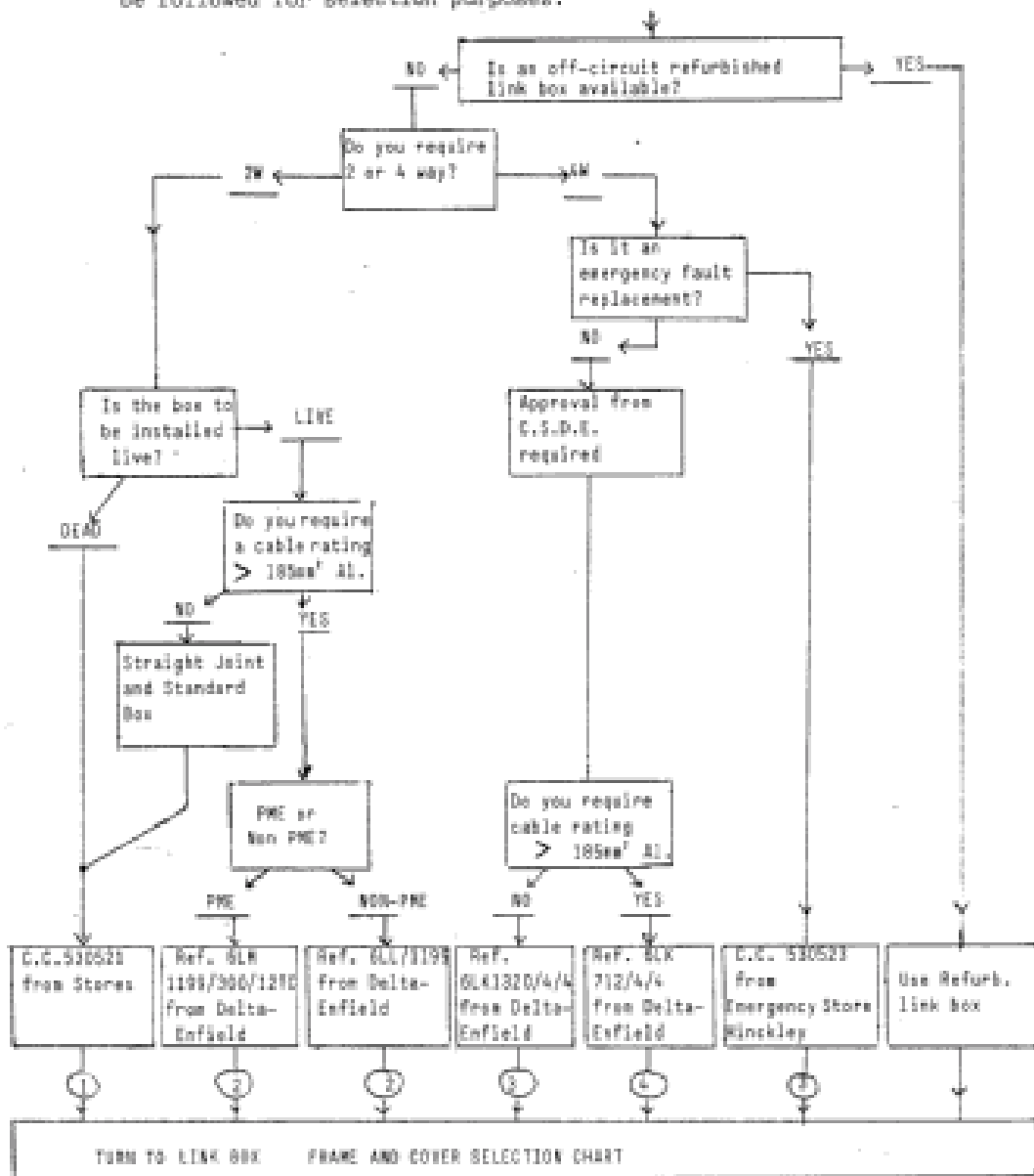
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4.2 LINK BOX SELECTION CHART

New boxes should only be drawn from stores if there are no off-circuit refurbished boxes available locally.

There is only one standard 2 way link box now stocked by the E.M.E.B. and this should be used in all situations where possible. However, for replacement situations and special cases the following chart should be followed for selection purposes.



Delta Enfield Cables Ltd. Accessories Division, West Road, Tottenham, London N17 0RP

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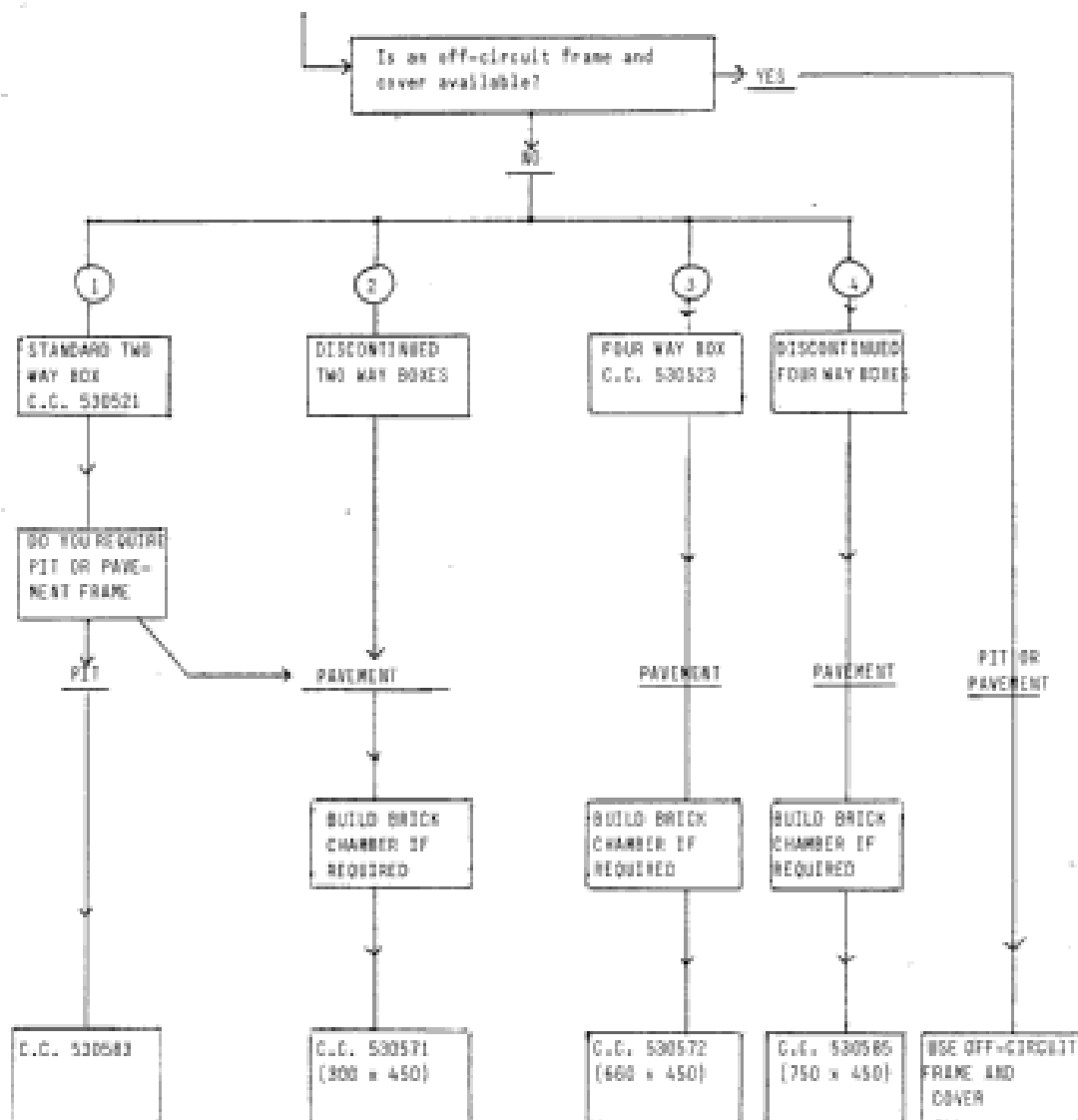
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4.3 LINK BOX FRAME AND COVER SELECTION CHART

If any off-circuit frames and covers are available that have been recovered from the system, these are to be utilised first.



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4.4 STANDARD LINK BOXES AND ACCESSORIES

ITEM

Two-way 400 amp Link Box (185mm Cables) Suitable for PME and Non-PME systems Must be installed onto a Dead network.	Commodity Code 530521
Pit Frame and Cover Suitable for above	Commodity Code 530583
Pavement Frame and Cover (300mm X 450mm) Suitable for above	Commodity Code 530571
Four-way 400 amp Link Box (185mm cables) Suitable for PME and Non-PME systems Must be installed onto a Dead network.	Commodity Code 530523
Pavement Frame and Cover (660mm X 450MM) Suitable for 4W box above.	Commodity Code 530572
Pavement Frame and Cover (750mm X 450MM) For replacements only	Commodity Code 530573

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SECTION 5

CABLE CORROSION

SECTION

TITLE

5.1	List of Relevant Publications
5.2	Introduction
5.3	Types of Corrosion (Examples of types of corrosion issued under separate cover, one set per group)
5.4	Reporting Procedure
5.5	Field Tests
5.6	Corrosion and Cathodic Protection Tables

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CABLES AND ACCESSORIES MANUAL

SECTION 5.1

LIST OF RELEVANT PUBLICATIONS

C46/1 Measures necessary to prevent corrosion damage to buried structures by neighbouring Cathodic Protection Installations.

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CABLES AND ACCESSORIES MANUAL

SECTION 5

CABLE CORROSION

5.2 INTRODUCTION

The importance of cable corrosion, as a study, is not easily appreciated by the Supply Engineer and cable corrosion faults often occur in isolated spots and are dealt with by Engineers whose prime concern is the restoration of supplies. Consequently little evidence to enable a detailed study is available.

In recent years the increased use of Cathodic Protection has resulted in the Electricity Supply being more directly associated with the problem and the experience has enabled a Nationally agreed routine to be followed and has stimulated more interest in cable corrosion generally.

Field experience would indicate that the hessian served, steel tape or wire armoured, lead sheathed cable, as used by Electricity Boards, is not usually prone to serious corrosion damage provided that the constituents of the soil are normal i.e. the soil is not excessively acid or alkali. However, new designs of cable utilising extruded aluminium sheaths are now being used on both M.V. and 33kv systems. Although past experience has shown that the aluminium sheathed cable can suffer from corrosion the new designs of cable have an approved type of anti-corrosion sheath of either extruded PVC or Ploythene and corrosion of the aluminium sheath should not occur provided that the anti-corrosion sheath is not mechanically damaged during the laying of the cable or subsequently during digging operations by other utilities.

From time to time, during jointing or fault location, corrosion may be found on cables and it is essential that the cases be reported to the Engineer as quickly as possible after discovery so that field tests can be carried out and remedial measures instituted to prevent recurrence of the corrosion. Where possible, the local ground conditions should be disturbed as little as possible before the test procedures detailed in Section 5.4 are carried out. To help in the diagnosis of the cause of the corrosion, samples of the corroded cable and surrounding soil or electrolyte should be submitted to Headquarters for laboratory analysis.

Section 5.2 describes the various causes of cable corrosion and the way they affect the cable.

Usually it will not be possible to make a correct diagnosis of the cause of the corrosion until the results of the field tests and laboratory analysis have been completed.

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CABLES AND ACCESSORIES MANUAL

SECTION 5

TYPES OF CABLE CORROSION

5.3 INTRODUCTION

The corrosion may be defined as the destruction of a metal by its conversion into some compound by chemical or electro-chemical action. As applied to buried cables, this is generally the action of corrosive environments, aggressive soil, moisture or water and also electrolysis due to electric currents circulating from any cause whatsoever. Types of corrosion are many and varied and a multiplicity of names describing the corrosion is used, but all cases resolve into the following main groups.

5.3.1 CHEMICAL OR NON-ELECTROLYTIC CORROSION

Chemical corrosion is caused by aggressive substances such as sewage and drainage water or effluent from factories being present in the soil or electrolyte surrounding the cable. The corrosion attack on the cable will proceed without stimulated by any external electric force, but nevertheless is accompanied by circulating currents in the corroding metal. The path of the circulating currents is usually very restricted and corrosion will take place at the point where the current leaves the metal.

Both acids and alkalies can cause corrosion although in practice it will be found that the majority of the corrosion on cables is due to acids. Acidic soils have a pH value less than 5.5 and alkaline soils have a pH value greater than 7.5.

A lead sheath that has been chemically corroded is smooth over the corrosion area with no signs of pitting or intercrystalline attack. Where the cable has been laying partially buried in water white or red corrosion products may be found on the lead sheath.

The so called phenolic corrosion may be encountered on cables installed prior to 1930 when jute impregnated with coal tar was commonly used as the bedding in the cable. It was originally thought that the corrosion was caused by carbon dioxide and moisture reacting with the coal tar impregnated jute forming acetic acid which attacks and corrodes the lead sheath. Recent opinion would indicate that the formation of the acetic acid may be due to sulphate reducing bacteria in the soil which have an affinity for coal tar impregnated jute.

Phenolic corrosion may be found either in the form of a flakey white corrosion product which tends to follow the line of the jute fillers or, where jute string has been used for the bedding of the cable, a succession of small cavities following the lay of the jute strings with very few armour on affected cables to suffer severe corrosion.

Electrolytic corrosion is always accompanied by the flow of current by an ionic path to or from a cable sheath and the formation of anodes and cathodes on the surface of the sheath. The anodic area is the place where the current leaves the metal and the corrosion damage occurs. The lead sheath at these positions is generally rough with a clear evidence of inter-crystalline attack and has characteristic deep sided pitting often running along the length of the sheath.

Generally electrolytic corrosion may be caused in three different ways but the corrosion pattern is similar.

LOCAL CELL OR NATURAL CURRENT CORROSION

This corrosion is set up by circulating currents developed in the cable system itself. The origin of these currents may be differences in the cable sheathing material (or of any material connected to it) but is more generally due to differences in the soil through which the cable passes. The current gives rise to natural current electrolysis and the actual values are very small. This is sometimes referred to as "Long Line Currents".

This type of corrosion is quite often to be found where bare lead sheathed cables are laid in ducts.

(b) BI-METALLIC GALVANIC CORROSION

When dis-similar metals are connected together in the presence of oxygen and/or moisture, stray direct currents will flow between the metals with corrosion occurring on the metal from which the current is flowing. Every metal has a natural electrode potential. Typical values of various metals are given in Table A. Silver is the most 'noble' metal and magnesium the most 'base'. Current will always flow from the base metal to the noble. The greater the potential difference between the metals the greater the risk of corrosion.

The compound hessian serving of power cables gives little protection against stray current corrosion although approved types of anti-corrosion sheathing, such as PVC, are very effective.

Bi-metallic corrosion can occur on cabling in substations if they are laid close to earth nests made up of coke breeze with copper, iron or steel earth electrodes.

Engineering Recommendation S5/1 "Earthing Installations in Substations" recommends that coke should not be used for earth electrodes and all copper connections should be installed above ground where possible or wrapped. If the cables are neither provided with anti-corrosion servings nor installed in surface troughing it is necessary to maintain a separation of at least 10' between the cables and the buried conductors to avoid the possibility of electrolytic action.

Aluminium sheathed cables, because of their natural electrode potential, are particularly prone to bi-metallic corrosion if they are connected to other metals in corrosive conditions.

(c) STRAY CURRENT CORROSION

Severe corrosion may be caused by stray currents d.c. traction systems or cathodic protection installations which use total or partial earth return. At places where the stray current enters the cable, protection against corrosion will be afforded but where the current leaves, which is usually the closest point to the current source, severe corrosion may occur depending upon the size of the current flowing. For example 1 amp direct current for one year will deposit or move 11b of lead. If all the current is concentrated at one point then the damage will be more severe if it is spread over a length of cable.

5.3.4 FATIGUE CORROSION

Intercrystalline fracture or cracking due to metal fatigue is generally accepted as wholly mechanical failure and this is probably true for the majority of cases. If, however, the initial crystal separation in a fatigue metal takes place in the presence of an electrolyte, as with, say an immersed cable sheath, failure can be accelerated due to local action between the crystals.

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SECTION 5

REPORTING PROCEDURE

- 5.4 All incidents of corrosion resulting in cable fault or incidents necessitating remedial action should be reported to the Chief Engineer's Department.

In order to obtain some of the information it may be necessary to carry out field tests. These tests should be carried out as soon as possible after the reporting of the fault and preferably before the cable or surrounding soil has been unduly disturbed.

New installations of Cathodic Protection by other bodies on plant which crosses or moves close to existing cables should be referred to Head Office Equipment Policy & Development. The procedures laid down in C4611 will then be followed to ensure minimal impact on our plant.

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CABLES AND ACCESSORIES MANUAL

SECTION 5

FIELD TRIALS

5.5 INTRODUCTION

It is usually impossible to come to any firm conclusions to the cause of the corrosion without the analysis of the cable and soil and without carrying out the full range of field tests described below.

5.5.1 POTENTIAL MEASUREMENT TESTS

Details of the instruments and methods of carrying out the potential measurement tests are described in Appendix 4 of Engineering Recommendation C.46. Potential measurements should be taken as close as possible to the position of fault using the faulty cable as the reference connection. Where possible, the tests should be carried out with the faulty cable still connected into the main cable system using the lead sheath of the cable as reference and the half-cell buried as close as possible but without touching the cable. If the potential measurements taken near the position of fault are -500 mV or less then it may be concluded that the corrosion is of an electrolytic nature i.e. due to stray currents or local cell action. However, in order that a full picture may be obtained, further potential measurements should be made at two yard intervals along the route of the cable and away from the fault to see whether the potential is varying and if so, to locate the lowest potential position. Normally this is the position where the corrosion risk is the greatest.

In carrying out the tests, whilst the most accurate measurements are obtained by putting the half-cell as close as possible to the structure under test, provided that the route of the cable is accurately determined, then it is sufficient to place the half-cell directly above the cable concerned.

The potential measurement method of test is particularly useful for determining whether cables are being corroded or likely to be corroded by nearby substation earth tests.

5.5.2 SOIL RESISTIVITY TESTS

It is now generally recognised that it is possible to determine whether a soil is corrosive or not by taking soil resistivity tests on the surface of the ground above the affected structure using a Bridge Megger and the Wenner four pin method of test. If the depth of the cable is known, the pins should be spaced with the equivalent distance in centimetres. The resistivity of the soil at cable

depth in ohms per centimetres is given by $2 \frac{a}{R}$ where 'a' is the distance between the pins in centimetres and 'R' is the resistance in ohms measured on the Bridge Megger.

Bridge Meggers which measure soil resistivity normally use alternating current in order to avoid undesirable polarisation effects at the interface between the electrodes and the ground.

Whilst it is not possible to give absolute guidance on the levels at which corrosion can be said to occur, resistivity figures given in Table B have been found to give a good guide.

Even without testing it is possible to tell by look and feel the type of soil in which the cable or structure is buried. Tables C and D give approximate values for the types of soil which may be encountered out in the field.

5.5.3 SHEATH CURRENT MEASUREMENT

British Telecom have adopted a technique of measuring sheath currents and it has been found to be very successful where corrosion due to stray currents is suspected. Briefly, the instrument consists of a Tinsley Reflecting galvanometer having a resistance of 10ohms and a deflection sensitivity of 10 micro volts per millimetre, together with an auxiliary circuit which enables a known current to be passed through the section of cable sheath under test for calibrating the galvanometer in terms of sheath current per unit deflection. The reflecting galvanometer is sufficiently dead beat to enable it to follow accurately the rapid changes of current met with in stray current systems. In use tests are at 1/4 or 1/2 minute intervals over a period of about 10 or 20 minutes and the results are recorded on a standard form.

5.5.4 LABORATORY AND FIELD TESTS ON SOIL AND CABLE

Facilities are available to obtain the assistance of the Laboratories of the C.E.G.B Non Destructive Test Department in assessing cable corrosion. In such cases where assistance is required, samples of the corroded cable and surrounding soil should be sent to the Chief Engineer's Department for forwarding onto the Laboratories. The soil samples should be of not less than 250 grammes weight, sealed in a plastic bag and clearly labelled as to the sampling position. Ideally a section of the faulty cable should be cut out for examination in the laboratory and care should be taken not to disturb or clean off any of the corrosion products which may be present on the cable sample, in particular scraping the affected part clean should be avoided as valuable evidence may be destroyed.

When taking soil samples care should be taken to remove the soil from undisturbed earth as far as possible as this will not disturb any of the existing conditions.

It is possible to carry out simple tests in the field to test the chemical reaction of soil or duct water using litmus comparative papers. The papers are available in book form to cover both coarse and fine ranges of 'PH' values from Johnsons the photographic suppliers.

The usual procedure for using these books is to put a drop of the duct or soil water on the underside of the paper and the colour subsequently appearing on the upper side is compared and the pH value obtained from a colour chart which is shown on the inside of the book cover. It is important to keep the papers as dry as possible before use and to avoid handling them unnecessarily. If, in order to obtain a satisfactory indication, it is necessary to damp the soil, pure distilled water should be used.

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SECTION 5

CORROSION AND CATHODIC PROTECTION TABLES

TABLE A

METALS	NORMAL ELECTRODE POTENTIAL (RELATIVE TO THE NORMAL HYDROGEN ELECTRODE)
“Noble End”	Volts
Silver	+ 0.7995
Copper	+ 0.3448
Hydrogen	0.0000
Lead	- 0.126
Iron	- 0.440
Zinc	- 0.7620
Aluminium	- 1.67
Magnesium	- 2.34
“Base End”	

TABLE B

RESISTIVITY (OHM - METRE)	ASSESSMENT
23	Very Aggressive
23 - 50	Moderately Aggressive
50 - 100	Slightly Aggressive
100	Non-Aggressive

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CORROSION AND CATHODIC PROTECTION TABLES

TABLE C

NATURE OF SOIL	RESISTIVITY (OHM - METRE)
Clay in colloidal Dispersion	3 -10
Lean clay or sand, finely dispersed	10 - 100
Sand moderately dispersed	100 - 400
Gravel and stones, coarsely dispersed	4 - 1700

TABLE D

BEHAVIOUR WITH RESPECT TO IRON	PH	DESCRIPTION	BEHAVIOUR WITH RESPECT TO LEAD
Very Aggressive	4 4.0 - 4.5	Extremely Acid Very Acid	Very Aggressive
	4.5 - 5.0 5.0 - 6.0	Acid Slightly Acid	
Aggressive	6.0 - 6.5	Slightly Acid	Slightly Aggressive
Non-Aggressive	6.5 - 7.5 7.5 - 8.5	Neutral Slightly Alkaline	Non-Aggressive
Doubtful	8.5	Very Alkaline	Very Aggressive

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SECTION 6

MAINTENANCE

SUB-SECTION

- 6.1 Procedure for X-Raying Cable Joints
- 6.2 Preventive Maintenance on Oil Systems of Pressure Assisted Cables.
- 6.3 Repair to Lead/Aluminium Sheaths on Pressure Assisted Cables.
- 6.4 Procedure for the Inspection of Faulted Cables.
- 6.5 Site testing of contact pressure gauge with test valve.
- 6.6 Inspection and Maintenance - Underground Cables.
- 6.7 Strategic Consortium Stock - 25/33kv Cables and Accessories.
- 6.8 Compression heads and die sets for B.I.C.C. lugs, stalks and ferrules.

PROCEDURE FOR X-RAYING CABLE JOINTS

The regulations governing the use of radio active substances on site including radio active sources used to take X-ray photographs are:-

- No. 808 "The Ionising Radiation (Sealed Sources) Regulations 1969
- No.1974 The Radio Active Substances (Carriage by road) (Great Britain) Regulations 1974
- Radio Active Substances Act 1960
- Radio Active Substances Act 1948

Other useful Government publication are:-

Code of Practice for the carriage of Radio Active Materials by Road Guidance Notes for the protection of persons exposed to Ionising Radiations in Research and Teaching.

The major point which comes out of the regulations is that if an ionising or radio active source is to be used on a site controlled by E.M.E.B., then the Board must appoint an 'Ionising Radiation Competent Person'. The Board's Safety Officer has had training in the field and is normally appointed the Competent Person (IR). It is necessary for the competent person to be on site.

The C.E.G.B. Midlands Region Non Destructive Testing Department are willing to implement X-ray work for the Board. The Engineer concerned is Mr. Fred Price and he may be contacted on Derby 850059 or Coles Hill 64339.

The C.E.G.B. Non Destructive Testing Offices are situated at Castle Donington Power Station.

The C.E.G.B. usually use contractors to carry out the work. The main contractor is "Non Destructive Ltd.", a member of the Technical Services Division of Royal Insurance. Their laboratories are located at East Midlands Airport, Castle Donington, near Derby, Telephone No. 0332 811206.

The procedure is:-

- (a) Contact Mr. F. Price, tell him the name of the E.M.E.B. Competent Person (IR) and fix a date to visit the site.
- (b) A member of Mr. Price's staff will visit the site to assess the technical requirements. Fix a date for the X-ray.
- (c) On the agreed date the C.E.G.B. and their contractors will appear on site. They will implement all safety measures, including barriers, and test radiation readings. They will take X-rays.
- (d) The X-ray photographs may be viewed the next day at Non Destructive Testing Laboratories at Castle Donington Airport.

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CABLES AND ACCESSORIES MANUAL

PREVENTIVE MAINTENANCE ON OIL SYSTEMS OF PRESSURE ASSISTED

CABLES

The following makes recommendations as regards certain aspects of maintenance of oil filled cable circuits following experience on 132KV cable faults and reflects practice adopted prior to the takeover of the 132KV System by E.M.E.B.

1. OIL PIPE INSULATORS

A majority of the earlier oil filled circuits were fitted with bakelite oil pipe insulators. These have been found to deteriorate with time and crack leading to oil leaks at these points. It is therefore recommended that when the opportunity arises for example during investigations for oil leaks or cable diversions etc., where work is required on a cable joint, the oil pipe insulators shall be replaced with the epoxy resin type irrespective of whether they are leaking or not.

2. PERMANENTLY BURIED OIL TANKS

For economy a number of circuits were provided with buried tank oil feed points which were not equipped with readily accessible isolating valves or pumping pits. This feature unnecessarily extends fault maintenance outages and in the long term will lead to increased maintenance costs.

It is therefore recommended that when the opportunity arises, for example during investigations of oil leaks or cable diversions etc., pumping pits with isolating features shall be installed at all buried oil tank positions when this is practicable.

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REPAIR TO LEAD/ALUMINIUM SHEATHS ON PRESSURE ASSISTED CABLES

In the event of either third party damage or a works fault in a localised area which requires minor remedial work to the CSA/lead sheath this is carried out using split copper sleeve.

This method is only employed when in the opinion of a specialist from the Cable Manufacturer, and with the agreement of the Board, a new section of cable is not required. This usually means that the damage/works fault is only to the CSA/lead sheath and that the screening and papers are not badly torn.

The cable is usually frozen on both sides of the repair position but on some oil systems the profile is such that a freeze need only be carried on the high pressure side of the repair.

Copper strips and grub screws are used to seal the splits and are plumbed over. On lead sheathed cables the tin bronze reinforcing tapes would be terminated into the plumbs. As there are no standard fibre-glass boxes (each repair merits a different diameter and length of sleeve) the sleeve would be insulated to protect the integrity of the fully insulated cable system. A compound filled wood box is fitted over the sleeve to give some additional protection.

(Note: The clearance between the CSA/lead cable sheath and the sleeve can be as little as 12mm).

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CABLES AND ACCESSORIES MANUAL

PROCEDURE FOR THE INSPECTION OF FAULTED CABLES

All faulted 33kv cable and joints, other than those caused by third party damage, require detailed examination by Headquarters engineers to ascertain, if possible, the cause of the fault.

11kv cable joint faults will also be examined, if required, by Districts.

The following procedure is to be followed in order that faulted cables can be examined expeditiously.

1. All relevant paperwork is to be sent to Headquarters FAO Chief Construction and Maintenance Engineer, and not attached to joints and cables.
2. Cables and joints requiring inspection should not be sent to Headquarters for forwarding to Wollaton.
3. Cables and joints requiring inspection should be delivered to the Jointing Section, Craft Training Centre, Wollaton between 08.30 hours and 16.00 hours.
4. The circuit details should be given on an attached label enclosed in a weather proof envelope. The label should not only give the location at which the fault occurred.
5. Faulted cable lengths and a reference piece, if possible, should not exceed one metre in length.
6. Cables and joints received, without the paperwork, will be retained for two months after which they will be scrapped.
7. Part 1 of the Condition Survey Proforma is to be completed by Groups or Districts with part 2 completed with the details of the inspection carried out by the Headquarters engineer. (see specimen proforma).

ENGINEERING DEVISION

CONDITION SHEET - 35, 31 AND 6, 65V CABLE SYSTEMS

PART I (to be completed by Group E.O. or District)

1 Name of Circuit.....District.....
 Design Voltage.....Working Voltage.....Conductor Size.....
 Type of Cable.....Date of Fault.....
 Manufacturer.....Date.....
 Installed.....Operated.....
 2 Loading
 Last Water's Max Load (amps).....
 Type of Load: Domestic/Industrial/Mixed Domestic Industrial
 Load Variation: Even/Severe/Moderate
 Remarks on Past History of Load.....

3 Site Description

Length of Circuit	From	To	Profile

4 Fault History
 (Attach single line diagram indicating position and dates of previous faults at sealed locations)

5 Other comments on installation, e.g. amount of cables in ducts, soil conditions etc.

PART 2 (to be completed by Board E.O.) Date of Examination.....

Summary of Examination Results

1 External condition of cable (apart from fault damage) Satisfactory External Damage
 2 Metallic Sheath Satisfactory Scored or ripped Corroded
 3 CWI Satisfactory Fers Rockled
 4 Screen tapes Satisfactory Fers Rockled
 5 Insulation (a) registration Satisfactory Fair Poor
 (b) papers Satisfactory bers Rockled Slightly Creased
 (c) belts (i) core (ii) (iii) (i) (ii) (iii) (i) (ii) (iii) Collapsed
 Moderately creased Severely creased Collapsed
 (c) fillers Satisfactory Damaged Collapsed
 (d) impregnant Satisfactory Moderately dry Dry Slight waxing
 Moderate waxing Severe waxing Slight carbonisation
 Excessive carbonisation Carbon tracing
 6 Conductor condition Bright Turnished Smooth Sharp edged
 Well Perseid- Badly Perseid
 7 Insulation thickness (mm) ACTUAL SPECIFIED (SERC).....
 Mean Sheath / Core 11KV and
 Max Core / Core
 Phase 1 33KV
 Phase 2
 Phase 3
 8 Examiners Comments

Examiners Signature.....Date.....
 Chief Construction & Maintenance Engineers Signature.....Date.....

SECTION 6

PRESSURISED CABLE SYSTEMS

SITE TESTING OF CONTACT PRESSURE GAUGE WITH TEST VALVES

1. Equipment required is as follows:

- 1 - Mercury Reservoir type Manometer
- 1 - Oil Pressure Gun
- 1 - Four Way Connector
- 5 ft - Annealed Copper Pipe with Fittings
- 10 ft - Annealed Copper Pipe with End Firings
- 1 - Saunders 1/2" Valve
- 1 - Drum Tank charged with Degassed Cable Oil

The general arrangement of connections is shown in Appendix A.

2. Disconnect the blank nut and nipple on the gauge test valve block, the plunger inside the test valve should spring outwards and thus cut off the oil supply from the tank to the gauge.
3. Connect the apparatus as shown in the general arrangement drawing with the valve on the drum tank closed. Make sure that the correct nipple end of the 10ft copper pipe is connected to the test valve of the contact pressure gauge. This special nipple has a large bore and will fit into the test valve without depressing the plunger.
4. Make sure that all connections are tight.
5. Release the nut at the bottom of the contact pressure gauge.
6. Turn the handle of the pressure gun in a clockwise direction to expel any air or oil from the pressure gun. During this process a small quantity of oil may be expelled through the bottom connection of the contact pressure gauge.
7. When the handle of the pressure gun is screwed in fully, open the valve on the drum tank slowly to fill the pipework with degasified oil. A small quantity of air may emerge at the bottom connection of the contact pressure gauge. When it is clear that all the air is bled out of the system, tighten the connection at the bottom of the contact pressure gauge.
8. Turn the handle at the bottom of the pressure gun in the anti-clockwise direction, this operation will enable the pressure gun to be filled with degasified oil.
9. When the handle on the pressure gun is wound our fully, close the 1/2" valve to isolate the drum tank. Now the system is filled with degasified oil ready for pressure testing.

10. The pressure readings on the contact pressure gauge should be zero. If the pressure reading is above zero - release the bottom connection of the contact pressure gauge lose some oil thus reducing the pressure to zero. Thereafter tighten the bottom connection on the contact pressure gauge.
11. Screw in slowly the handle of the pressure gun in a clockwise direction so that the pressure in the system is increasing. Readings on the manometer should be compared with the readings on the contact pressure gauge. Allowing for the difference of height, the pressure reading must correspond. The error on a standard pressure gauge should be + 1.0% of the full scale. The maximum pressure should not exceed 35 p.s.i. as any further increase of pressure would cause the mercury in the manometer to be expelled.
12. The contact alarm if necessary can be tested on slow falling pressure. To achieve this, the handle on the pressure gun must be screwed in the anti-clockwise direction slowly to reduce the pressure. When the contact is made, the reading on the manometer and the contact pressure gauge must be noted and compared with the profile data. Three repeat tests should be made to ensure the regularity of the gauge contact. If the contact pressure differs by + 0.5 p.s.i. then the contact needle must be manually re-set on the correct position.
13. The maximum pressure that can be tested using a manometer is 35 p.s.i. If it is required to check the contact pressure gauge through the full range, then it is necessary to replace the pressure gauge on the gun with an accurate, full range (equal to the range on the contact pressure gauge or more) standard test pressure gauge.

SECTION 6

INSPECTION AND MAINTENANCE - UNDERGROUND CABLES

GENERAL

As the greater part of these cables is buried there is little requirement for inspection is almost entirely confined to remedial.

The Board is however required to “Maintain in sound condition the insulation of all electric lines and apparatus (including service lines up to the supply terminals)”. It is also required to regularly inspect all street boxes i.e. underground chambers, and is responsible for all electric lines placed on a consumers premises. Exposed cables other than those in a Boards substation or those connected to an overhead line should be located and inspected as follows:-

Services - Meter reading/changing visits

Exposed cables on public property - Annually

HV, MV, LV in other positions - Annually
(i.e. play areas, bridges, gantries, factory areas).

PRESSURISED CABLE SYSTEMS

A record shall be kept of all installations at the Control Centre detailing location of equipment operating pressures, alarm/trip gauge settings and action to be taken on receipt of alarm etc. or report of low pressure. Details of the facilities offered by manufacturers together with telephone numbers and addresses shall be included.

Inspection/test of these systems shall be carried out by persons instructed in the operation and maintenance of the equipment and a proper record kept of all inspection/tests and maintenance of the equipment including records of make up of oil or gas.

Groups shall ensure at least one engineer is fully acquainted with each of the installations in service within the Group. Group and District staff shall be adequately instructed to carry out any duties which may be required of them (especially out of office hours) with these installations.

Cable pressure gauges shall be read and recorded at each substation inspection. Where leakage has occurred or is suspected a simple graphical record of the pressure variation shall be maintained as long as necessary. In such cases note shall be made of the ambient temperature, load and time the pressure is read.

Cable pressure gauges shall be tested and the correct operation of associated alarm/trip circuits verified at intervals not exceeding two years. It should be noted that recent oil installations incorporate a Pirelli Slide Test Valve which is virtually fool proof. Older installations incorporate a number of valves and when these installations are tested it is

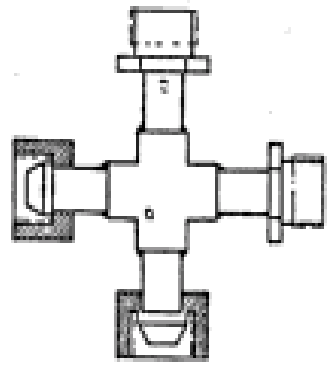
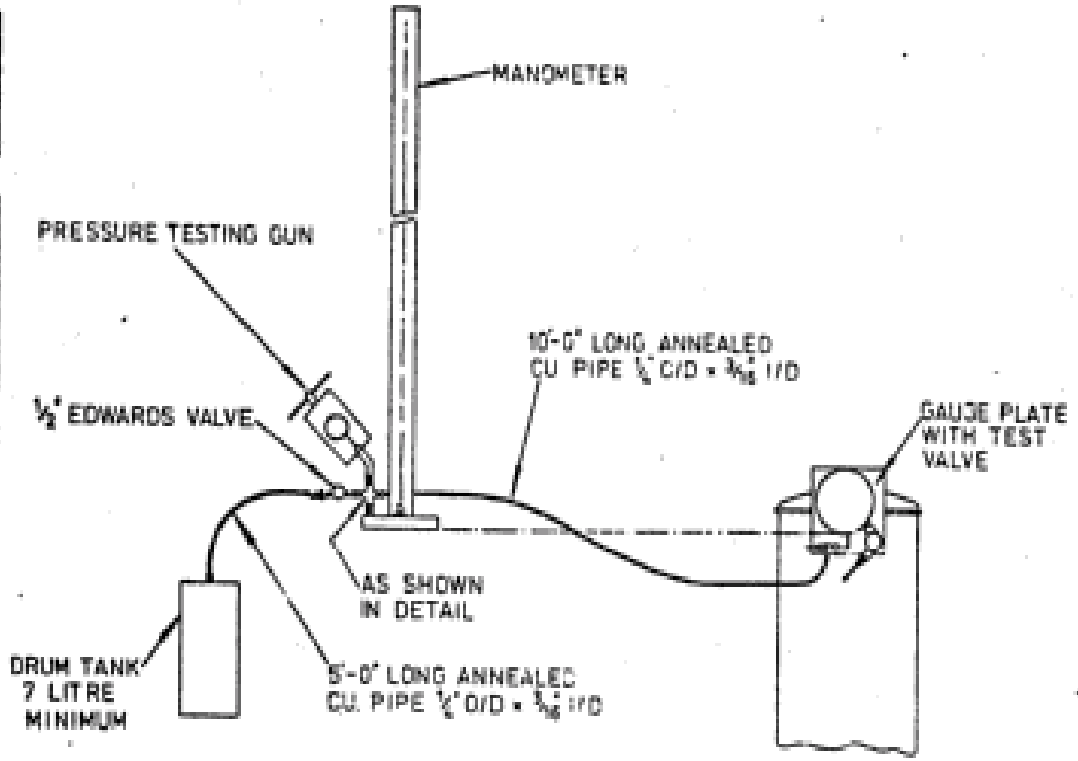
important to ensure the valves are left in the correct position. All installations should be locked off to prevent unauthorised interference.

Oil and gas filled cables which have their sheaths covered with anti-corrosion coverings are to be subjected to a routine pressure test of 5kv DC for one minute as follows.

During the takeover maintenance period every 6 months and a test shall be carried out 6 weeks before the end of the takeover maintenance period and the manufacturer advised immediately if the test is unsatisfactory.

Any breakdown should be dealt with in accordance with the procedure set out in section 15.1 Part 11 of the Operations Manual.

SECTION 12 - 31
 (ISSUE A)
 APPENDIX A



DETAIL OF 4-WAY UNION FITTING

			THE EAST MIDLANDS ELECTRICITY BOARD CHIEF ENGINEER'S DEPARTMENT COPPICE ROAD - ARNOLD - NOTTINGHAM		DRAWN BY: RD 3831	
					CHECKED BY: AR 100875	
					APPROVED BY:	
					SCALE:	
					DRG. No.	
					CE/OM/100/1885	

ADWEL 40074

THE EAST MIDLANDS ELECTRICITY BOARD
CABLES AND ACCESSORIES MANUAL

STRATEGIC CONSORTIUM STOCK - 25/33KV CABLES AND ACCESSORIES

A consortium has been formed with the Midlands and North Western Electricity Boards for the stocking of 25/33kV solid and pressure assisted cables and accessories for fault use.

Detailed schedules of rationalised sizes of cables and accessories etc. were included in the consortium report sent to Districts on 2 March 1987. The types of cables held by the three Boards are summarised as follows:-

E.M.E.B. 33kV three core and single core paper cables and accessories
33kV single core XLPE cables and accessories 25kV concentric oil filled cables and accessories

M.E.B. 33kV three core and single core paper cables and accessories
33kV three core gas filled cable and accessories 25kV concentric oil filled cable accessories

NORWEB 33kV three core and single core paper cable and: accessories
33kV three core and single core paper cable and accessories
33kV three core oil filled cable and accessories

NOTE: 185mm.sq. (cu.) three core PLYSWS cable and accessories are held by all three Boards.

Materials Withdrawal Procedure

- (a) In the event of a fault all material requests and stores issue notes are still to be submitted to South Regional Stores (Hinckley) and not direct to the other consortium members.
- (b) The commodity codes for cables and accessories, held by other consortium members, should be quoted to stores in the normal manner.
- (c) The withdrawal of materials and rechargeable account procedures are generally as Appendix F of the consortium report and will be undertaken by South Regional Stores.
- (d) Under no circumstances are materials to be-drawn other than for faults i.e. on small works except with the specific approval of the Chief Construction and Maintenance Engineer.

The E.M.E.B. is responsible for issuing the quarterly print-outs of all material purchased or issued by all consortium members and this information is available at H.Q. Supplies and Administration Section.

OCTOBER 1987

UNDER REVIEW

THE EAST MIDLANDS ELECTRICITY BOARD

CABLES AND ACCESSORIES MANUAL

B.I.C.C. COMPRESSION HEADS AND DIE SETS ETC. FOR POLYMERIC CABLES

The above equipment is held at the Craft Training Centre, Wollaton.

Appendix A will assist you in ascertaining your requirements for selecting dies for compressed stalks, ferrules or lugs.

Equipment required for jointing will be issued to Districts, upon request, by the Craft Training Centre and the persons to contact between the hours of 08.30 and 16.30 Monday/Thursday and 08.30 and 16.00 on Friday, are Bernard Finch or Bob Bent. In an emergency, during out of hours working, the following personnel can be contacted:-

1. Mr. R. Jackson 0602-293831
2. Mr. R. Palmer 0602-283295
3. Mr. C. Shock 0602-281025

Equipment will be signed for on collection or booked to the appropriate H.Q./District authorised person, if sent via the internal mail system. Replacement of damaged items will be ordered against the appropriate H.Q./District allocation by H.Q. Construction, Cables and Lines Section.

H.Q./Inter-District transfer of items is strictly prohibited without prior authorisation by Craft Training Centre, Wollaton. Stripping tools will not be loaned out from Craft Training Centre. The tools can be purchased by direct order on the various Suppliers by Districts.

Appendix B is a Performa for either collection of items from Wollaton or sending through the internal mail which will be returned to H.Q./Districts when the items are received back at Wollaton. Under no circumstances will equipment be issued without the completed Performa signed by an engineer. Dies or heads should not be collected weeks before planned new works as this makes equipment unavailable when urgently wanted for fault repairs.

If dies etc. are not returned to Craft Training Centre, Wollaton within two weeks of the "Return Date" shown on appendix "B" new dies will be purchased and charged to the appropriate H.Q./ District allocation.

Should a fault occur in another District and a "loaned out" compression head has not been returned, by the date stated, a unit will be hired from B.I.C.C. Components against the holding H.Q./Districts appropriate allocation.

SECTION 6
SUB-SECTION 6.8
ISSUE A

EAST MIDLANDS ELECTRICITY BOARD

CABLES AND ACCESSORIES MANUAL

APPENDIX A

B.I.C.C. COMPRESSION DIES HELD AT CRAFT TRAINING CENTRE, WOLLATON

CONNECTORS AND DIE SET RECOMMENDATIONS					
Conductor Size MM.SQ.	Copper Stalk	Copper Ferrule	Copper Lug	Tin Plated Aluminium Lugs for (CU) or (AI) Cables	
	TOSCC (K)	CC2) ADD CC4) BTH SPLICE CC6) CAT.NO	ECC4C (K) MCCC(K)	MCCU (K)	BIMOLD REF
	35MTC (K)M - 11	250 SC (K) 400 SC (K) M11-2 650 SC (K)	440L RC M11-2 650L RC M11-2	650LRC (K) M-14	ELASTIMOLD REF
				650LRC (K) M-14	Elastimold Ref
120	U168	U185H	U168	U29 ART	
150	U249	U185H	U249	U30 ART	
185	U251	U185H	U251	U31 ART	
240	U267	U300H	U267	U34 ART	
300	U317	U300H	U317	P40 ART	
400	U36 ART	P400H	U36 ART	P40 ART	
500	P40 ART	* P500H	P40 ART	P44 ART	
630	P44 ART		P44 ART	P44 ART	

* Hired as required Prefix U -G10H/G14 Heads
P - G14 Head Only

Note: PU ADAPT - Adaptor for G10 dies into G14 head

THE EAST MIDLANDS ELECTRICITY BOARD

CABLES AND ACCESSORIES MANUAL

APPENDIX B

PROFORMA FOR THE ISSUING AND RETURN OF COMPRESSION HEADS AND DIE SETS ETC

H.Q./DISTRICT: _____

DATE: _____

AUTHORISING PERSON (BLOCK LETTERS) : _____

Would you please supply the following item (s) by.....

Item Description	Return Date	Issued By	Received By	Condition		Received By
				Issue	Return	

SIGNATURE: _____
(Authorising Person)