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Code of Practice 203

Issue 7 May 2023

Current Ratings – Underground Cables



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Amendment Summary

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132kV	Modern and historic (Cont'd)	76,000/132,000V Single core Copper stranded conductor, XLPE insulated, Copper foil laminate with Copper wire screen, MDPE oversheath IEC 60840 (laid direct)	52	48
		76,000/132,000V Single core Copper stranded conductor, XLPE insulated, Copper foil laminate with Copper wire screen, MDPE oversheath IEC 60840 (ducted)	53	49

2 Scope

This Code of Practice (CP) specifies the continuous and cyclic current ratings of underground cables. It covers all those installed on cable systems owned and operated by Electricity North West Limited, (together with selected other distribution and transmission cables that are, or have been, available on the UK market. To ensure a consistent approach to network design and operation, this document shall be the only source of information on the ratings of underground cables for voltages from LV to 76/132kV. The charts in Section 13 of this CP summarise the data for the more important cables and also provide equivalent kVA and MVA ratings, based upon the nominal system voltage.

The tables of ratings in this CP shall be the approved ratings for cables on the Electricity North West Limited network. However, there are circumstances where specific operational or environmental situations indicate that revised ratings are applicable. Examples of such cases are; cable types not included, differing ground thermal resistivity or ground temperature, ratings for multi-cable runs or where additional heat sources are nearby, cyclic loadings for differing load patterns, etc. In these cases, revised ratings shall be calculated using the ratings software package CRATER. The policy for the use of the CRATER to calculate cable ratings is included in this CP.

3 Note on Standards

The ratings of modern cables listed in this CP are obtained from current standards, which are specified. Standards are also generally available for obsolete designs of cable produced after about 1980 and have been referred to. Standards for historic designs of cable prior to that date are often no longer in print. Although older British Standards for cables specified current ratings, modern British and IEC Standards do not, preferring to leave this to the cable manufacturers. This includes the principal paper insulated cable standard, BS 6480. Where the relevant original standard is no longer available, or the modern standard does not specify ratings, recourse has been made to manufacturer's literature. Manufacturer's ratings are generally calculated according to IEC 287.

4 Technical Background to Cable Ratings

The current capacity of any given power cable of fixed conductor cross section, conductor metal and operating voltage depends upon the thermal conditions of the environment in which it operates. There are three factors to consider:

- All types of cable insulation have a specified maximum operating temperature; therefore, the temperature of the environment determines the available temperature rise between that of the non-loaded cable and that of the fully loaded cable. The higher the ambient temperature, the less

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the current capacity of the cable. The tables in this CP all specify the environmental temperature, except those for 132kV cables.

- The thermal resistivity of the ground, which controls the rate at which the heat generated by the cable loss is dissipated. Ground thermal resistivity g is nowadays measured in units of Kelvin metre/Watt, in the past by K cm/Watt, when g is larger by a factor of 100. Sometimes °C are used instead of K, but this makes no material difference. The higher the value of g, the lower is the rate of heat transfer through the ground and the lower is the current rating of the cable. The tables in this CP specify the current rating at a declared value of g, except those for 132kV cables. For modern cables, manufacturers and the Industry standards normally specify only the current rating for g = 1.2KmW-1, because this conservative value is the 'worst case' for UK conditions. However, g = 0.9KmW-1 is considered to be more representative of ground conditions in the Electricity North West Limited licensed supply area and so the current rating for this value is given in the tables, where it is available; if it is not, the value is for g = 1.2KmW-1. In some tables, current ratings for both values of g are specified.

- The presence of other cables or heat sources (for example district steam heating pipes) adjacent to the cable. For cables other than for single phase service cables, the tables specify either a single three-phase circuit or three single-phase cables forming a three-phase circuit and in both cases 'thermal independence' is assumed. Thermal independence means that there is no additional heat source in close proximity, along any part of the cable route. If there is a nearby additional heat source, it will reduce the current capacity of the cable.

More information on these factors is available in Appendix B. Where this CP refers to the rating of a cable installed in a duct, this means a single cable in a single duct. Single core cable ratings are for solidly bonded installations.

4.1 Multi-Cable Runs

It shall be noted that this CP does not give current ratings for cables that are installed in multi-cable runs installed direct or in ducts. Examples of this are where a number of cables emanating from a substation are running together. In such instances it is vitally important that current ratings of cables are calculated on an individual basis. If not, there is a real possibility of localised overheating leading to thermal runaway and premature failure of the cable.

4.2 LV 3-Phase Mains Cables

The tables of ratings for LV 3-phase mains cables in common use in Electricity North West Limited have been derived for a winter ground temperature of 10°C and ground thermal resistivity of 0.9KmW^{-1} representative of ground conditions in the Electricity North West area. This is to reflect that the peak loads on LV cables normally occur during the winter and so allows more economical design of LV networks than would be the case if ratings based on summer ground temperature were used. A continuous and a cyclic rating is given for each cable, thermally independent of any other cable, both laid-direct and in a single-way duct. In addition, cyclic ratings are provided for cables in groups of 2, 3 and 4 cables: laid-direct at 150mm spacing and in touching ducts. The cyclic ratings are derived for a load cycle of 8 hour at 1.0pu and 16 hour at 0.75pu loading. The ratings have been derived from CRATER.

To provide guidance in other ground conditions, tables of continuous ratings are also provided for a ground temperature of 15°C and ground thermal resistivity of 1.2KmW^{-1} using manufacturers' data.

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5 Short Time Ratings

5.1 Cyclic Ratings

The cyclic ratings of those 11kV and 33kV cables installed on Electricity North West Limited's system are specified in the body of this CP and in the summary tables at the end. These ratings are calculated for type A loading (8 hours ON, 16 hours OFF). Under this operating regime, the cyclic loading factors for cables laid directly in the ground, during the 8 hour ON period are:

- Up to 0.06 in² (35mm²) = Factor 1.09
- Between 0.10 in² (70mm²) and 1.00 in² (630mm²) = Factor 1.13

  The above factors are reduced if the cable is in ducts. For 11kV and 6.6kV cables, the cyclic ratings may be restricted by the switchgear rating, for example:

- 400 Amps = 4.57 MVA at 6.6kV and 7.62 MVA at 11kV (at the nominal system voltage).

NOTE: CRATER allows calculation of cyclic ratings for different load curves. In addition, it can be used to calculate the allowable emergency loadings, given the initial and final conductor temperatures.

5.2 Distribution Ratings

'Distribution ratings' are specified for some 11kV cables in Engineering Recommendation P17, published in 1976. These ratings are defined in that publication as 'Ratings calculated for stated conditions commonly occurring on distribution systems'. These are specified as:

- Maximum conductor temperature = 65°C.
- Depth of laying = 0.6 to 3.0 m.
- Ground temperature = 10°C.
- Air temperature = 10°C.
- Soil thermal resistivity g = 0.9KmW^{-1}.
- No allowance for grouping.
- Up to 5 day limited cyclic loading conditions (except in air).
- Winter peak loading.
- Two feeder open ring operation, that is, 50% loading.

'Distribution ratings' are quoted for some of the cables in this CP, in the summary tables on the end pages.

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6 Modern and Historic Designs of LV Service Cables

6.1 Modern LV Service Cable Designs

Table 1

PVC INSULATED STRAIGHT OR SPLIT CONCENTRIC SINGLE PHASE SERVICE CABLES WITH STRANDED COPPER OR SOLID ALUMINIUM PHASE CONDUCTORS AND HELICAL CONCENTRIC COPPER NEUTRAL / EARTH CONDUCTORS				
Conductor size mm²		**Current rating A (*Max core temp = 70°C*)**		
		Direct in ground, g = 1.2KmW^{-1}, T_g = 15°C	**Drawn into ducts, one cable per duct g = 1.2KmW^{-1}, T_g = 15°C**	**In air T = 25°C**
4 (Single Cu core Cu CNE / earth street lighting)		58	43	42
25 (Single Al/ Cu core Cu CNE / earth hybrid domestic service)	Cu Core	163	121	135
	Al Core	126	94	104
35 (Single Al core Cu CNE / earth hybrid domestic service)		154	116	133

Source: Pirelli provided data - 25 April 2001 - See Technical Library 'Rationale Directory'

Table 1a

POLYMERIC INSULATED STRAIGHT OR SPLIT CONCENTRIC SINGLE PHASE SERVICE CABLES WITH STRANDED COPPER OR SOLID ALUMINIUM PHASE CONDUCTORS AND HELICAL CONCENTRIC COPPER NEUTRAL / EARTH CONDUCTORS				
Conductor size mm²		**Current rating A (*Max core temp = 90 °C*)**		
		Direct in ground, g = 1.2KmW^{-1}, T_g = 15°C	**Drawn into ducts, one cable per duct g = 1.2KmW^{-1}, T_g = 15°C**	**In air T = 25°C**
4 (Single Cu core Cu CNE / earth street lighting)		65	49	51
25 (Single Al/ Cu core Cu CNE / earth hybrid domestic service)	Cu Core	185	137	163
	Al Core	143	107	125
35 (Single Al core Cu CNE / earth hybrid domestic service)		174	132	160

Source: Pirelli provided data - 25 April 2001 - See Technical Library 'Rationale Directory'

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Table 2

POLYMERIC INSULATED 3 PHASE STRAIGHT OR SPLIT CONCENTRIC CABLES WITH SOLID ALUMINIUM PHASE CONDUCTORS AND CONCENTRIC COPPER WAVEFORM NEUTRAL/EARTH WIRES			
Conductor size mm²	**Current rating A (*Max core temp = 90 °C*)**		
	Direct in ground, g = 1.2KmW^{-1}, T_g = 15°C	**Drawn into ducts, one cable per duct, g = 1.2KmW^{-1}, T_g = 15°C**	**In air T = 25°C**
25 (Al core /Cu CNE three core)	116	95	106
35 (Al core /Cu CNE three core)	139	113	129

Source: Pirelli provided data – 25 April 2001 - See Technical Library 'Rationale Directory'

6.2 Historic LV Service Cable Designs

Table 3

660/1,100V PVC INSULATED COPPER SINGLE CORE PLUS HELICAL CONCENTRIC COPPER NEUTRAL AND EARTH SPLIT CONCENTRIC SERVICE CABLE.			
Conductor size mm²	**Current rating A (*Max core temp = 70°C*)**		
	Direct in ground, g = 1.2KmW^{-1}, T_g = 15°C	**Drawn into ducts, one cable per duct, g = 1.2KmW^{-1}, T_g = 15°C**	**In air T = 25°C**
16 Cu (Split concentric)	128	94	101

Source: Pirelli provided data – 25 April 2001 - See Technical Library 'Rationale Directory'

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Table 4

660/1,100V TWIN CORE COPPER CONDUCTOR PAPER INSULATED LEAD SHEATHED STEEL TAPE ARMOURED SERVICE CABLES, TABLE 8 BS 480 PART 1 AND CES C2 (1955) PAGE 26					
Conductor size in²	**Current rating A**				
	Direct in ground, g = 0.9 KmW^{-1}, T_g = 15°C	**Direct in ground, g = 1.2 KmW^{-1}, T_g = 15°C**	**Drawn into ducts, one cable per duct g = 0.9 KmW^{-1}, T_g = 15°C**	**Drawn into ducts, one cable per duct g = 1.2 KmW^{-1}, T_g = 15°C**	**In air T = 25°C**
0.007 Cu circular conductor	66	62	54	52	55
0.0145 Cu shaped conductor	99	93	81	78	82
0.0225 Cu shaped conductor	125	120	100	99	105
0.04 Cu shaped conductor	180	165	145	140	150
0.06 Cu shaped conductor	225	210	180	175	190
0.1 Cu shaped conductor	310	285	245	235	265

Source: AEI publication 5513-51.

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Table 5

660/1,100V FOUR CORE COPPER CONDUCTOR PAPER INSULATED LEAD SHEATHED STEEL TAPE ARMOURED SERVICE CABLES, BS 480					
Conductor size in²	**Current rating A**				
	Direct in ground, g = 0.9 KmW^{-1}, T_g = 15°C	**Direct in ground, g = 1.2 KmW^{-1}, T_g = 15°C**	**Drawn into ducts, one cable per duct g = 0.9 KmW^{-1}, T_g = 15°C**	**Drawn into ducts, one cable per duct g = 1.2 KmW^{-1}, T_g = 15°C**	**Laid in air T = 25°C**
0.007 Cu circular conductor	54	51	45	43	45
0.0145 Cu circular conductor	82	77	67	65	69
0.0225 Cu shaped conductor	105	100	86	83	90
0.04 Cu shaped conductor	150	140	120	115	125
0.06 Cu shaped conductor	190	175	150	140	160
0.10 Cu shaped conductor	260	240	205	195	225

Source: AEI publication 5513-51.

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7 LV Mains Cables

7.1 Modern LV Mains Cable Designs

Table 6

BS 7870:1997 (ENA TS 09-9) POLYMERIC INSULATED, COMBINED NEUTRAL/EARTH (CNE) CABLES WITH SOLID ALUMINIUM PHASE CONDUCTORS AND CONCENTRIC COPPER WAVEFORM NEUTRAL/EARTH CONDUCTOR						
Conductor size mm²	**Current rating A ***					
	Direct in ground, $g = 0.9KmW^{-1}$, $T_g = 10°C$			**Single-way duct $g = 0.9KmW^{-1}$, $T_g = 10°C$**		
	Continuous	**Cyclic**		**Continuous**	**Cyclic**	
95 Al	270	300		205	220	
185 Al	390	440		305	325	
240 Al	450	515		355	380	
300 Al	510	580		400	430	
	Grouped cables, Cyclic rating A *					
	Direct in ground, 150mm spacing $g = 0.9KmW^{-1}$, $T_g = 10°C$			**Single-way ducts, touching $g = 0.9KmW^{-1}$, $T_g = 10°C$**		
	2	**3**	**4**	**2**	**3**	**4**
95 Al	290	280	280	215	210	210
185 Al	425	415	405	320	310	310
240 Al	495	485	475	370	365	360
300 Al	555	545	535	420	410	410
	Current rating A **					
	Direct in ground, $g = 1.2KmW^{-1}$, $T_g = 15°C$	**Drawn into ducts $g = 1.2KmW^{-1}$, $T_g = 15°C$**	**Laid in air T = 25°C**			
70 Al	195	160	185			
95 Al (preferred size)	235	190	230			
120 Al	265	220	265			
150 Al	295	245	300			
185 Al (preferred size)	335	275	350			
240 Al	390	320	415			
300 Al (preferred size)	435	360	475			

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Source: * Calculated using CRATER. The ratings apply to both CNE cables and 4 core cables of this type.

** Delta Crompton, based upon the 1991 revision of ENA TS 09-9. This maker also advises that the current ratings for Aluminium CNE cables are the same, as are those for 4 core cables of this type.

Table 7

BS 6346:1989 SINGLE CORE SOLID ALUMINIUM 4 X 90° SECTOR SHAPED CONDUCTOR, PVC INSULATED, 600/1,000V, PVC SHEATHED OVERALL		
Conductor size mm²	**Current rating A**	
	Direct in ground, trefoil $g = 1.2KmW^{-1}$, $T_g = 15°C$	**In air, trefoil T = 25°C**
600 Al (unarmoured)	613	717
600 Al (Aluminium strip armoured, armour bonded at both ends)	586	678

Source: BICC publication No. 598. These single core cables are normally used for transformer tails.

Table 8

BS 5467:1989 SINGLE CORE SOLID ALUMINIUM 4 X 90° SECTOR SHAPED CONDUCTOR, XLPE INSULATED, 600/1,000V, PVC SHEATHED OVERALL		
Conductor size mm²	**Current rating A**	
	Direct in ground, trefoil $g = 1.2KmW^{-1}$, $T_g = 15°C$	**In air, trefoil T = 25°C**
400 Al	550	660

Source: Pirelli General technical office. These single core cables are normally used for transformer tails.

Table 8a

BS 7889:1997 SINGLE CORE COPPER CONDUCTOR, XLPE INSULATED, UN-ARMOURED, 600/1,000V, PVC SHEATHED OVERALL				
Conductor size mm²	**Current rating A**			
	Direct in ground, $g = 1.2KmW^{-1}$, $T_g = 15°C$		**In air, T = 25°C**	
400 Cu	Trefoil	Flat	Trefoil	Flat
	Not to be Used		887	1127

Source: Pirelli Datasheet – See Technical Library 'Rationale Directory'

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Table 8b

BS 5467:1997 SINGLE CORE COPPER CONDUCTOR, XLPE INSULATED, ALUMINIUM WIRE ARMOURED, 600/1,000V, PVC SHEATHED OVERALL				
Conductor size mm²	**Current rating A**			
	Direct in ground, g = 1.2KmW^{-1}, T_g = 15°C		**In air, T = 25°C**	
	Trefoil	Flat	Trefoil	Flat
400 Cu	691	657	851	887

Source: Pirelli Datasheet – See Technical Library 'Rationale Directory't

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7.2 Historic LV Mains Cable Designs

Table 9

ENA TS 09-8 IMPREGNATED PAPER INSULATED 600/1,000V CABLE WITH THREE SOLID ALUMINIUM PHASE CONDUCTORS AND ALUMINIUM SHEATH/NEUTRAL CONDUCTOR (CONSAC)						
Conductor size mm²	**Current rating A ***					
	Direct in ground, g = 0.9KmW^{-1}, T_g = 10°C			**Single-way duct g = 0.9KmW^{-1}, T_g = 10°C**		
	Continuous	**Cyclic**		**Continuous**	**Cyclic**	
95 Al	255	280		195	205	
185 Al	365	405		290	305	
300 Al	485	545		385	410	
	Grouped cables, Cyclic rating A *					
	Direct in ground, 150mm spacing g = 0.9KmW^{-1}, T_g = 10°C			**Single-way ducts, touching g = 0.9KmW^{-1}, T_g = 10°C**		
	2	**3**	**4**	**2**	**3**	**4**
95 Al	270	265	260	200	195	195
185 Al	390	380	375	300	290	290
300 Al	525	510	505	400	395	390
	Current rating A**					
	Direct in ground, g = 1.2KmW^{-1}, T_g = 15°C	**Drawn into ducts, one cable per duct, g = 1.2KmW^{-1}, T_g = 15°C**		**In air T = 25°C**		
70 Al	185	150		165		
95 Al	220	180		205		
120 Al***	250	210		235		
150 Al	280	235		270		
185 Al	320	265		310		
240 Al	370	310		370		
300 Al	420	350		425		

Source: * Calculated using CRATER.
** ENA TS 09-8.
*** Electricity North West Information

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Table 10

660/1,100V STRANDED COPPER CONDUCTOR 4 CORE PAPER INSULATED LEAD SHEATHED STEEL TAPE ARMOURED CABLE TO BS 480 (IMPERIAL SIZES)						
Conductor size Copper in² (Shaped)	**Current rating A ***					
	Direct in ground, g = 0.9KmW^{-1}, T_g = 10°C			**Single-way duct g = 0.9KmW^{-1}, T_g = 10°C**		
	Continuous	**Cyclic**		**Continuous**	**Cyclic**	
0.0225 Cu	115	120		90	95	
0.04 Cu	155	170		115	125	
0.05 Cu	175	190		130	140	
0.06 Cu	200	215		150	165	
0.075 Cu	220	240		170	185	
0.10 Cu	265	290		200	225	
0.12 Cu	295	325		230	250	
0.15 Cu	340	375		260	285	
0.20 Cu	395	440		310	335	
0.25 Cu	450	500		355	380	
0.30 Cu	500	565		400	430	
0.50 Cu	655	745		525	565	
	Grouped cables, Cyclic rating A *					
	Direct in ground, 150mm spacing g = 0.9KmW^{-1}, T_g = 10°C			**Single-way ducts, touching g = 0.9KmW^{-1}, T_g = 10°C**		
	2	**3**	**4**	**2**	**3**	**4**
0.0225 Cu	115	115	110	95	90	90
0.04 Cu	165	160	155	125	120	120
0.05 Cu	185	180	175	135	135	135
0.06 Cu	205	200	200	160	160	155
0.075 Cu	230	225	220	180	175	175
0.10 Cu	280	270	270	220	215	215
0.12 Cu	310	305	300	245	240	240
0.15 Cu	360	350	345	280	275	270
0.20 Cu	425	415	405	330	320	320
0.25 Cu	480	470	465	370	365	360
0.30 Cu	545	530	525	420	410	410
0.50 Cu	715	700	690	555	540	535

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660/1,100V STRANDED COPPER CONDUCTOR 4 CORE PAPER INSULATED LEAD SHEATHED STEEL TAPE ARMOURED CABLE TO BS 480 (IMPERIAL SIZES)					
Conductor size Copper in² (Shaped)	**Current rating A****				
	Direct in ground, g = 0.9 KmW^{-1}, T_g = 15°C	**Direct in ground, g = 1.2 KmW^{-1}, T_g = 15°C**	**Drawn into ducts, one cable per duct g = 0.9 KmW^{-1}, T_g = 15°C**	**Drawn into ducts, one cable per duct, g = 1.2 KmW^{-1}, T_g = 15°C**	**In air T = 25°C**
0.04 Cu	150	140	120	115	125
0.06 Cu	190	175	150	140	160
0.10 Cu	260	240	205	195	225
0.12 Cu***	----	260	----	----	----
0.15 Cu	320	290	255	240	285
0.20 Cu	385	345	305	285	345
0.25 Cu	440	395	345	325	400
0.30 Cu	495	445	385	365	455
0.40 Cu	580	520	455	430	550
0.50 Cu	640	570	500	475	610

Source: * Calculated using CRATER.
** AEI publication 5513-51
*** Electricity North West Information

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Table 11

660/1,100V SOLID ALUMINIUM CONDUCTOR 4 CORE PAPER INSULATED LEAD SHEATHED STEEL TAPE ARMOURED CABLE TO BS 480 (IMPERIAL SIZES)						
Conductor size Aluminium in² (Solid)	**Current rating A ***					
	Direct in ground, g = 0.9KmW^{-1}, T_g = 10°C			**Single-way duct g = 0.9KmW^{-1}, T_g = 10°C**		
	Continuous	**Cyclic**		**Continuous**	**Cyclic**	
0.10 Al	195	215		155	165	
0.20 Al	305	340		240	250	
0.30 Al	390	430		305	325	
0.50 Al	520	585		410	440	
	Grouped cables, Cyclic rating A *					
	Direct in ground, 150mm spacing g = 0.9KmW^{-1}, T_g = 10°C			**Single-way ducts, touching g = 0.9KmW^{-1}, T_g = 10°C**		
	2	**3**	**4**	**2**	**3**	**4**
0.10 Al	205	200	200	160	160	155
0.20 Al	325	320	315	245	240	240
0.30 Al	415	405	400	320	310	310
0.50 Al	560	550	540	430	420	420

660/1,100V stranded Aluminium conductor 4 core paper insulated Lead sheathed Steel tape armoured cable to BS 480 (Imperial sizes)					
Conductor size Aluminium in² (Shaped)	**Current rating A****				
	Direct in ground, g = 0.9 KmW^{-1}, T_g = 15°C	**Direct in ground, g = 1.2 KmW^{-1}, T_g = 15°C**	**Drawn into ducts, one cable per duct, g = 0.9 KmW^{-1}, T_g = 15°C**	**Drawn into ducts, one cable per duct, g = 1.2 KmW^{-1}, T_g = 15°C**	**In air T = 25°C**
0.04 Al	115	110	95	90	95
0.06 Al	150	135	115	110	125
0.10 Al	200	185	160	150	175
0.15 Al	250	225	200	185	225
0.20 Al	300	270	235	220	270
0.25 Al	345	310	270	255	310
0.30 Al	385	350	300	285	355
0.40 Al	460	410	360	340	435
0.50 Al	505	450	395	375	480

Source: * Calculated using CRATER.
** AEI publication 5513-51

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Table 12

660/1,100V STRANDED COPPER CONDUCTOR 4 CORE PAPER INSULATED LEAD SHEATHED STEEL TAPE ARMOURED CABLE TO BS 480 (METRIC SIZES)			
Conductor size mm²	**Current rating A**		
	Direct in ground, g = 1.2KmW^{-1}, T_g = 15°C	**Drawn into ducts, one cable per duct g = 1.2KmW^{-1}, T_g = 15°C**	**In air T = 25°C**
16 Cu	89	76	80
25 Cu	115	99	105
35 Cu	140	120	130
50 Cu	165	140	155
70 Cu	205	175	195
95 Cu	245	210	240
120 Cu	280	240	275
150 Cu	315	265	315
185 Cu	355	300	360
240 Cu	410	355	425
300 Cu	460	395	490
400 Cu	520	445	560

Source: Delta Crompton publication EC1005 9410.

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Table 13

660/1,100V SOLID ALUMINIUM CONDUCTOR 4 CORE PAPER INSULATED LEAD SHEATHED STEEL TAPE ARMOURED CABLE TO BS 6480 (METRIC SIZES)						
Conductor size mm²	**Current rating A ***					
	Direct in ground, $g = 0.9KmW^{-1}$, $T_g = 10°C$			**Single-way duct $g = 0.9KmW^{-1}$, $T_g = 10°C$**		
	Continuous	**Cyclic**		**Continuous**	**Cyclic**	
70 Al	210	230		165	175	
120 Al	295	325		230	240	
185 Al	375	420		295	315	
300 Al	495	560		395	420	
	Grouped cables, Cyclic rating A *					
	Direct in ground, 150mm spacing $g = 0.9KmW^{-1}$, $T_g = 10°C$			**Single-way ducts, touching $g = 0.9KmW^{-1}$, $T_g = 10°C$**		
	2	**3**	**4**	**2**	**3**	**4**
70 Al	220	215	215	170	170	165
120 Al	310	305	300	235	230	230
185 Al	405	395	390	310	300	300
300 Al	540	525	520	410	405	400

660/1,100V stranded Aluminium conductor 4 core paper insulated Lead sheathed Steel tape armoured cable to BS 480 (Metric sizes)			
Conductor size mm²	**Current rating A**		
	Direct in ground, $g = 1.2KmW^{-1}$, $T_g = 15°C$	**Drawn into ducts, one cable per duct, $g = 1.2KmW^{-1}$, $T_g = 15°C$**	**Laid in air T = 25°C**
16 Al	69	59	62
25 Al	89	77	82
35 Al	110	92	100
50 Al	130	110	120
70 Al	160	135	150
95 Al	190	160	185
120 Al	220	185	215
150 Al	245	210	245
185 Al	280	235	280
240 Al	325	280	335
300 Al	365	315	385

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400 Al	415	360	450

Source: * Calculated using CRATER

**Delta Crompton publication EC1005 9410.

Table 14

660/1,100V STRANDED COPPER CONDUCTOR SINGLE CORE PAPER INSULATED LEAD SHEATHED CABLE BS6 480 (IMPERIAL SIZES)					
Cable size in²	**Current rating A**				
	Trefoil groups laid direct, maximum conductor temperature 80 °C T_g = 15°C		**Cables in trefoil ducts, one cable per duct, maximum conductor temperature 60 °C T_g = 15°C**		**Cables in trefoil in air, maximum conductor temperature 80 °C**
	g = 0.9 KmW^{-1}	**g = 1.2 KmW^{-1}**	**g = 0.9 KmW^{-1}**	**g =1.2 KmW^{-1}**	
0.4 Cu	610	540	460	425	650
0.5 Cu	690	610	510	465	750
0.6 Cu	760	670	550	500	840
0.75 Cu	830	730	600	540	940
1.0 Cu	950	830	660	610	1110

Source: AEI publication 5513-51. These cables were mainly used as transformer tails.

Table 14A

BS 6480:1988 SINGLE CORE COPPER CONDUCTOR, PAPER INSULATED, LEAD SHEATHED, 600/1,000V, PVC SHEATHED OVERALL				
Conductor size mm²	**Current rating A**			
	Direct in ground, g = 1.2KmW^{-1}, T_g = 15°C		**In air, T = 25°C**	
	Trefoil	Flat	Trefoil	Flat
400 Cu	680	700	820	930

Source: BICC Electric Cables Handbook – 3rd Edition. These cables were mainly used as transformer tails.

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8 Modern and Historic Designs of 11/6.6kV Cables

8.1 Modern 11/6.6kV cable Designs

Table 15

6,350/11,000V THREE CORE STRANDED SHAPED ALUMINIUM CONDUCTOR, PAPER INSULATION, ALUMINIUM SHEATH, PVC SHEATH OVERALL TO TABLE 1 ENA TS 09-12 [PICAS (CORRUGATED SHEATH) AND ACAS (SMOOTH SHEATH)]				
Cable size mm²	Current rating A			
	Laid direct, g = 1.2KmW^{-1} T_g = 15°C		Cables in ducts, one cable per duct, g = 1.2KmW^{-1} T_g = 15°C	Cables in air, ambient temperature 25°C
	Continuous	Cyclic	Continuous	Continuous
95 Al	185	210	160	180
185 Al	270	305	230	270
300 Al	355	400	305	370

Source: ENA TS 09-12, Issue 2, 1990. BICC confirm that the ratings are the same for ACAS as for PICAS

Table 16

6,350/11,000V STRANDED COPPER AND ALUMINIUM CONDUCTOR SINGLE CORE TRIPLE EXTRUDED POLYMERIC INSULATED COPPER WIRE SCREEN PVC SHEATH OVERALL CABLE TO ENA TS 09-17							
Cable size mm²	Current rating A						
	Laid direct, g = 1.2KmW^{-1} T_g = 15°C Screens solidly bonded				Cables in ducts, g = 1.2KmW^{-1} T_g = 15°C Screens solidly bonded		Cables in air, ambient temperature 25°C Screens solidly bonded
	In trefoil		Flat formation at 2 x D separation between cable centres		Ducts in trefoil	Flat with ducts touching	
	Cont.	Cyclic	Cont.	Cyclic	Continuous	Continuous	Continuous
300 Cu	597	674	585	661	550	536	756
400 Cu	674	761	653	737	615	597	873
400 Al	537	606	534	603	507	494	695
500 Al	612	691	602	680	572	556	811

Source: ENA TS 09-17. These cables are mainly used as transformer tails in Primary substations.

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Table 17

6,350/11,000V SINGLE CORE STRANDED COPPER CONDUCTOR, TRIPLE EXTRUDED POLYMERIC (3.4MM) INSULATION, COPPER WIRE SCREEN, PVC OVERSHEATH TO BS 6622 AND IEC 502				
Cable size mm²	**Current rating A**			
	Laid direct $g = 1.2KmW^{-1}$ $T_g = 15°C$		**Laid in ducts, one cable per duct, $g = 1.2KmW^{-1}$ $T_g = 15°C$**	**Cables in air, ambient temperature 25°C**
	Continuous	**Cyclic**		
70 Cu	270	305	270	310
95 Cu	320	360	320	375
120 Cu	360	405	360	430
150 Cu	410	460	400	490
185 Cu	460	520	440	560
240 Cu	530	600	505	660
300 Cu	600	675	560	760
400 Cu	680	765	610	880
500 Cu	750	845	680	1000
630 Cu	830	935	750	1140

Source: AEI publication AM-PCD-10

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Table 18

6,350/11,000V THREE CORE STRANDED COPPER CONDUCTOR, TRIPLE EXTRUDED POLYMERIC (3.4MM) INSULATION, COPPER WIRE SCREEN, UNARMOURED, PVC OVERSHEATH TO BS 6622 AND IEC 502				
Cable size mm²	Current rating A			
	Laid direct $g = 1.2KmW^{-1}$ $T_g = 15°C$		Laid in ducts, one cable per duct, $g = 1.2KmW^{-1}$ $T_g = 15°C$	Cables in air, ambient temperature 25°C
	Continuous	Cyclic		
70 Cu	255	285	220	285
95 Cu	300	340	255	330
120 Cu	340	385	295	385
150 Cu	380	430	325	435
185 Cu	430	485	370	500
240 Cu	500	565	430	580
300 Cu	560	630	485	660

Source: AEI publication AM-PCD-10.

Table 19

6,350/11,000V STRANDED SINGLE CORE ALUMINIUM CONDUCTOR, TRIPLE EXTRUDED POLYMERIC (3.4MM) INSULATION, COPPER WIRE SCREEN, UNARMOURED, PVC OVERSHEATH TO BS 6622 AND IEC 502				
Cable size mm²	Current rating A			
	Laid direct $g = 1.2KmW^{-1}$ $T_g = 15°C$		Laid in ducts, one cable per duct, $g = 1.2KmW^{-1}$ $T_g = 15°C$	Cables in air, ambient temperature 25°C
	Continuous	Cyclic		
70 Al	210	235	215	240
95 Al	250	280	255	300
120 Al	280	315	285	335
150 Al	320	360	315	380
185 Al	360	405	350	435
240 Al	415	470	405	510
300 Al	475	535	455	600
400 Al	540	610	510	700
500 Al	610	690	570	810
630 Al	680	765	640	930

Source: AEI publication AM-PCD-10.

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Table 20

6,350/11,000V THREE CORE STRANDED ALUMINIUM CONDUCTOR, TRIPLE EXTRUDED POLYMERIC (3.4MM) INSULATION, COPPER WIRE SCREEN, UNARMOURED, PVC OVERSHEATH TO BS 6622 AND IEC 502				
Cable size mm²	Current rating A			
	Laid direct $g = 1.2KmW^{-1}$ $T_g = 15°C$		Laid in ducts, one cable per duct, $g = 1.2KmW^{-1}$ $T_g = 15°C$	Cables in air, ambient temperature 25°C
	Continuous	Cyclic		
70 Al	200	225	170	220
95 Al	235	265	200	255
120 Al	265	300	230	295
150 Al	295	330	255	335
185 Al	335	375	290	385
240 Al	390	440	340	450
300 Al	435	490	380	510

Source: AEI publication AM-PCD-10.

Table 20A – Triplex Cable

11,000V SINGLE CORE, SOLID ALUMINIUM CONDUCTOR, POLYMERIC INSULATION, COPPER SCREEN, MDPE SHEATH OVERALL AND LAID IN TRIPLEX FORMATION TO BS 7870 PART 4 SECTION 10.				
Cable size mm²	Current rating A			
	Laid direct, ungrouped cable, $g = 1.2KmW^{-1}$ $T_g = 15°C$	Cables in ducts, one cable per duct, ungrouped cable, $g = 1.2KmW^{-1}$ $T_g = 15°C$	Cables in air & shade or clipped to wall, ambient temperature 25°C	
	Cont. / Cyclic / Dist.	Cont. / Cyclic / Dist.	Air & shade	Clipped to wall
			Cont.	Cont.
95 Al	245 / 284 / 316	214 / 238 / 255	285	266
185 Al	353 / 412 / 461	308 / 346 / 372	430	399
300 Al	461 / 542 / 610	403 / 455 / 493	580	540

Source: Calculated using CRATER

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Table 20B – Triplex Cable

11,000V SINGLE CORE, STRANDED ALUMINIUM CONDUCTOR, POLYMERIC INSULATION, COPPER SCREEN, MDPE SHEATH OVERALL AND LAID IN TRIPLEX FORMATION TO BS 7870 PART 4 SECTION 10.		
Cable size mm²	Current rating A	
	Laid direct, ungrouped cable, $g = 1.2KmW^{-1}$ $T_g = 15°C$	Cables in ducts, one cable per duct, ungrouped cable, $g = 1.2KmW^{-1}$ $T_g = 15°C$
	Cont. / Cyclic / Dist.	Cont. / Cyclic / Dist.
400 Al	552 / 646 / 713	477 / 538 / 576

Source: Calculated using CRATER

8.2 Historic 11/6.6kV Cable Designs

Table 21

6,350/11,000V THREE CORE STRANDED COPPER CONDUCTOR BELTED PAPER INSULATED LEAD SHEATHED STEEL WIRE ARMOURED TO BS 6480 (IMPERIAL SIZES)				
Cable size in²	Current rating A			
	Laid direct $g = 0.9KmW^{-1}$ $T_g = 15°C$		Laid in ducts, one cable per duct $g = 0.9KmW^{-1}$ $T_g = 15°C$	In air, ambient temperature 25°C
	Continuous	Cyclic	Continuous	Continuous
0.0225 Cu	92	100	78	79
0.04 Cu	130	140	110	115
0.06 Cu	160	175	135	140
0.10 Cu	220	245	185	200
0.15 Cu	270	305	230	250
0.20 Cu	320	360	270	295
0.25 Cu	370	415	315	345
0.30 Cu	410	460	350	390
0.40 Cu	475	535	405	465
0.50 Cu	530	600	450	530

Source: AEI publication 5513-51

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Table 22

6,350/11,000V THREE CORE STRANDED ALUMINIUM CONDUCTOR BELTED PAPER INSULATED LEAD SHEATHED STEEL WIRE ARMOURED TO BS 6480 (IMPERIAL SIZES)				
Cable size in²	Current rating A			
	Laid direct $g = 0.9KmW^{-1}$ $T_g = 15°C$		Laid in ducts, one cable per duct $g = 0.9KmW^{-1}$ $T_g = 15°C$	In air, ambient temperature 25°C
	Continuous	Cyclic	Continuous	Continuous
0.0225 Al	72	78	60	62
0.04 Al	100	110	85	90
0.06 Al	125	135	105	110
0.10 Al	170	190	145	155
0.15 Al	210	235	180	195
0.20 Al	250	280	210	230
0.25 Al	290	325	245	270
0.30 Al	325	365	275	310
0.40 Al	375	420	320	360
0.50 Al	420	475	355	420

Source: AEI publication 5513-51

Table 23

6,350/11,000V THREE CORE STRANDED COPPER CONDUCTOR BELTED PAPER INSULATED LEAD SHEATHED STEEL WIRE ARMOURED TO BS 6480 (METRIC SIZES)				
Cable size mm²	Current rating A			
	Laid direct $g = 1.2KmW^{-1}$ $T_g = 15°C$		Laid in ducts, one cable per duct $g = 1.2KmW^{-1}$ $T_g = 15°C$	In air, ambient temperature 25°C
	Continuous	Cyclic	Continuous	Continuous
95 Cu	245	275	210	240
120 Cu	280	315	240	275
185 Cu	355	400	300	360
240 Cu	410	460	355	425
300 Cu	460	520	395	490

Source: Delta Crompton publication EC1005 941

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Table 24

6,350/11,000V THREE CORE STRANDED ALUMINIUM CONDUCTOR BELTED PAPER INSULATED LEAD SHEATHED STEEL WIRE ARMOURED TO BS 6480 (METRIC SIZES)				
Cable size in²	**Current rating A**			
	Laid direct $g = 1.2KmW^{-1}$ $T_g = 15°C$		**Laid in ducts, one cable per duct $g = 1.2KmW^{-1}$ $T_g = 15°C$**	**In air, ambient temperature 25°C**
	Continuous	**Cyclic**	**Continuous**	**Continuous**
95 Al	190	215	160	185
120 Al	220	245	185	215
185 Al	280	315	235	280
240 Al	325	365	280	335
300 Al	365	410	315	385

Source: Delta Crompton publication EC1005 9410

Table 25

6,350/11,000V SINGLE CORE STRANDED COPPER CONDUCTOR PAPER INSULATED LEAD SHEATHED UNARMOURED TO BS 6480				
Cable size mm²	**Current rating A**			
	Laid direct $g = 1.2KmW^{-1}$ $T_g = 15°C$ (trefoil, solid bonded)		**Laid in ducts, one cable per duct, $g = 1.2KmW^{-1}$ $T_g = 15°C$ (trefoil, solid bonded)**	**In air, ambient temperature 25°C (trefoil, solid bonded)**
	Continuous	**Cyclic**	**Continuous**	**Continuous**
500 Cu	660	745	500	840
630 Cu	740	835	550	960

Source: ERA Report 69-30 Part 1 Tables 14 & 15. These cables were mainly used as transformer tails in Primary substations.

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9 Modern and Historic Designs of 33kV Cables

9.1 Modern 33kV Cable Designs

Table 26

19,000/33,000V THREE CORE STRANDED COPPER AND ALUMINIUM CONDUCTOR CARBON PAPER SCREENED PAPER INSULATED HOCHSTADTER FOLIE SCREENED MASS IMPREGNATED NON DRAINING LEAD ALLOY SHEATHED STEEL WIRE ARMOURED HESSIAN SERVED TO BS 6480				
Cable size mm²	**Current rating A**			
	Laid direct $g = 0.9KmW^{-1}$ $T_g = 15°C$		**Laid in ducts, one cable per duct, $g = 1.2KmW^{-1}$ $T_g = 15°C$**	**In air, ambient temperature 25°C**
	Continuous	**Cyclic**	**Continuous**	**Continuous**
185 Cu	400	450	315	385
240 Cu	460	520	360	450
300 Cu	515	580	410	510
185 Al	315	355	245	300
240 Al	365	410	285	355
300 Al	410	460	325	405

Source: ERA Report 69-30 Part 1, Tables 23 & 48, in the case of directly buried cables (0.8 m depth), adjusted for g =0.9 (Table 52).

Table 27

19,000/33,000V SINGLE CORE COPPER AND ALUMINIUM STRANDED CONDUCTOR, PAPER INSULATED, MASS IMPREGNATED NON DRAINING S.L.* CABLES TO BS 6480				
Cable size mm²	**Current rating A**			
	Laid direct $g = 0.9KmW^{-1}$ $T_g = 15°C$		**Laid in ducts, one cable per duct, $g = 1.2KmW^{-1}$ $T_g = 15°C$**	**In air, ambient temperature 25°C**
	Continuous	**Cyclic**	**Continuous**	**Continuous**
185 Cu	395	445	315	385
240 Cu	455	515	365	455
300 Cu	505	570	405	515
185 Al	310	350	245	300
240 Al	360	405	290	355
300 Al	405	455	325	405

Source: ERA Report 69-30 Part 1, Tables 24 & 45, in the case of directly buried cables (0.8 m depth), adjusted for g =0.9 (Table 52). * SL = Separate Lead.

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Table 28

19,000/33,000V SINGLE CORE STRANDED COPPER AND ALUMINIUM CONDUCTOR CARBON PAPER SCREENED PAPER INSULATED METALLISED PAPER SCREENED MASS IMPREGNATED NON DRAINING LEAD ALLOY SHEATHED UNARMOURED HESSIAN SERVED TO BS 6480				
Cable size mm²	**Current rating A**			
	Laid direct, trefoil touching, $g = 0.9KmW^{-1}$ $T_g = 15°C$		**Laid in ducts, one cable per duct, $g = 1.2KmW^{-1}$ $T_g = 15°C$**	**In air, trefoil touching, ambient temperature 25°C**
	Continuous	**Cyclic**	**Continuous**	**Continuous**
185 Cu	430	485	315	440
240 Cu	500	565	360	520
300 Cu	560	630	400	590
400 Cu	635	715	445	690
500 Cu	705	795	490	780
630 Cu	800	905	540	890
800 Cu	880	995	580	1010
960 Cu	985	1115	620	1170
240 Al	390	440	285	405
300 Al	440	495	320	465
400 Al	500	565	360	540
500 Al	565	640	405	620
630 Al	645	730	450	730

Source: ERA Report 69-30 Part 1, Tables 21, 22, 46 & 47 in the case of directly buried cables (0.8 m depth), adjusted for g =0.9 (Table 52). Cables are solid bonded.

Table 29

19,000/33,000V THREE CORE STRANDED COPPER CONDUCTOR TRIPLE EXTRUDED MDPE STEEL WIRE ARMOURED MDPE OVERSHEATHED TO BS 6622 AND IEC 502				
Cable size mm²	**Current rating A**			
	Laid direct $g = 1.2KmW^{-1}$ $T_g = 15°C$		**In ducts, one duct per cable $g = 1.2KmW^{-1}$ $T_g = 15°C$**	**In air, ambient temperature 25°C**
	Continuous	**Cyclic**		
185 Cu	420	475	380	490
240 Cu	480	540	430	570
300 Cu	530	600	480	650

Source: BICC publication ECD XLPE/9.93.

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Table 30

19,000/33,000V SINGLE CORE STRANDED COPPER CONDUCTOR TRIPLE EXTRUDED MDPE, 50MM² COPPER WIRE SCREEN, UNARMOURED MDPE OVERSHEATHED TO BS 7870 PART 4 SECTION 4.10 AND IEC 502 NOTE: CABLE RATINGS ARE PROVIDED FOR BOTH SINGLE CORES LAID IN TRIPLEX FORMATION IN A SINGLE DUCT, AND FOR SINGLE CORES LAID IN SEPARATE DUCTS IN TREFOIL							
Cable size mm²	Current rating A						
	Laid direct (trefoil) g = 1.2KmW-1 Tg = 15°C		In a duct (triplex), three cables/duct, g = 1.2KmW-1 Tg = 15°C		In ducts (trefoil), one cable/duct, g = 1.2KmW-1 Tg = 15°C		In air and shade (trefoil) ambient temperature 25°C
	Cont.	Cyclic	Cont.	Cyclic	Cont.	Cyclic	Cont.
185 Cu	448	524	396	450	413	483	561
240 Cu	515	605	455	519	466	547	656
300 Cu	577	682	510	584	514	607	748
400 Cu	652	775	575	662	571	678	864
500 Cu	732	875	645	746	631	753	992
630 Cu	818	983	719	836	695	834	-

Source: CRATER for MV Polymeric cables. Cables ratings assume solid sheath bonding

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Table 30A

19,000/33,000V SINGLE CORE STRANDED ALUMINIUM CONDUCTOR TRIPLE EXTRUDED MDPE, 50MM² COPPER WIRE SCREEN, UNARMOURED MDPE OVERSHEATHED TO BS 7870 PART 4 SECTION 4.10 AND IEC 502 NOTE: CABLE RATINGS ARE PROVIDED FOR BOTH SINGLE CORES LAID IN TRIPLEX FORMATION IN A SINGLE DUCT, AND FOR SINGLE CORES LAID IN SEPARATE DUCTS IN TREFOIL							
Cable size mm²	Current rating A						
	Laid direct (trefoil) g = 1.2KmW-1 Tg = 15°C		In a duct (trefoil), three cables/duct, g = 1.2KmW-1 Tg = 15°C		In ducts (triplex), one cable/duct, g = 1.2KmW-1 Tg = 15°C		In air and shade (trefoil) ambient temperature 25°C
	Cont.	Cyclic	Cont.	Cyclic	Cont.	Cyclic	Cont.
185 Al	357	416	315	356	345	398	439
240 Al	412	482	364	412	393	456	515
300 Al	465	545	409	466	437	509	589
400 Al	531	627	467	534	492	577	687
500 Al	604	717	531	609	551	650	798
630 Al	685	818	608	703	617	730	925
800 Al	769	923	681	791	684	815	1061
1000 Al	850	1026	762	891	751	899	1198

Source: CRATER for MV Polymeric cables. Cables ratings assume solid sheath bonding.

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Table 31

19,000/33,000V THREE CORE STRANDED COPPER AND ALUMINIUM COMPACTED CIRCULAR CONDUCTOR PAPER INSULATED LEAD ALLOY SHEATHED FLUID FILLED CABLE TO ENA TS 09-3					
Cable size mm²		**Current rating A**			
		Laid direct $g = 1.2KmW^{-1}$ $T_g = 15°C$		**In ducts, one cable per duct $g = 1.2KmW^{-1}$ $T_g = 15°C$**	**In air, ambient temperature 25°C**
		Continuous	**Cyclic**	**Continuous**	**Continuous**
400 one circuit 0.9 m cover	Cu	635	715	565	795
	Al	505	570	450	630
400 two circuits 0.45 m centres, 0.9 m cover	Cu	560	630	505	(as one circuit)
	Al	445	500	405	(as one circuit)
630 one circuit 0.9 m cover	Cu	795	900	720	1050
	Al	650	735	585	860
630 two circuits 0.45 m centres, 0.9 m cover	Cu	690	780	635	(as one circuit)
	Al	565	635	520	(as one circuit)

Source: ENA TS 09 – 3, Schedule D.

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Table 32

19,000/33,000V THREE CORE STRANDED COPPER AND ALUMINIUM COMPACTED OVAL CONDUCTOR PAPER INSULATED CORRUGATED ALUMINIUM SHEATHED FLUID FILLED CABLE TO ENA TS 09-3					
Cable size mm²		**Current rating A**			
		Laid direct $g = 1.2KmW^{-1}$ $T_g = 15°C$		**In ducts, one cable per duct $g = 1.2KmW^{-1}$ $T_g = 15°C$**	**In air, ambient temperature 25°C**
		Continuous	**Cyclic**	**Continuous**	**Continuous**
400 one circuit 0.9 m cover	Cu	600	675	535	735
	Al	480	540	430	585
400 two circuits 0.45 m centres, 0.9 m cover	Cu	530	600	480	(as one circuit)
	Al	425	480	380	(as one circuit)
630 one circuit 0.9 m cover	Cu	735	830	655	935
	Al	610	690	545	775
630 two circuits 0.45 m centres, 0.9 m cover	Cu	645	730	590	(as one circuit)
	Al	520	590	485	(as one circuit)

Source: ENA TS 09 – 3, Schedule D.

Table 33

19,000/33,000V THREE CORE STRANDED COPPER AND ALUMINIUM COMPACTED OVAL CONDUCTOR PAPER INSULATED SMOOTH ALUMINIUM SHEATHED GAS FILLED CABLE TO ENA TS 09-3					
Cable size mm²		**Current rating A**			
		Laid direct $g = 1.2KmW^{-1}$ $T_g = 15°C$		**In ducts, one cable per duct $g = 1.2KmW^{-1}$ $T_g = 15°C$**	**In air, ambient temperature 25°C**
		Continuous	**Cyclic**	**Continuous**	**Continuous**
400 one circuit 0.9 m cover	Cu	575	650	510	715
	Al	475	535	415	575
400 two circuits 0.45 m centres, 0.9 m cover	Cu	500	565	450	(as one circuit)
	Al	415	470	370	(as one circuit)

Source: ENA TS 09 – 3, Schedule D.

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9.2 Historic 33kV Cable Designs

Table 34

19,000/33,000V THREE CORE STRANDED COPPER CONDUCTOR MASS IMPREGNATED PAPER INSULATED H TYPE LEAD SHEATHED, ARMOURED AND SERVED CABLE TO BS 6480				
Cable size in²	**Current rating A**			
	Laid direct $g = 0.9KmW^{-1}$ $T_g = 15°C$		**In ducts, one cable per duct, $g = 0.9KmW^{-1}$ $T_g = 15°C$**	**In air, ambient temperature 25°C**
	Continuous	**Cyclic**	**Continuous**	**Continuous**
0.1 Cu	220	250	190	215
0.15 Cu	270	305	235	265
0.2 Cu	315	355	275	315
0.25 Cu	360	405	310	360
0.3 Cu	400	450	345	410
0.4 Cu	465	525	405	485
0.5 Cu	510	575	445	540

Source: AEI publication 5513-51.

Table 35

19,000/33,000V THREE CORE STRANDED COPPER CONDUCTOR MASS IMPREGNATED PAPER INSULATED, SL* SHEATHED, ARMOURED AND SERVED CABLE TO BS 6480				
Cable size in²	**Current rating A**			
	Laid direct $g = 0.9KmW^{-1}$ $T_g = 15°C$		**In ducts, one cable per duct, $g = 0.9KmW^{-1}$ $T_g = 15°C$**	**In air, ambient temperature 25°C**
	Continuous	**Cyclic**	**Continuous**	**Continuous**
0.1 Cu	230	260	195	225
0.15 Cu	270	305	235	275
0.2 Cu	320	360	280	325
0.25 Cu	360	405	315	375
0.3 Cu	405	460	350	420
0.4 Cu	470	530	405	500
0.5 Cu	520	590	445	550

Source: AEI publication 5513-51. * SL = Separate Lead.

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Table 36

19,000/33,000V THREE SINGLE CORE COPPER STRANDED CONDUCTOR MASS IMPREGNATED PAPER INSULATED, LEAD SHEATHED AND SERVED CABLE TO BS 6480				
Cable size. in²	**Current rating A**			
	Laid direct, touching trefoil, g = 0.9KmW^{-1} T_g = 15°C		**In ducts, one cable per duct, g = 0.9KmW^{-1} T_g = 15°C**	**In air, ambient temperature 25°C**
	Continuous	**Cyclic**	**Continuous**	**Continuous**
0.1 Cu	230	260	195	240
0.15 Cu	285	320	235	305
0.2 Cu	335	380	275	360
0.25 Cu	380	430	310	415
0.3 Cu	420	475	345	465
0.4 Cu	490	555	395	560
0.5 Cu	550	620	430	630

Source: AEI publication 5513-51. Cable ratings assume solid sheath bonding.

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Table 37

19,000/33,000V THREE CORE OVAL COMPACTED COPPER OR ALUMINIUM STRANDED CONDUCTOR, FLUID FILLED, PAPER INSULATED AND SCREENED, WITHOUT FILLINGS OR OIL DUCTS (DSO) CORRUGATED ALUMINIUM SHEATHED (CAS) PVC SHEATHED OVERALL, BEBS C4 (1966) SCHEDULE 5				
Cable size in²	**Current rating A**			
	Laid direct, 42 in. cover, g = 0.9KmW^{-1} T_g = 15°C		**In ducts, 42 in. cover, g = 0.9KmW^{-1} T_g = 15°C**	**Cable in air, ambient temperature 25°C**
	Continuous	**Cyclic**	**Continuous**	**Continuous**
0.2 Cu	380	430	310	380
0.25 Cu	435	490	350	440
0.3 Cu	475	535	385	490
0.35 Cu	520	590	425	540
0.4 Cu	550	620	455	590
0.45 Cu	580	655	485	625
0.5 Cu	610	690	510	655
0.55 Cu	645	730	530	690
0.6 Cu	670	755	555	730
0.3 Al	375	425	305	390
0.4 Al	435	490	360	465
0.5 Al	480	540	405	515
0.6 Al	530	600	440	575

Source: BEBS C4.

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Table 38

19,000/33,000V THREE CORE CIRCULAR COMPACTED COPPER OR ALUMINIUM STRANDED CONDUCTOR, FLUID FILLED, PAPER INSULATED AND SCREENED, LEAD ALLOY SHEATHED OVERALL, BEBS C4 (1966) SCHEDULE 5				
Cable size in²	Current rating A			
	Laid direct, 42 in cover, g = 0.9KmW^{-1} T_g = 15°C		In ducts, 42 in cover, g = 0.9KmW^{-1} T_g = 15°C	Cable in air, ambient temperature 25°C
	Continuous	Cyclic	Continuous	Continuous
0.2 Cu	385	435	320	390
0.25 Cu	440	500	365	450
0.3 Cu	485	550	405	510
0.35 Cu	535	605	445	570
0.4 Cu	565	635	470	610
0.45 Cu	600	675	510	655
0.5 Cu	630	710	530	690
0.55 Cu	660	745	550	730
0.6 Cu	700	790	585	780
0.3 Al	385	435	320	405
0.4 Al	445	500	370	480
0.5 Al	500	565	420	545
0.6 Al	555	625	465	615

Source: BEBS C4.

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Table 39

19,000/33,000V THREE CORE SHAPED OR OVAL COPPER OR ALUMINIUM STRANDED CONDUCTOR, FLUID FILLED, PAPER INSULATED AND SCREENED, LEAD ALLOY SHEATHED OVERALL, BEBS C4 (1966) SCHEDULE 5				
Cable size in²	**Current rating A**			
	Laid direct, 42 in cover, g = 0.9KmW^{-1} T_g = 15°C		**In ducts, 42 in cover, g = 0.9KmW^{-1} T_g = 15°C**	**Cable in air, ambient temperature 25°C**
	Continuous	**Cyclic**	**Continuous**	**Continuous**
0.2 Cu	380	430	310	385
0.25 Cu	435	490	355	435
0.3 Cu	485	545	390	500
0.35 Cu	530	600	430	550
0.4 Cu	560	630	465	600
0.45 Cu	595	670	495	635
0.5 Cu	620	700	520	670
0.55 Cu	655	740	545	705
0.3 Al	385	435	310	395
0.4 Al	445	500	370	475
0.5 Al	490	555	410	530

Source: BEBS C4.

10 132kV Cable Designs

The current ratings of 132kV cables are normally specific to each particular circuit, for which a ground thermal resistivity survey will have been undertaken. The table values in this section are approximate and provided for general guidance purposes only; no value of thermal resistivity g, or ground temperature Tg, is specified.

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Table 40

76,000/132 000V SINGLE CORE COPPER CONDUCTOR, PAPER INSULATED, LEAD ALLOY SHEATH, PVC OR POLYETHYLENE OVERSHEATH, FLUID FILLED						
Cable size mm²	Current rating A					
	Summer			Winter		
	Solid bonded trefoil group	Specially bonded, 3 cables at 2 x D centres	Specially bonded, 3 cables at 300mm centres	Solid bonded trefoil group	Specially bonded, 3 cables at 2 x D centres	Specially bonded, 3 cables at 300mm centres
120 Cu	350	365	400	375	395	430
150 Cu	390	410	445	420	445	480
185 Cu	435	465	505	475	505	545
240 Cu	510	545	590	555	590	645
260 Cu	530	565	615	577	615	670
300 Cu	570	615	670	620	670	725
350 Cu	610	660	720	665	720	780
400 Cu	645	700	760	705	765	830
500 Cu	725	795	870	790	870	945
630 Cu	810	910	995	890	995	1080
800 Cu	895	1025	1115	980	1125	1215
1000 Cu	965	1140	1240	1055	1250	1350
1150 Cu	1065	1285	1380	1170	1410	1505
1300 Cu	1110	1370	1465	1220	1500	1600
1600 Cu	1180	1520	1620	1300	1670	1775
2000 Cu	1245	1680	1790	1370	1845	1965

Source: Pirelli publication HVP15.6.95.

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Table 41

76,000/132 000V SINGLE CORE COPPER CONDUCTOR, PAPER INSULATED, CORRUGATED ALUMINIUM SHEATH, PVC OR POLYETHYLENE OVERSHEATH, FLUID FILLED						
Cable size mm²	Current rating A					
	Summer			Winter		
	Solid bonded trefoil group	Specially bonded 3 cables at 2 x D centres	Specially bonded 3 cables at 300mm centres	Solid bonded trefoil group	Specially bonded 3 cables at 2 x D centres	Specially bonded 3 cables at 300mm centres
120 Cu	340	360	390	365	390	420
150 Cu	375	405	440	410	440	475
185 Cu	420	455	495	455	495	535
240 Cu	485	535	585	525	585	630
260 Cu	500	560	605	545	610	660
300 Cu	535	605	660	585	660	715
350 Cu	570	650	710	620	710	770
400 Cu	595	690	750	650	750	815
500 Cu	660	785	855	720	855	930
630 Cu	720	895	975	790	975	1060
800 Cu	765	1005	1095	840	1,100	1190
1000 Cu	810	1115	1215	885	1220	1320
1150 Cu	855	1245	1345	940	1365	1465
1300 Cu	880	1320	1425	965	1445	1555
1600 Cu	910	1455	1570	1005	1595	1715
2000 Cu	945	1595	1720	1045	1750	1885

Source: Pirelli publication HVP11.6.95.

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Table 42

76,000/132 000V THREE CORE COPPER CONDUCTOR, PAPER INSULATED, LEAD ALLOY SHEATH, POLYETHYLENE OVERSHEATH, FLUID FILLED		
Cable size mm²	**Current rating A**	
	Summer	**Winter**
120 Cu	335	360
150 Cu	375	405
185 Cu	420	445
240 Cu	485	525
260 Cu	505	550
300 Cu	545	595
350 Cu	585	635
400 Cu	620	670
500 Cu	690	750
630 Cu	770	840

Source: Pirelli publication HVP14.6.95.

Table 43

76,000/132 000V THREE CORE COPPER CONDUCTOR, PAPER INSULATED, CORRUGATED ALUMINIUM SHEATH, POLYETHYLENE OVERSHEATH, FLUID FILLED		
Cable size mm²	**Current rating A**	
	Summer	**Winter**
120 Cu	325	350
150 Cu	360	390
185 Cu	405	435
240 Cu	460	500
260 Cu	480	520
300 Cu	515	560
350 Cu	550	595
400 Cu	580	625
500 Cu	640	695
630 Cu	705	770

Source: Pirelli publication HVP16.6.95.

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Table 44

76,000/132 000V SINGLE CORE COPPER CONDUCTOR, XLPE INSULATED, LEAD SHEATH, PVC OR POLYETHYLENE OVERSHEATH						
Cable size mm²	Current rating A					
	Summer			Winter		
	Solid bonded trefoil group	Specially bonded 3 cables at 2 x D centres	Specially bonded 3 cables at 300mm centres	Solid bonded trefoil group	Specially bonded 3 cables at 2 x D centres	Specially bonded 3 cables at 300mm centres
185 Cu	455	480	510	490	520	550
240 Cu	525	560	590	565	605	635
300 Cu	585	635	670	635	685	720
400 Cu	660	720	760	720	780	820
500 Cu	740	820	865	805	890	935
630 Cu	825	935	985	900	1015	1065
800 Cu	910	1060	1105	990	1145	1200
1000 Cu	980	1175	1225	1070	1275	1330
1200 Cu	1095	1355	1410	1195	1475	1530
1400 Cu	1155	1465	1525	1260	1595	1655
1600 Cu	1200	1570	1630	1310	1710	1770

Source: Pirelli publication HVP46.6.95.

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Table 45

76,000/132 000V SINGLE CORE COPPER CONDUCTOR, XLPE INSULATED, CORRUGATED ALUMINIUM SHEATH, PVC OR POLYETHYLENE OVERSHEATH						
Cable size mm²	Current rating A					
	Summer			Winter		
	Solid bonded trefoil group	Specially bonded 3 cables at 2 x D centres	Specially bonded 3 cables at 300mm centres	Solid bonded trefoil group	Specially bonded 3 cables at 2 x D centres	Specially bonded 3 cables at 300mm centres
185 Cu	425	470	495	460	510	530
240 Cu	485	545	570	525	590	615
300 Cu	535	620	645	580	665	695
400 Cu	595	705	735	645	760	790
500 Cu	650	795	835	710	860	900
630 Cu	710	905	945	775	980	1020
800 Cu	770	1015	1060	835	1,100	1145
1000 Cu	815	1120	1170	890	1215	1265
1200 Cu	890	1290	1340	970	1400	1450
1400 Cu	935	1380	1430	1020	1500	1550
1600 Cu	970	1470	1515	1060	1595	1645

Source: Pirelli publication HVP48.6.95.

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Table 46

76,000/132,000V SINGLE CORE ALUMINIUM STRANDED CONDUCTOR, XLPE INSULATED, SMOOTH WELDED ALUMINIUM SHEATH, MDPE OVERSHEATH IEC 60840						
Cable size mm²	**Current rating A (cables laid direct, 900mm to top of cable)**					
	Summer			**Winter**		
	Solid bonded trefoil group	**Specially bonded 3 cables at 2 x D centres**	**Specially bonded 3 cables at 3 x D centres**	**Solid bonded trefoil group**	**Specially bonded 3 cables at 2 x D centres**	**Specially bonded 3 cables at 3 x D centres**
	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic
300 AL	450 / 530	486 / 586	504 / 604	516 / 595	555 / 653	573 / 671
400 AL	511 / 604	558 / 677	579 / 698	587 / 681	638 / 757	660 / 779
500 AL	576 / 685	638 / 780	664 / 807	664 / 776	732 / 874	760 / 902
630 AL	651 / 779	732 / 900	764 / 933	753 / 885	842 / 1013	876 / 1048
800 AL	724 / 871	832 / 1030	871 / 1072	839 / 993	960 / 1164	1002 / 1208
1000 AL	790 / 955	931 / 1158	980 / 1211	918 / 1091	1076 / 1311	1129 / 1366

Source: Calculated using CRATER

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Table 47

76,000/132,000V SINGLE CORE ALUMINIUM STRANDED CONDUCTOR, XLPE INSULATED, SMOOTH WELDED ALUMINIUM SHEATH, MDPE OVERSHEATH IEC 60840						
Cable size mm²	**Current rating A (cables in ducts at 900mm top of duct)**					
	Summer			**Winter**		
	Solid bonded trefoil group	**Specially bonded 3 cables at 2 x D centres**	**Specially bonded 3 cables at 3 x D centres**	**Solid bonded trefoil group**	**Specially bonded 3 cables at 2 x D centres**	**Specially bonded 3 cables at 3 x D centres**
	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic
300 AL	412 / 495	486 / 575	501 / 587	462 / 543	537 / 623	552 / 634
400 AL	459 / 555	557 / 663	576 / 678	516 / 612	618 / 720	636 / 734
500 AL	507 / 618	639 / 764	661 / 783	573 / 684	710 / 832	731 / 849
630 AL	565 / 692	733 / 881	759 / 904	640 / 769	817 / 962	842 / 983
800 AL	616 / 761	834 / 1009	865 / 1037	701 / 849	933 / 1105	963 / 1131
1000 AL	663 / 825	934 / 1137	972 / 1171	755 / 923	1047 / 1248	1084 / 1280

Source: Calculated using CRATER

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Table 48

76,000/132,000V SINGLE CORE COPPER STRANDED CONDUCTOR, XLPE INSULATED, SMOOTH WELDED ALUMINIUM SHEATH, MDPE OVERSHEATH IEC 60840						
Cable size mm²	Current rating A (cables laid direct at a depth of 900mm to top of cable)					
	Summer			Winter		
	Solid bonded trefoil group	Specially bonded 3 cables at 2 x D centres	Specially bonded 3 cables at 3 x D centres	Solid bonded trefoil group	Specially bonded 3 cables at 2 x D centres	Specially bonded 3 cables at 3 x D centres
	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic
300 Cu	567 / 669	624 / 754	648 / 778	650 / 753	712 / 840	737 / 865
400 Cu	635 / 753	711 / 864	740 / 894	730 / 851	813 / 966	844 / 996
500 Cu	707 / 844	810 / 991	846 / 1029	817 / 957	929 / 1112	967 / 1151
630 Cu	789 / 946	921 / 1133	965 / 1181	913 / 1076	1060 / 1277	1107 / 1326
800 Cu	860 / 1038	1035 / 1281	1090 / 1343	999 / 1185	1194 / 1449	1254 / 1513
1000 Cu	919 / 1116	1141 / 1421	1209 / 1497	1070 / 1277	1320 / 1610	1393 / 1692

Source: Calculated using CRATER

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Table 49

76,000/132,000V SINGLE CORE COPPER STRANDED CONDUCTOR, XLPE INSULATED, SMOOTH WELDED ALUMINIUM SHEATH, MDPE OVERSHEATH IEC 60840						
Cable size mm²	Current rating A (cables in ducts at a depth of 900mm to top of duct)					
	Summer			Winter		
	Solid bonded trefoil group	Specially bonded 3 cables at 2 x D centres	Specially bonded 3 cables at 3 x D centres	Solid bonded trefoil group	Specially bonded 3 cables at 2 x D centres	Specially bonded 3 cables at 3 x D centres
	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic
300 Cu	499 / 605	625 / 741	645 / 757	562 / 667	692 / 803	710 / 818
400 Cu	547 / 667	713 / 849	737 / 870	618 / 739	791 / 923	813 / 941
500 Cu	596 / 734	814 / 975	843 / 1000	676 / 816	905 / 1063	933 / 1086
630 Cu	654 / 810	927 / 1117	961 / 1148	743 / 904	1034 / 1221	1067 / 1249
800 Cu	701 / 876	1044 / 1268	1086 / 1306	799 / 981	1168 / 1390	1209 / 1424
1000 Cu	741 / 935	1154 / 1411	1024 / 1457	847 / 1051	1295 / 1550	1343 / 1593

Source: Calculated using CRATER

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Table 50

76,000/132,000V SINGLE CORE ALUMINIUM STRANDED CONDUCTOR, XLPE INSULATED, ALUMINIUM FOIL LAMINATE WITH COPPER WIRE SCREEN, MDPE OVERSHEATH IEC 60840						
Cable size mm²	**Current rating A (cables laid direct at 900mm to top of cable)**					
	Summer			**Winter**		
	Solid bonded trefoil group	**Specially bonded 3 cables at 2 x D centres**	**Specially bonded 3 cables at 3 x D centres**	**Solid bonded trefoil group**	**Specially bonded 3 cables at 2 x D centres**	**Specially bonded 3 cables at 3 x D centres**
	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic
300 AL	451 / 532	490 / 591	507 / 607	516 / 597	558 / 658	576 / 675
400 AL	511 / 605	562 / 682	582 / 702	587 / 683	642 / 762	664 / 783
500 AL	576 / 686	645 / 787	669 / 812	664 / 777	739 / 882	765 / 908
630 AL	648 / 776	741 / 911	770 / 941	749 / 882	852 / 1024	883 / 1056
800 AL	722 / 870	843 / 1044	879 / 1081	838 / 992	972 / 1178	1011 / 1217
1000 AL	790 / 957	946 / 1175	989 / 1221	918 / 1093	1092 / 1329	1138 / 1377

Source: Calculated using CRATER

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Table 51

76,000/132,000V SINGLE CORE ALUMINIUM STRANDED CONDUCTOR, XLPE INSULATED, ALUMINIUM FOIL LAMINATE WITH COPPER WIRE SCREEN, MDPE OVERSHEATH IEC 60840						
Cable size mm²	**Current rating A (cables in ducts at depth of 900mm to top of duct)**					
	Summer			**Winter**		
	Solid bonded trefoil group	**Specially bonded 3 cables at 2 x D centres**	**Specially bonded 3 cables at 3 x D centres**	**Solid bonded trefoil group**	**Specially bonded 3 cables at 2 x D centres**	**Specially bonded 3 cables at 3 x D centres**
	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic
300 AL	410 / 492	485 / 573	500 / 585	461 / 540	537 / 621	551 / 632
400 AL	458 / 553	557 / 661	575 / 676	515 / 609	618 / 718	634 / 731
500 AL	507 / 616	638 / 761	659 / 779	572 / 682	709 / 828	730 / 845
630 AL	559 / 684	732 / 879	758 / 901	633 / 760	817 / 959	841 / 979
800 AL	614 / 756	834 / 1007	865 / 1033	698 / 844	933 / 1102	962 / 1126
1000 AL	664 / 825	935 / 1135	971 / 1167	757 / 923	1048 / 1245	1082 / 1274

Source: Calculated using CRATER

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Table 52

76,000/132,000V SINGLE CORE COPPER STRANDED CONDUCTOR, XLPE INSULATED, COPPER FOIL LAMINATE WITH COPPER WIRE SCREEN, MDPE OVERSHEATH IEC 60840						
Cable size mm²	**Current rating A (cables laid direct at 900mm to top of cable)**					
	Summer			**Winter**		
	Solid bonded trefoil group	**Specially bonded 3 cables at 2 x D centres**	**Specially bonded 3 cables at 3 x D centres**	**Solid bonded trefoil group**	**Specially bonded 3 cables at 2 x D centres**	**Specially bonded 3 cables at 3 x D centres**
	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic
300 Cu	562 / 664	629 / 760	652 / 782	645 / 749	718 / 846	741 / 869
400 Cu	628 / 746	717 / 871	744 / 899	723 / 844	820 / 974	848 / 1002
500 Cu	698 / 835	819 / 1002	853 / 1036	807 / 948	940 / 1124	975 / 1159
630 Cu	769 / 926	933 / 1148	973 / 1191	892 / 1055	1073 / 1293	1116 / 1337
800 Cu	840 / 1017	1050 / 1301	1100 / 1356	978 / 1163	1212 / 1470	1266 / 1527
1000 Cu	900 / 1095	1161 / 1445	1221 / 1512	1049 / 1255	1342 / 1637	1407 / 1708

Source: Calculated using CRATER

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Table 53

76,000/132,000V SINGLE CORE COPPER STRANDED CONDUCTOR, XLPE INSULATED, COPPER FOIL LAMINATE WITH COPPER WIRE SCREEN, MDPE OVERSHEATH IEC 60840						
Cable size mm²	**Current rating A (cables in ducts at depth of 900mm to top of duct)**					
	Summer			**Winter**		
	Solid bonded trefoil group	**Specially bonded 3 cables at 2 x D centres**	**Specially bonded 3 cables at 3 x D centres**	**Solid bonded trefoil group**	**Specially bonded 3 cables at 2 x D centres**	**Specially bonded 3 cables at 3 x D centres**
	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic	Cont/Cyclic
300 Cu	492 / 596	624 / 738	644 / 755	554 / 657	691 / 800	709 / 814
400 Cu	539 / 657	712 / 847	736 / 866	609 / 728	790 / 920	812 / 937
500 Cu	586 / 721	814 / 973	842 / 997	664 / 801	905 / 1060	931 / 1081
630 Cu	633 / 785	927 / 1115	960 / 1144	719 / 876	1034 / 1218	1066 / 1244
800 Cu	682 / 853	1046 / 1266	1085 / 1302	777 / 956	1169 / 1386	1208 / 1419
1000 Cu	724 / 914	1157 / 1410	1203 / 1453	828 / 1028	1297 / 1548	1342 / 1588

Source: Calculated using CRATER

11 Crater

11.1 General

The CRATER series of programmes was developed by EA Technology having been commissioned by Module 3 of the STP Programme to cover a very wide range of cable rating problems. The tables of ratings contained in this document cover all the cables commonly in use on the Electricity North West network. However, there are occasions where a cable type or size not covered is encountered or there is a need to assess the rating for different ground conditions, multi-cable installation, etc. Deriving a rating is a far from trivial task. CRATER has addressed this problem, being a user friendly suite of spreadsheet tools that can be used to determine the current rating of cables covering the whole range of cable types currently used in the UK with modules to handle individual cable types, arrays of mixed cable types, cables crossing, cables in ducts, dynamic and emergency situations, allowing ratings to be established for a wide variety of cable laying and operational scenarios.

Because of these advantages and confidence in the accuracy of the derived ratings, CRATER has been introduced into Electricity North West. Currently, CRATER is made available to selected Electricity North West staff on an as-needed basis, the suite of spreadsheets being loaded onto an individual PC, under the control of the Electricity North West Cable Policy Manager. This arrangement may be amended in the future because EA Technology is currently introducing a licensing arrangement for use of CRATER.

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11.2 Use of Crater

Where amendments to cable ratings provided in this CP are planned, the calculations shall be made by CRATER. Before any revised ratings area assigned to the affected cable(s) or circuits the following procedures shall be followed. This is not intended to stifle improvements to the design and operation of the network but to ensure that the present consistent approach to network design and operation is maintained.

11.2.1 Approval

Any proposed revision to or newly assigned ratings using CRATER shall not be applied to the cable(s) unless authorised by the Electricity North West Limited Cable Policy Manager.

11.2.2 Record of Design Conditions

Where ratings are re-calculated for different design conditions then a record of the design conditions used shall be forwarded to the Electricity North West Limited Cable Policy Manager for approval, showing:

- Maximum conductor temperature
- Depth of laying
- Ducted / laid in ground / in air (as appropriate)
- Ground temperature
- Air temperature (where applicable)
- Soil thermal resistivity
- Any allowance for grouping
- Loading conditions (continuous, cycling, etc.)
- Cyclic load pattern (where applicable)

11.2.3 Cable Types and Sizes not Covered by this Document

Where ratings are to be assigned to cable and/or sizes not covered by the ratings tables in this CP, the same design conditions shall be used as in this document (sections 4 and 5), unless otherwise agreed with the Electricity North West Limited Cable Policy Manager.

NOTE: The maximum conductor temperature specified by the manufacturer is normally to be used to calculate the rating. Where this not specified then a maximum of 65°C shall be assumed.

11.2.4 Circuit Model

Where a rating is assigned to a specific circuit or cables within a circuit differs from that provided in tables of ratings in this CP then the data entry for such item(s) in the circuit model shall be marked to show that the rating is non-standard.

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12 Documents Referenced

DOCUMENTS REFERENCED	
IEC 502	Extruded solid dielectric insulated power cables for rated voltages from 1kV to 30kV.
BS 6622:1991	Specification for cables with extruded polythene or ethylene propylene rubber insulation for rated voltages from 3 800/6 600V to 19,000/33,000V.
BS 480/6480	Specification for impregnated paper - insulated Lead or Lead alloy sheathed electric cables of rated voltage up to and including 33,000V.
BS 4553: 1970	Single core stranded Copper (metric) service cable (split concentric).
BS 7870:1997	LV and MV polymeric insulated cables for use by distribution and generation utilities.
BS 7889: 1997	Specification for 600/1000V single core unarmoured electric cables having thermosetting insulation.
BS 5467:1989	Specification for cables with thermosetting insulation for electricity supply for rated voltages up to and including 600/1,000V and up to and including 1 900/3 300V.
BS 6346:1989	Specification for PVC-insulated cables for electricity supply.
ENA TS 09-3	3kV impregnated paper insulated oil-filled and gas compression type power cable systems.
ENA TS 09-7	PVC insulated concentric single-phase service cables with stranded Copper or solid Aluminium phase conductors and Copper concentric conductors.
ENA TS 09-8	Impregnated paper insulated 600/1,000V cable with three solid Aluminium phase conductors and Aluminium sheath/neutral conductor (CONSAC).
ENA TS 09-9	Polymeric insulated 3 phase combined neutral/earth (CNE) cables with solid Aluminium phase conductors and concentric Copper neutral/earth wires.
ENA TS 09-12	Impregnated paper insulated corrugated Aluminium sheathed 6,350/ 11,000V cable (PICAS).
ENA TS 09-17	Single core cables for use in substations having extruded insulation and rated voltages of 6,350/11,000V and 19,000/33,000V.
CES - C2 (1955)	Impregnated paper insulated solid type Lead or Lead alloy sheathed power cables for voltages up to and including 22kV.
BEBS - C4 (1966)	
ERA Report 69-30	Current rating standards for distribution cables.
Engineering Recommendation P17	Current rating guide for distribution cables

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AEI publication 5513-51	
AEI publication AM-PCD-10	
Delta Crompton publication EC 1005 9410	
Pirelli publication HVP	
BICC publication ECD XLPE/9.93	

13 Keywords

Cable; HV; LV; 11kV; 33kV; 132kV; Rating.

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Appendix A – Summary Cable Ratings

A1 Modern Service Cables

TYPE	SIZE MM²	LAID DIRECT G = 1.2 °C M/W T = 15 °C		KVA*	
PVC insulated straight or split concentric 1 phase with stranded Cu or solid Al phase conductor & Cu neutral/earth conductor.	4	58A		14	
	25	Cu Core = 163A	Al Core = 126A	39	30
	35	154A		37	
Polymeric insulated straight or split concentric 1 phase with stranded Cu or solid Al phase conductor & Cu neutral/earth conductor.	4	65A		15	
	25	Cu Core = 185A	Al Core = 143A	44	34
	35	174A		42	
Polymeric insulated straight or split concentric 3 phase with solid Al phase conductor and Cu neutral / earth conductor.	25	116A		83	
	35	139A		100	

* The kVA ratings shown in this table are based upon the LV network design voltage of 415/240V. Those for single phase service cables are single phase ratings; the ratings of all other cables including single core mains cables are three phase ratings.

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A2 Historic Service Cables

TYPE	SIZE	LAID DIRECT G = 1.2 °C M/W T = 15 °C	KVA*
PVC Cu single core plus helical concentric Cu neutral and earth service cable (split concentric).	16mm^2	128A	31
BS 480 twin Cu conductor, paper insulated, lead sheath, steel tape armoured. (CES C2 1955)	0.007 in^2 circ	62A	15
	0.0145 in^2 shaped	93A	22
	0.0225 in^2 shaped	120A	29
	0.04 in^2 shaped	165A	40
	0.06 in^2 shaped	210A	50
	0.1 in^2 shaped	285A	68
BS 480 four core Cu conductor, paper insulated, lead sheath, steel tape armoured. (CES C2 1955)	0.007 in^2 circ	51A	37
	0.0145 in^2 circ	77A	55
	0.0225 in^2 shaped	100A	72
	0.04 in^2 shaped	140A	101
	0.06 in^2 shaped	175A	126
	0.1 in^2 shaped	240A	172
* The kVA ratings shown in this table are based upon the LV network design voltage of 415/240V. Those for single phase service cables are single phase ratings; the ratings of all other cables including single core mains cables are three phase ratings.			

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A3 Modern LV Mains Cables

MODERN LV MAINS CABLES (1 of 2)			
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**	**KVA***
ENA TS 09-9 polymeric insulated combined neutral/earth (CNE) with solid Al phase conductors and concentric Cu waveform neutral/earth conductor.	95	235A	169
	185	335A	241
	240	390A	280
	300	435A	313
BS 6346 single core solid Al 4 x 90° sector shaped, PVC insulated, PVC sheathed. (Transformer tails, armoured version bonded both ends.)	600 (unarmoured)	613A	440
	600 (Al strip armoured)	586A	421
BS 5467 single core solid Al 4 x 90° sector shaped XLPE insulated, PVC sheathed. (Transformer tails.)	400	550A	395
* The kVA ratings shown in this table are based upon the LV network design voltage of 415/240V. Those for single phase service cables are single phase ratings; the ratings of all other cables including single core mains cables are three phase ratings.			

MODERN LV MAINS CABLES (2 of 2)									
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °CM/W T = 15 °C**				**IN AIR T = 25 °C**			
		Trefoil	**Flat**	**kVA***		**Trefoil**	**Flat**	**kVA***	
BS 7889 single core Cu conductor, XLPE insulated, PVC sheathed, UNARMOURED. (Transformer tails.)	400	Not to be used				887	1127	637	810
BS 5467 single core Cu conductor, XLPE insulated, PVC sheathed, Al wire ARMOURED. (Transformer tails.)	400	691	657	497	472	851	887	612	638
* The kVA ratings shown in this table are based upon the LV network design voltage of 415/240V. Those for single phase service cables are single phase ratings; the ratings of all other cables including single core mains cables are three phase ratings.									

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A4 Historic LV Mains Cables

HISTORIC LV MAINS CABLES (1 of 7)			
TYPE	**SIZE IN^2**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**	**KVA***
BS 480 four core Cu conductor, paper insulated, lead sheath, steel tape armoured. (CES C2 1955) (IMPERIAL) Cu	0.04	140A	101
	0.06	175A	126
	0.1	240A	173
	0.12	260A	187
	0.15	290A	208
	0.2	345A	248
	0.25	395A	284
	0.3	445A	320
	0.4	520A	374
	0.5	570A	410
* The kVA ratings shown in this table are based upon the LV network design voltage of 415/240V. Those for single phase service cables are single phase ratings; the ratings of all other cables including single core mains cables are three phase ratings.			

HISTORIC LV MAINS CABLES (2 of 7)			
TYPE	**SIZE IN^2**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**	**KVA***
BS 480 four core Al conductor, paper insulated, lead sheath, steel tape armoured. (CES C2 1955) (IMPERIAL) Al	0.04	110A	79
	0.06	135A	97
	0.1	185A	133
	0.15	225A	162
	0.2	270A	194
	0.25	310A	223
	0.3	350A	252
	0.4	410A	295
	0.5	450	323
* The kVA ratings shown in this table are based upon the LV network design voltage of 415/240V. Those for single phase service cables are single phase ratings; the ratings of all other cables including single core mains cables are three phase ratings.			

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HISTORIC LV MAINS CABLES (3 of 7)			
TYPE	**SIZE IN²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**	**KVA***
BS 480 stranded Cu single core, paper insulated, lead sheathed. (Imperial sizes in trefoil groups.) Cu	0.4	540A	388
	0.5	610A	438
	0.6	670A	482
	0.75	730A	524
	1.0	830A	597
* The kVA ratings shown in this table are based upon the LV network design voltage of 415/240V. Those for single phase service cables are single phase ratings; the ratings of all other cables including single core mains cables are three phase ratings.			

HISTORIC LV MAINS CABLES (4 of 7)			
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**	**KVA***
BS 480 four core Cu conductor, paper insulated, lead sheath, steel tape armoured. (CES C2 1955) (METRIC) Cu	16	89A	64
	25	115A	83
	35	140A	101
	50	165A	119
	70	205A	147
	95	245A	176
	120	280A	201
	150	315A	226
	185	355A	255
	240	410A	295
	300	460A	331
	400	520A	374
* The kVA ratings shown in this table are based upon the LV network design voltage of 415/240V. Those for single phase service cables are single phase ratings; the ratings of all other cables including single core mains cables are three phase ratings.			

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HISTORIC LV MAINS CABLES (5 of 7)			
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**	**KVA***
BS 480 four core Al conductor, paper insulated, lead sheath, steel tape armoured. (CES C2 1955) (METRIC) Al	16	69A	50
	25	89A	64
	35	110A	79
	50	130A	93
	70	160A	115
	95	190A	137
	120	220A	158
	150	245A	176
	185	280A	201
	240	325A	234
	300	365A	262
	400	415A	298
* The kVA ratings shown in this table are based upon the LV network design voltage of 415/240V. Those for single phase service cables are single phase ratings; the ratings of all other cables including single core mains cables are three phase ratings.			

HISTORIC LV MAINS CABLES (6 of 7)			
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**	**KVA***
EATS 09-8 impregnated paper insulated with three solid Al phase conductors and Al sheath neutral conductor. (CONSAC)	95	220A	158
	185	320A	230
	240	370A	266
	300	420A	302
* The kVA ratings shown in this table are based upon the LV network design voltage of 415/240V. Those for single phase service cables are single phase ratings; the ratings of all other cables including single core mains cables are three phase ratings.			

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HISTORIC LV MAINS CABLES (7 of 7)									
TYPE	**SIZE MM^2**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**				**IN AIR T = 25 °C**			
		TREFOIL	**FLAT**	**KVA***		**TREFOIL**	**FLAT**	**KVA***	
BS 6480 single core Cu conductor, paper insulated, lead sheathed, PVC sheathed overall. (Transformer tails.)	400	680	700	489	503	820	930	589	668
* The kVA ratings shown in this table are based upon the LV network design voltage of 415/240V. Those for single phase service cables are single phase ratings; the ratings of all other cables including single core mains cables are three phase ratings.									

A5 Modern 11/6.6kV Cables

The conditions under which Distribution Ratings apply are listed in Engineering Recommendation P17. They are:

- Maximum conductor temperature = 65 °C.
- Depth of laying = 0.6 to 3.0m.
- Ground temperature = 10 °C.
- Ambient air temperature = 10 °C.
- Soil thermal resistivity (g) = 0.9 °C m/W.
- No allowance for grouping of cables.
- Up to 5 day limited cyclic loading.
- Winter peak period.
- Two feeder open ring operation.

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MODERN 11/6.6KV CABLES (1 OF 7)							
TYPE	SIZE MM²	LAID DIRECT G = 1.2 °C M/W T = 15 °C					
		CONTINUOUS	MVA*	CYCLIC	MVA*	DISTRIBUTION RATING	MVA*
ENA TS 09-12 three core stranded, shaped Al conductor, paper insulation, corrugated Al sheath, PVC overall. (PICAS)	95	185A	3.52	210A	4.00	245A	4.66
	185	270A	5.14	305A	5.81	370A	7.04
	300	355A	6.76	400A	7.62	490A	9.33
* The kVA ratings and MVA ratings shown in this table are based upon the nominal system voltage of 11kV. To obtain the ratings at 6.6kV, multiply the 11kV rating by 0.6.							

MODERN 11/6.6kV CABLES (2 of 7)					
Type	Size mm²	Laid direct g = 1.2 °C m/W T = 15 °C			
		Continuous	MVA*	Cyclic	MVA*
ENA TS 09-17 single core stranded Cu and Al conductor, triple extruded insulation, Cu wire screen, PVC sheath overall. (Laid in trefoil.)	300 Cu	597A	11.37	674A	12.83
	400 Cu	674A	12.83	761A	14.49
	400 Al	537A	10.22	606A	11.54
	500 Al	612A	11.65	691A	13.16
* The kVA ratings and MVA ratings shown in this table are based upon the nominal system voltage of 11kV. To obtain the ratings at 6.6kV, multiply the 11kV rating by 0.6.					

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MODERN 11/6.6kV CABLES (3 of 7)					
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
BS 6622/IEC 502 single core stranded Cu conductor, triple extruded insulation, 3.4mm, Cu wire screen, PVC sheath overall. Cu	70	270A	5.14	305A	5.81
	95	320A	6.09	360A	6.85
	120	360A	6.85	405A	7.71
	150	410A	7.81	460A	8.76
	185	460A	8.76	520A	9.90
	240	530A	10.09	600A	11.43
	300	600A	11.43	675A	12.85
	400	680A	12.95	765A	14.57
	500	750A	14.28	845A	16.09
	630	830A	15.81	935A	17.81
* The kVA ratings and MVA ratings shown in this table are based upon the nominal system voltage of 11kV. To obtain the ratings at 6.6kV, multiply the 11kV rating by 0.6.					

MODERN 11/6.6kV CABLES (4 of 7)					
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
BS 6622/IEC 502 three core stranded Cu conductor, triple extruded insulation, 3.4mm, Cu wire screen, unarmoured, PVC sheath overall. Cu	70	255A	4.85	285A	5.42
	95	300A	5.71	340A	6.47
	120	340A	6.47	385A	7.33
	150	380A	7.23	430A	8.19
	185	430A	8.19	485A	9.23
	240	500A	9.52	565A	10.76
	300	560A	10.66	630A	12.0
* The kVA ratings and MVA ratings shown in this table are based upon the nominal system voltage of 11kV. To obtain the ratings at 6.6kV, multiply the 11kV rating by 0.6.					

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MODERN 11/6.6kV CABLES (5 of 7)					
TYPE	SIZE MM²	LAID DIRECT G = 1.2 °C M/W T = 15 °C			
		CONTINUOUS	MVA*	CYCLIC	MVA*
BS 6622/IEC 502 three core stranded Al conductor, triple extruded insulation, 3.4mm, Cu wire screen, PVC sheath overall. Al	70	200A	3.81	225A	4.28
	95	235A	4.47	265A	5.04
	120	265A	5.04	300A	5.71
	150	295A	5.61	330A	6.28
	185	355A	6.38	375A	7.14
	240	390A	7.42	440A	8.38
	300	435A	8.28	490A	9.33
* The kVA ratings and MVA ratings shown in this table are based upon the nominal system voltage of 11kV. To obtain the ratings at 6.6kV, multiply the 11kV rating by 0.6.					

MODERN 11/6.6kV CABLES (6 of 7)					
TYPE	SIZE MM²	LAID DIRECT G = 1.2 °C M/W T = 15 °C			
		CONTINUOUS	MVA*	CYCLIC	MVA*
BS 6622/IEC 502 single core stranded Al conductor, triple extruded insulation, 3.4mm, Cu wire screen, PVC sheath overall. Al	70	210A	4.0	235A	4.47
	95	250A	4.76	280A	5.33
	120	280A	5.33	315A	6.0
	150	320A	6.09	360A	6.85
	185	360A	6.85	405A	7.71
	240	415A	7.90	470A	8.95
	300	475A	9.04	535A	10.19
	400	540A	10.28	610A	11.62
	500	610A	11.62	690A	13.14
	630	680A	12.95	765A	14.57
* The kVA ratings and MVA ratings shown in this table are based upon the nominal system voltage of 11kV. To obtain the ratings at 6.6kV, multiply the 11kV rating by 0.6.					

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MODERN 11/6.6kV CABLES (7 of 7)					
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
Single core, solid Al conductor, polymeric insulation, Cu screen, MDPE sheath overall and laid in triplex formation to BS 7870 Part 4 Section 10.	95	245A	4.66	284A	5.41
	185	353A	6.72	412A	7.85
	300	461A	8.78	542A	10.33
Single core, stranded Al conductor, polymeric insulation, Cu screen, MDPE sheath overall and laid in triplex formation to BS 7870 Part 4 Section 10.	400	552A	10.5	646A	12.3
* The kVA ratings and MVA ratings shown in this table are based upon the nominal system voltage of 11kV. To obtain the ratings at 6.6kV, multiply the 11kV rating by 0.6.					

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A6 Historic 11/6.6kV Cables

HISTORIC 11/6.6kV CABLES (1 of 5)							
TYPE	**SIZE IN^2**	**LAID DIRECT G = 0.9 °C M/W T = 15 °C**					
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***	**DISTRIBUTION RATING**	**MVA***
BS 480/6480 three core stranded Cu conductor, paper insulation belted, lead sheathed steel wire armoured. (IMPERIAL) Cu	0.0225	92A	1.75	100A	1.90	-	-
	0.04	130A	2.47	140A	2.66	145A	2.76
	0.06	160A	3.05	175A	3.33	185A	3.52
	0.1	220A	4.19	245A	4.66	255A	4.85
	0.15	270A	5.14	305A	5.81	320A	6.09
	0.2	320A	6.09	360A	6.85	385A	7.33
	0.25	370A	7.04	415A	7.90	440A	8.38
	0.3	410A	7.81	460A	8.76	500A	9.52
	0.4	475A	9.04	535A	10.19	595A	11.33
	0.5	530A	10.09	600A	11.43	670A	12.76
* The kVA ratings and MVA ratings shown in this table are based upon the nominal system voltage of 11kV. To obtain the ratings at 6.6kV, multiply the 11kV rating by 0.6.							

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HISTORIC 11/6.6kV CABLES (2 of 5)							
TYPE	**SIZE IN^2**	**LAID DIRECT G = 0.9 °C M/W T = 15 °C**					
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***	**DISTRIBUTION RATING**	**MVA***
BS 480/6480 three core stranded Al conductor, paper insulation belted, lead sheathed steel wire armoured. (IMPERIAL) Al	0.0225	72A	1.37	78A	1.48	-	-
	0.04	100A	1.90	110A	2.09	-	-
	0.06	125A	2.38	135A	2.57	145A	2.76
	0.1	170A	3.23	190A	3.62	195A	3.71
	0.15	210A	4.0	235A	4.47	250A	4.76
	0.2	250A	4.76	280A	5.33	300A	5.71
	0.25	290A	5.52	325A	6.19	345A	6.57
	0.3	325A	6.19	365A	6.95	390A	7.42
	0.4	375A	7.14	420A	8.0	470A	8.95
	0.5	420A	8.0	475A	9.05	530A	10.09
* The kVA ratings and MVA ratings shown in this table are based upon the nominal system voltage of 11kV. To obtain the ratings at 6.6kV, multiply the 11kV rating by 0.6.							

HISTORIC 11/6.6kV CABLES (3 of 5)							
TYPE	**SIZE MM^2**	**LAID DIRECT G = 0.9 °C M/W T = 15 °C**					
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***	**DISTRIBUTION RATING**	**MVA***
BS 480/6480 three core stranded Cu conductor, paper insulation belted, lead sheathed steel wire armoured. (METRIC) Cu	95	245A	4.66	275A	5.23	330A	6.28
	120	280A	5.33	315A	6.0	380A	7.23
	185	355A	6.76	400A	7.62	500A	9.52
	240	410A	7.81	460A	8.76	-	-
	300	460A	8.76	520A	9.9	665A	12.66
* The kVA ratings and MVA ratings shown in this table are based upon the nominal system voltage of 11kV. To obtain the ratings at 6.6kV, multiply the 11kV rating by 0.6.							

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HISTORIC 11/6.6kV CABLES (4 of 5)							
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**					
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***	**DISTRIBUTION RATING**	**MVA***
BS 480/6480 three core stranded Al conductor, paper insulation belted, lead sheathed steel wire armoured. (METRIC) Al	95	190A	3.61	215A	4.09	260A	4.95
	120	220A	4.19	245A	4.66	300A	5.71
	185	280A	5.33	315A	6.0	390A	7.42
	240	325A	6.19	365A	6.95	460A	8.76
	300	365A	6.95	410A	7.81	525A	10.0
* The kVA ratings and MVA ratings shown in this table are based upon the nominal system voltage of 11kV. To obtain the ratings at 6.6kV, multiply the 11kV rating by 0.6.							

HISTORIC 11/6.6kV CABLES (5 of 5)					
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
BS 480/6480 single core stranded Cu, paper insulated, lead sheath, unarmoured. Cu	500	660A	12.57	745A	14.19
	630	740A	14.09	835	15.9
* The kVA ratings and MVA ratings shown in this table are based upon the nominal system voltage of 11kV. To obtain the ratings at 6.6kV, multiply the 11kV rating by 0.6.					

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A7 Modern 33kV Cables – Mind & XLPE

MODERN 33kV CABLES – MIND & XLPE (1 of 6)					
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
Three core stranded Cu and Al conductor, paper insulated, carbon paper screened, H foil screened, MIND, lead alloy sheathed, steel wire armoured to BS 6480.	185 Cu	400A	22.8	450A	25.7
	240 Cu	460A	26.3	520A	29.7
	300 Cu	515A	29.4	580A	33.1
	185 Al	315A	18.0	355A	20.3
	240 Al	365A	20.8	410A	23.4
	300 Al	410A	23.4	460A	26.3
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.					

MODERN 33kV CABLES – MIND & XLPE (2 of 6)					
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
Three single core stranded Cu and Al conductor, paper insulated MIND, lead alloy sheathed, SL cables to BS 6480.	185 Cu	395A	22.5	445A	25.4
	240 Cu	455A	26.0	515A	29.4
	300 Cu	505A	28.8	570A	32.5
	185 Al	310A	17.7	350A	20.0
	240 Al	360A	20.5	405A	23.1
	300 Al	405A	23.1	455A	26.0
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.					

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MODERN 33kV CABLES – MIND & XLPE (3 of 6)					
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
Single core stranded Cu and Al conductor, paper insulated, MIND, lead alloy sheathed, unarmoured cables to BS 6480.	185 Cu	430A	24.5	485A	27.7
	240 Cu	500A	28.5	565A	32.2
	300 Cu	560A	32.0	630A	36.0
	400 Cu	635A	36.3	715A	40.8
	500 Cu	705A	40.3	795A	45.3
	630 Cu	800A	45.7	905A	51.7
	800 Cu	880A	50.3	995A	56.8
	960 Cu	985A	56.3	1115A	63.7
	240 Al	390A	22.3	440A	25.1
	300 Al	440A	25.1	495A	28.2
	400 Al	500A	28.5	565A	32.2
	500 Al	565A	32.2	640A	36.5
	630 Al	645A	36.8	730A	41.7
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.					

MODERN 33kV CABLES – MIND & XLPE (4 of 6)					
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
Three core stranded Cu conductor, triple extruded XLPE insulated, MDPE sheathed, steel wire armoured, MDPE oversheathed to BS 6622 and IEC 502.	185 Cu	420A	24.0	475A	27.1
	240 Cu	480A	27.4	540A	30.8
	300 Cu	530A	30.3	600A	34.2
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.					

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MODERN 33kV CABLES – MIND & XLPE (5 of 6)					
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
Single core stranded Cu conductor, triple extruded XLPE insulated, MDPE sheathed, unarmoured, Cu wire screen, MDPE oversheathed to BS 7870 Part 4 Section 4.10 and IEC 502.	185	448A	25.6	524	29.9
	240	515A	29.4	605	34.5
	300	577A	32.9	682	38.9
	400	652A	37.2	775	44.2
	500	732A	41.8	875	50.0
	630	818A	46.7	983	56.1
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.					

MODERN 33kV CABLES – MIND & XLPE (6 of 6)					
TYPE	**SIZE MM²**	**LAID DIRECT G = 1.2 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
Single core stranded Al conductor, triple extruded XLPE insulated, MDPE sheathed, unarmoured, Cu wire screen, MDPE oversheathed to BS 7870 Part 4 Section 4.10 and IEC 502.	185	357	TBA	416	TBA
	240	412	TBA	482	TBA
	300	465	TBA	545	TBA
	400	531	TBA	627	TBA
	500	604	TBA	717	TBA
	630	685	TBA	818	TBA
	800	769	TBA	923	TBA
	1000	850	TBA	1026	TBA
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.					

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A8 Modern 33kV Cables – Fluid Filled

MODERN 33kV CABLES – FLUID FILLED (1 of 3)						
TYPE	SIZE MM²		LAID DIRECT G = 1.2 °C M/W T = 15 °C			
			CONTINUOUS	MVA*	CYCLIC	MVA*
Three core Cu and Al compacted circular conductor, paper insulated, lead alloy sheathed, fluid filled to ENA TS 09-3.	400 One circuit 0.9m cover	Cu	635A	36.3	715A	40.8
		Al	505A	28.8	570A	32.5
	400 Two circuits 0.45m centres 0.9m cover	Cu	560A	32.0	630A	36.0
		Al	445A	25.4	500A	28.5
	630 One circuit 0.9m cover	Cu	795A	45.4	900A	51.4
		Al	650A	37.1	735A	42.0
	630 Two circuits 0.45m centres 0.9m cover	Cu	690A	39.4	780A	44.6
		Al	565A	32.3	635A	36.2
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.						

MODERN 33kV CABLES – FLUID FILLED (2 of 3)						
TYPE	SIZE MM²		LAID DIRECT G = 1.2 °C M/W T = 15 °C			
			CONTINUOUS	MVA*	CYCLIC	MVA*
Three core Cu and Al compacted oval conductor, paper insulated, corrugated Al sheathed, fluid filled to ENA TS 09-3.	400 One circuit 0.9m cover	Cu	600A	34.2	675A	38.5
		Al	480A	27.4	540A	30.8
	400 Two circuits 0.45m centres 0.9m cover	Cu	530A	30.2	600A	34.2
		Al	425A	24.2	480A	27.4
	630 One circuit 0.9m cover	Cu	735A	42.0	830A	47.4
		Al	610A	34.8	690A	39.4
	630 Two circuits 0.45m centres 0.9m cover	Cu	645A	36.8	730A	41.7
		Al	520A	29.7	590A	33.7
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.						

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MODERN 33kV CABLES – FLUID FILLED (3 of 3)						
TYPE	SIZE MM²		LAID DIRECT G = 1.2 °C M/W T = 15 °C			
			CONTINUOUS	MVA*	CYCLIC	MVA*
Three core Cu and Al compacted oval conductor, paper insulated, corrugated Al sheathed, gas filled to ENA TS 09-3.	400 One circuit 0.9m cover	Cu	575A	32.8	650A	37.1
		Al	475A	27.1	535A	30.5
	400 Two circuits 0.45m centres 0.9m cover	Cu	500A	28.5	565A	32.2
		Al	415A	23.7	470A	26.8
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.						

A9 Historic 33kV Cables – Mind

HISTORIC 33kV CABLES – MIND (1 of 3)					
TYPE	SIZE IN²	LAID DIRECT G = 0.9 °C M/W T = 15 °C			
		CONTINUOUS	MVA*	CYCLIC	MVA*
Three core stranded Cu conductor, carbon paper screened, paper insulated, MIND, H type, lead alloy sheathed, unarmoured to BS 6480.	0.1	220A	12.5	250A	14.2
	0.15	270A	15.4	305A	17.4
	0.2	315A	18.0	355A	20.2
	0.25	360A	20.5	405A	23.1
	0.3	400A	22.8	450A	25.7
	0.4	465A	26.5	525A	30.0
	0.5	510A	29.1	575A	32.8
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.					

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HISTORIC 33kV CABLES – MIND (2 of 3)					
TYPE	**SIZE IN²**	**LAID DIRECT G = 0.9 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
Three core stranded Cu conductor, paper insulated, MIND, SL sheathed, armoured to BS 6480.	0.1	230A	13.1	260A	14.8
	0.15	270A	15.4	305A	17.4
	0.2	320A	18.3	360A	20.5
	0.25	360A	20.5	405A	23.1
	0.3	405A	23.1	460A	26.3
	0.4	470A	26.8	530A	30.3
	0.5	520A	29.7	590A	33.7
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.					

HISTORIC 33kV CABLES – MIND (3 of 3)					
TYPE	**SIZE IN²**	**LAID DIRECT G = 0.9 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
Single core stranded Cu conductor, paper insulated, MIND, lead sheathed, unarmoured to BS 6480.	0.1	230A	13.1	260A	14.8
	0.15	285A	16.2	320A	18.3
	0.2	335A	19.1	380A	21.7
	0.25	380A	21.7	430A	24.5
	0.3	420A	24.0	475A	27.1
	0.4	490A	28.0	555A	31.7
	0.5	550A	31.4	620A	35.4
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.					

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A10 Historic 33kV Cables – Fluid Filled

HISTORIC 33kV CABLES – FLUID FILLED (1 of 3)					
TYPE	**SIZE IN^2**	**LAID DIRECT G = 0.9 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
Three core oval compacted Cu or Al conductor, paper insulated and screened, without fillings or oil ducts, fluid filled, corrugated Al sheathed, PVC sheathed overall to BEBS C4 (1966).	0.2 Cu	380A	21.7	430A	24.5
	0.25 Cu	435A	24.8	490A	28.0
	0.3 Cu	475A	27.1	535A	30.5
	0.35 Cu	520A	29.7	590A	33.7
	0.4 Cu	550A	31.4	620A	35.4
	0.45 Cu	580A	33.1	655A	37.4
	0.5 Cu	610A	34.8	690A	39.4
	0.55 Cu	645A	36.8	730A	41.7
	0.6 Cu	670A	38.2	755A	43.1
	0.3 Al	375A	21.4	425A	24.3
	0.4 Al	435A	24.8	490A	28.0
	0.5 Al	480A	27.4	540A	30.8
	0.6 Al	530A	30.3	600A	34.2
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.					

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HISTORIC 33kV CABLES – FLUID FILLED (2 of 3)					
TYPE	**SIZE IN^2**	**LAID DIRECT G = 0.9 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
Three core circular compacted Cu or Al conductor, paper insulated and screened, fluid filled, lead alloy sheathed, PVC sheathed overall to BEBS C4 (1966).	0.2 Cu	385A	22.0	435A	24.8
	0.25 Cu	440A	25.1	500A	28.5
	0.3 Cu	485A	27.7	550A	31.4
	0.35 Cu	535A	30.5	605A	34.5
	0.4 Cu	565A	32.2	635A	36.3
	0.45 Cu	600A	34.2	675A	38.5
	0.5 Cu	630A	36.0	710A	40.5
	0.55 Cu	660A	37.7	745A	42.6
	0.6 Cu	700A	40.0	790A	45.1
	0.3 Al	385A	22.0	435A	24.8
	0.4 Al	445A	25.4	500A	28.5
	0.5 Al	500A	28.6	565A	32.2
	0.6 Al	555A	31.7	625A	35.7
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.					

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HISTORIC 33kV CABLES – FLUID FILLED (3 of 3)					
TYPE	**SIZE IN^2**	**LAID DIRECT G = 0.9 °C M/W T = 15 °C**			
		CONTINUOUS	**MVA***	**CYCLIC**	**MVA***
Three core shaped or oval Cu or Al conductor, paper insulated and screened, fluid filled, lead alloy sheathed to BEBS C4 (1966).	0.2 Cu	380A	21.7	430A	24.5
	0.25 Cu	435A	24.8	490A	28.0
	0.3 Cu	485A	27.7	545A	31.1
	0.35 Cu	530A	30.2	600A	34.2
	0.4 Cu	560A	32.0	630A	36.0
	0.45 Cu	595A	34.0	670A	38.3
	0.5 Cu	620A	35.4	700A	40.0
	0.55 Cu	655A	37.4	740A	42.2
	0.3 Al	385A	22.0	435A	24.8
	0.4 Al	445A	25.4	500A	28.5
	0.5 Al	490A	28.0	555A	31.7
* The MVA ratings shown in this table are 3 phase ratings based upon the nominal system voltage of 33kV.					

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Appendix B – Thermal Environment and Short-Circuit Levels

B1 Thermal Environment

The current rating of cables (sometimes referred to as the 'Ampacity') depends mainly upon three factors:

- The conductor material.
- The conductor cross sectional area.
- The thermal environment.

The factor defining the rate of heat transfer through the ground, its 'thermal resistivity', is assigned the letter g and is measured in units of Kelvin metre/Watt (KmW^{-1}, sometimes °C m/W). The higher the value of g, the lower the rate of heat transfer and the lower the current rating of the cable. Most modern cables have current ratings specified at a value of g of $1.2KmW^{-1}$, which is considered the 'worst case' for ground conditions in the U.K. Some older standards use an earlier unit of g defined as °C cm/W, usually 90 °C cm/W and/or 120°C cm/W. Use of the g = $1.2KmW^{-1}$ (or 1.2°C m/W) average value of ground thermal resistivity is satisfactory for 240/415V and 6.6/11kV cables. However in the case of 132kV and higher capacity 33kV circuits which represent a major financial investment, a survey of actual ground thermal resistivity along the proposed route, at the intended depth of laying, is appropriate. This will allow the conductor size to be more confidently matched to the required current carrying capacity. Because the soil moisture content and hence the value of g varies during the year, this survey should be undertaken during the season when the cable loading is expected to reach its maximum. Cable ratings are also quoted at specified ground (Tg) and air temperatures, normally 15°C and 25°C respectively.

The cable insulation is a thermal blanket reducing the cable's current carrying capacity and for this reason higher voltage cables have a lower capacity, per unit of conductor cross sectional area, than lower voltage cables. Similarly, three core cables, especially belted cables, have a lower capacity than otherwise equivalent single core cables.

Where cables operate in close proximity, their combined heat losses reduce the current rating in comparison with the same cables operating in complete thermal isolation. This is a critically important factor when two or more circuits are installed in the same trench. In these cases the cable spacing and the consequent rating will need to be optimised against the cost of installation. Laying the cables a sufficient distance apart to obtain thermal isolation is usually uneconomic. Increasing the cable spacing also somewhat increases the risk of third party damage. More information on ground thermal resistivity, short-term cyclic loading and the ratings applicable to grouped cables can be found in Engineering Recommendation P17 Current rating guide for Distribution Cables.

For 33kV and 132kV cables, which generally operate at higher load factors, the thermal conditions along the route need to be given close attention. This means carrying out an assessment of the effects of heat from adjacent cables or other sources, for example District heating pipes, also the poor thermal properties of ducts. In long duct runs the cable will suffer the additional handicap of a layer of air, which has a low thermal conductivity. To overcome this problem it is possible to fill the ducts after the cable has been installed with Bentonite, a finely divided material having good thermal properties. Use only single wall duct with these types of cable.

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A further consideration is the effect of high cable load factors. In most circuits there is a significant variation in load between day and night and between winter and summer; under these conditions the lower load periods afford the cable a cooling off period. However, in the case of highly loaded cables supplying continuous process plant, there is a danger that the constant heat output from the cables may dry out the ground. The ground's water content conducts heat much better than the solid constituents and the loss of water can lead to a rising value of g and eventually the danger of a thermal run away.

B2 Short Circuit Level

Under short circuit conditions, high current passing through the cable impedance generates large quantities of heat. Because there is no time for this heat to dissipate, the conductor temperature rise will be adiabatic; that is, the heat is absorbed mainly by the conductor material and to a very small extent by the insulation. There is a limit to the permissible temperature rise of the insulation and small conductor size cables having a low mass of metal and higher impedance have quite low short circuit level limits. This effect is independent of the rated voltage. The maximum short circuit capacity of a cable may be expressed in terms of its I^2t; that is, the square of the current multiplied by the period of time that the current flows, measured in seconds (expressed in units of Ampere^2 seconds). If the I^2t value is known, the limiting value of short circuit current over any required time period may be found by dividing the I^2t value by the short circuit time and taking the square root. For example:

Cable I^2t for a particular cable from the maker's tables = 2,000,000 A^2s

Maximum expected duration of short circuit = 3 seconds

Hence

2,000,000/3 = 666,666 A^2
therefore I = √666,666 = 816 A

Aluminium conductor cables have lower short circuit performance than Copper, because of the greater electrical resistance and lower specific heat of the metal. For example 95mm² XLPE insulated Aluminium conductor cables have a three-second short circuit limit of only approximately 5.7 kA (108 MVA), depending on the conductor temperature at the start of the short circuit.

The short circuit limitation will not apply if the circuit is fuse protected, because the energy limiting effect of the fuse predominates (as for example in low voltage circuits).

The table below specifies the maximum permissible 1second short circuit currents for various sizes of Copper and Aluminium conductors, for a conductor starting temperature of 65°C. The corresponding value for any time duration between 0.2 and 5 seconds can be found from the formula:

$$I_k = \frac{I_1}{\sqrt{t_k}}$$

Where I_k = Short circuit current during the time t_k
I_1 = Short circuit current for 1 second
t_k = Short circuit current duration in second

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Table 1

CONDUCTOR CROSS SECTION MM²	MAXIMUM 1 SECOND CURRENT, A, COPPER CONDUCTOR	MAXIMUM 1 SECOND CURRENT, A, ALUMINIUM CONDUCTOR
50	7 980	5 250
70	11,100	7 330
95	15 000	9 900
120	19,000	12 500
150	23 700	15 600
185	29 100	19 200
240	37 700	24 800
300	47 100	31,000
400	62 600	41 200
500	78 300	51 500

Figure 1

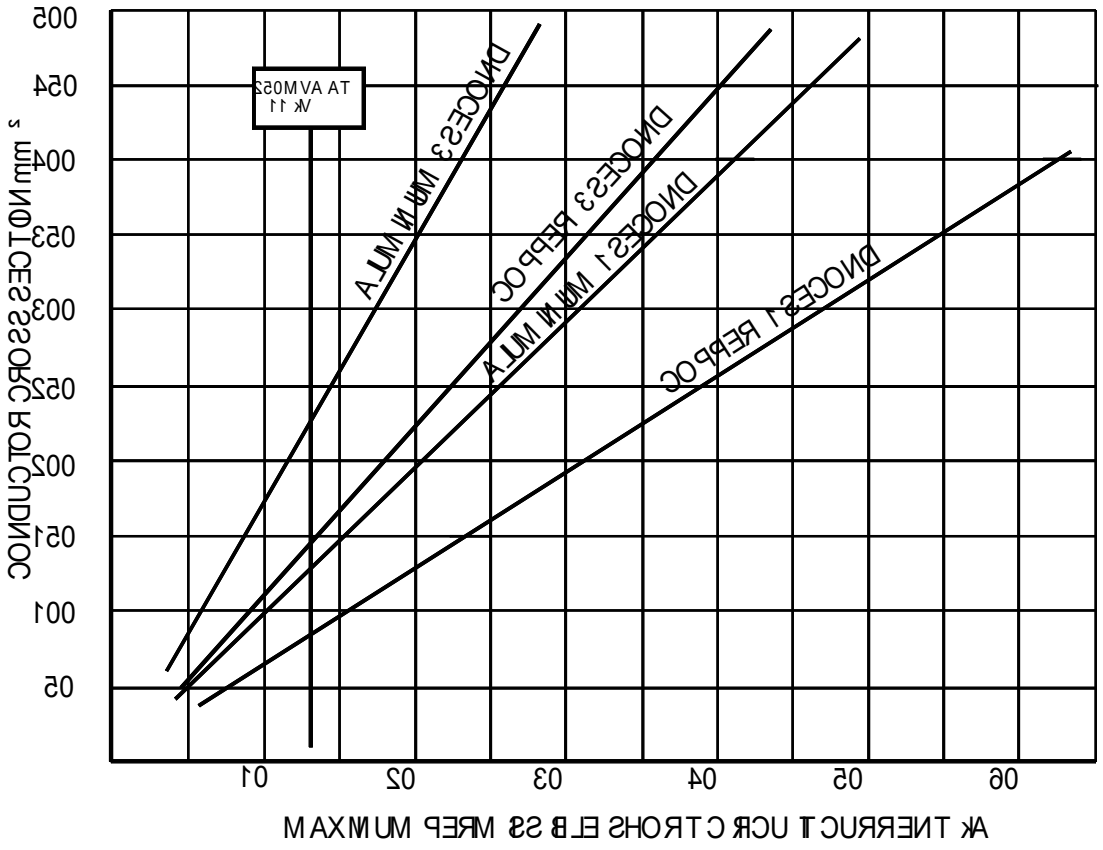


Figure 1. Variation of maximum permissible short circuit current with conductor size (conductor starting temperature 65°C, from Swedish standard SEN241407

Many polymeric insulated cables can operate at a higher conductor temperature than paper insulated cables, 90 °C compared with 65°C (70°C for single core and screened cables). For this reason they have a higher capacity per unit of conductor cross sectional area than paper insulated cables. However if this additional

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capacity is utilised, it is at the cost of increased energy losses**.** The maximum permissible conductor temperature under short circuit conditions is the same for both types of cable, 250 °C. Hence if the additional current capacity of polymeric insulated cables is used, the short circuit performance is reduced, because the available temperature difference between the maximum continuous and the maximum permissible under short circuit conditions is reduced.

B3 Sheath Losses

In single core 132kV and 33kV circuits, voltages are generated in the cable sheaths by electromagnetic effects from the passage of load current in the conductors. In long circuits, these voltages can be of sufficient magnitude to generate large circulating currents and additional heat losses, thereby reducing the cable rating, unless proper steps are taken. Reducing the sheath losses requires insulated and cross-bonded cable sheaths, together with special earthing arrangements. Information on this topic can be found in ENA TS C55/4 (1989) Insulated sheath power cable systems. It is Electricity North West Limited's policy to consider cross only bonding of 132kV cables.

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