BRITISH STANDARD

BS 6708 : 1998

Flexible cables for use at mines and quarries

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee MRE/3, Mining Electrical Equipment, to Subcommittee MRE/3/1, Cables and their connections, upon which the following bodies were represented:

Association of British Mining Equipment Companies
British Cable Makers' Confederation
Health and Safety Executive
Quarry Products Association

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Foreword

This British Standard has been prepared by Technical Committee MRE/3/1. It supersedes BS 6708 : 1991 which is withdrawn. It updates insulation specifications and short circuit current ratings, and now includes a section covering cable types 307, 307M and 307S for rated voltages of 1900/3300 V and having individual metallic screens.

All matters relating to the use of electric cables in mines and quarries are now included in the Electricity at Work Regulations 1989 [1] and the associated Health and Safety Executive (HSE) Approved Codes of Practice, i.e. *The use of electricity in mines* (COP 34) [2] and *The use of electricity at quarries* (COP 35) [3]. Guidance is given in annex A.

Attention is drawn to the Health and Safety at Work etc. Act 1974 [4], the Mines and Quarries Act 1954 [5], the regulations made under these, and also any other appropriate statutory requirements or by-laws. These place responsibility for complying with certain specific safety requirements on the manufacturer and the user.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 58, an inside back cover and a back cover.

1 Scope

This British Standard specifies requirements and dimensions for flexible cables used in mining and quarrying.

Specific types of cable covered in this standard are as follows:

a) non-armoured cables having individually metallic screened cores and a rated voltage of 640/1100 V, for use:

1) with coalface cutters and other similar machines: types 7, 7M, 7S, 11, 14 and 16;

2) in overhead catenary systems and similar applications: types FS4 (flat form cable);

b) cables with galvanized steel pliable wire armouring, with:

1) unscreened cores and a rated voltage 640/1100 V: types 20 and 21; or

2) individually metallic screened or unscreened cores and a rated voltage 640/1100 V used primarily for remote control circuits and coalface lighting: types 62, 63, 64, 70 and 71; or

3) individually metallic screened cores and a rated voltage 640/1100 V: types 201 and 211; or

4) a rated voltage 1900/3300 V used as trailing cables in quarries or for mine roadway cable extension purpose: types 321 and 331;

c) auxiliary cables with galvanized steel pliable wire armouring having up to 24 individually metallic screened cores and a rated voltage 320/550 V, primarily for use on large mining machines where interconnection between machine sections or a machine section and auxiliary equipment is required: types 506, 512, 518 and 524;

d) cables with galvanized steel pliable wire armouring having individually metallic screened or unscreened cores and a rated voltage 3800/6600 V, used as trailing cables in quarries and rated for roadway extension purposes: types 621, 630 and 631;

e) non-armoured cable having individually metallic screened cores and a rated voltage 600/1000 V, primarily for use with hand-held drilling machines in mines: type 44;

f) non-armoured cable having individually non-metallic screened cores and a rated voltage 600/1000 V, primarily for use with hand-held drilling machines in mines: type 43;

g) non-armoured cable having individually metallic screened cores and a rated voltage 3800/6600 V, primarily for use as trailing cables for large machines at quarries: type 730;

h) non-armoured cable having individually metallic screened cores and a rated voltage 6350/11000 V, primarily for use as trailing cables for large machines at quarries: type 830;

i) non-armoured cables having individually metallic screened cores and rated voltage 1900/3300 V, for use with coalface cutters and other similar machines: types 307, 307M and 307S.

NOTE 1. Information on approved codes of practice and conductivities related to the cables in this standard is given in annex A.

NOTE 2. Recommended current ratings are given in annex B.

NOTE 3. Short circuit current carrying capability of flexible cable screens is given in annex C.

2 Normative references

This British Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on the inside back cover. For dated references, only the edition cited applies; any subsequent amendments to or revisions of a cited publication apply to this British Standard only when incorporated in the text by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

3 Definitions

For the purposes of this British Standard, the definitions given in BS 4727 apply, together with the following.

NOTE. Unless otherwise specified, voltages and currents are expressed by their r.m.s. values.

3.1 rated voltage U_0

The power–frequency voltage to earth for which the cable is designed.

NOTE. It is assumed that cables may be operated continuously at a power–frequency voltage 10 % above the rated voltage.

3.2 rated voltage U

The power–frequency voltage between conductors for which the cable is designed.

NOTE. It is assumed that cables may be operated continuously at a power–frequency voltage 10 % above the rated voltage.

3.3 flexible cable

Cable designed to be moved while energized.

3.4 trailing cable

Cable used to supply apparatus that changes position while energized.

3.5 fixed cable

Cable that does not change position while energized.

3.6 stranded conductor

Conductor made up of a number of wires twisted together.

NOTE. When the conductor consists of more than one layer, alternate layers are twisted in opposite directions.

3.7 bunched conductor

Stranded conductor in which all wires are twisted together in the same direction and with the same lay throughout.

3.8 multiple stranded conductor

Stranded conductor consisting of a number of groups of wires assembled together in one or more helical layers, the wires in each group being either bunched or stranded.

3.9 braid

Plaited protective covering composed of a number of wires.

3.10 metallic screen

Braid enclosing the insulation of each conductor.

3.11 non-metallic screen

Conducting layer enclosing the insulation of each conductor.

3.12 core

Single conductor and its insulation, but not including any mechanical protective cover.

4 Abbreviations

The following abbreviations are used in this standard:

– PCP: polychloroprene;

– ETFE: ethylenetetrafluoroethylene.

5 Voltage designation

The cable shall be designated by the rated voltages U_0 and U expressed in the form U_0/U.

NOTE. The rated voltages recognized for the purposes of this British Standard are 320/550 V, 600/1000 V, 640/1100 V, 1900/3300 V, 3800/6600 V and 6350/11000 V.

6 Cables with individual metallic screens, rated voltage 640/1100 V, for use with coalcutters and for similar purposes (types 7, 7M, 7S, 11, 14 and 16) and flat cables for use on overhead catenary systems and for similar purposes (type FS4)

6.1 Types of cable

Cable types and construction shall be as given in table 1.

Constructional details and dimensions shall be as given in tables 3 to 9.

6.2 Conductors

The conductors shall be composed of round tinned annealed copper wires conforming to BS 6360 for class 5 conductors and shall be multiple stranded for conductors of 16 mm^2 and larger. Sizes below 16 mm^2 shall be bunched.

Joints made in the single wires forming the conductor shall be brazed, silver soldered or electrically welded. No joint shall be made in the conductor after it has been stranded.

The conceptual construction shall be as given in tables 3 to 9.

NOTE. At the manufacturer's discretion, a film separator of polyethylene terephthalate or other suitable non-hygroscopic tape may be applied over the conductor. Embrittlement or discoloration of this tape after vulcanization of the core may be disregarded.

6.3 Insulation

The core insulation shall be a close fit on the conductor without adhering, and shall be either type FR1 conforming to BS 7655 : Section 1.5 or type GP4 conforming to BS 7655 : Section 1.2, except that the tensile stress at 100 % elongation for GP4 shall be 2.0 N/mm^2 minimum.

For type 7 and type 14 cables, an additional layer of insulation shall be applied to the earth core and to the pilot core, as appropriate, of a thickness such that the finished outside diameters of the cores are the same as that of a screened power core. The additional layer of insulation on the pilot conductor shall be readily separable from the primary insulation.

NOTE 1. For the earth core, the additional layer of insulation may be separable from the primary insulation or, alternatively, the insulation may be applied in a homogeneous layer.

NOTE 2. If insulation colouring is used for identification purposes, it may be restricted to the outer layer.

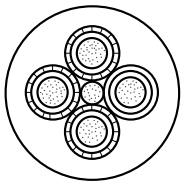
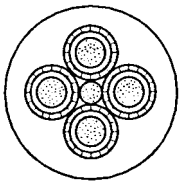
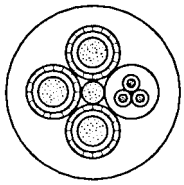
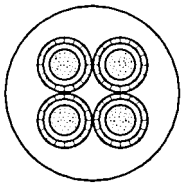
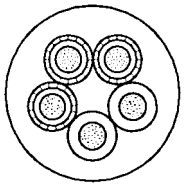
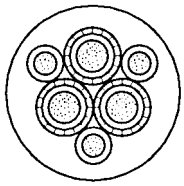
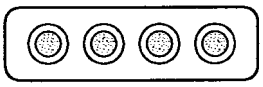
6.4 Thickness of insulation

The radial thickness of core insulation shall be determined in accordance with the method described in annex D, and the average value shall be not less than the nominal value given in tables 3 to 9. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 10 % of the nominal value.

6.5 Core tape

The insulation of each conductor shall be lapped with a tape of closely woven textile approximately 0.15 mm thick, without selvedge, proofed on one side with rubber or comparable material. The tape shall be applied with an overlap. The proofed side of the tape shall be coloured for identification purposes (see **6.6**) and shall be on the outside.

Table 1. Clause 6 cable types and construction

Type	System	Construction	Sectional diagram
7	3-phase	5-core. Three power cores each having a protective metallic screen and one pilot core unscreened, laid around a bare earth conductor with which the screens are in electrical contact, sheathed overall	
7M	3-phase	5-core. Three power cores and one pilot core having the same nominal cross-sectional area, each having a protective metallic screen, laid around a bare earth conductor with which the screens are in electrical contact, sheathed overall	
7S	3-phase	7-core. Three power cores each having a protective metallic screen, and one unscreened sheathed pilot unit containing three pilot cores, laid around a bare earth conductor with which screens are in electrical contact, sheathed overall	
11	3-phase	4-core. Three power cores and one pilot core having the same nominal cross-sectional area, each having a protective metallic screen, laid around an elastomeric centre, sheathed overall. The combined screens shall function as the cable earth conductor	
14	3-phase	5-core. Three power cores each having a protective metallic screen, one unscreened earth core and one unscreened pilot core, laid around an elastomeric centre, sheathed overall	
16	3-phase	6-core. Three power cores each having a protective metallic screen, one unscreened pilot core and two unscreened earth cores. The power cores laid around an elastomeric centre with the pilot and earth cores in the interstices, sheathed overall	
FS4	3-phase	4-core. Three power cores and one neutral core each having a protective screen, laid flat, sheathed overall	

6.6 Core identification

6.6.1 *General*

The core tapes described in **6.5** shall be coloured for identification purposes as follows:

– power cores: red, yellow and brown;

– pilot core (except type 7S, see **6.6.2**): blue;

– earth core(s): green/yellow.

6.6.2 *Type 7S pilot unit and pilot cores*

The pilot unit core tape described in **6.5** shall be coloured blue.

The pilot cores shall be identified either by the application of a coloured core tape in accordance with **6.5** or by the colour of the insulation in accordance with **6.3**. The identifying colours shall be black, white and blue.

6.7 Protective screen

The form of screen, method of application and materials shall be as given in annex E.

6.8 Central filler

For types 11, 14 and 16, the cores shall be laid around a centre of elastomeric compound that may include a textile carrier.

6.9 Laying-up of cores

6.9.1 *Types 7 and 7M*

The cores shall be laid around a bare earth conductor with a length of lay that permits the screens enclosing each power core to make electrical contact with the bare central earth conductor. The lay of the earth conductor strands shall be in the same direction as that of the laid-up cores, i.e. right hand.

6.9.2 *Type 7S*

The three pilot cores of the pilot unit shall be laid up with a right hand direction of lay with the length of lay not exceeding nine times the pitch circle diameter.

The power cores and pilot unit shall be laid around a bare earth conductor with a length of lay that permits the screens enclosing each power core to make electrical contact with the bare central earth conductor. The lay of the earth conductor strands shall be in the same direction as that of the laid-up cores, i.e. right hand.

6.9.3 *Types 11 and 14*

The cores shall be laid around an elastomeric compound centre.

6.9.4 *Type 16*

The power cores shall be laid around an elastomeric compound centre with the pilot and two earth cores laid up in the interstices of the power cores.

6.9.5 *Length and direction of lay*

The cores of all types of cable, with the exception of type FS4 and the pilot cores of cable type 7S (see **6.9.2**), shall be laid up with a right hand direction of lay with the length of lay not exceeding 15 times the pitch circle diameter.

The cores of type FS4 shall be laid parallel in flat configuration.

6.9.6 *Sequence of colours*

The laid-up cores shall be in the sequences given in table 2.

Table 2. Sequence of colours

Cable type	Sequence
7	red, yellow, brown (power); blue (pilot)
7M	red, yellow, brown (power); blue (pilot)
7S	red, yellow, brown (power); blue (pilot unit)
11	red, yellow, brown (power); blue (pilot)
14	red, yellow, brown (power); green/yellow (earth); blue (pilot)
16	red, yellow, brown (power); with green/yellow (earth, two in number); blue (pilot); one in each interstice, i.e. red, green/yellow, yellow, blue, brown, green/yellow
FS4	red, yellow, brown, blue

6.10 Sheath of pilot unit and outer sheath

6.10.1 *Sheath of pilot unit (type 7S)*

The assembled cores of the pilot unit shall be sheathed with a black compound conforming to BS 7655 : Section 2.1 for a type EM2 sheath. The sheath shall be of such thickness that the diameter of the taped sheath is the same as that of a screened power core.

6.10.2 *Outer sheath*

The assembled cores shall be filled and sheathed in one operation with a compound conforming to BS 7655 : Section 2.3 for a type RS6 sheath.

NOTE. If no colour is specified in the purchase order, black sheaths should normally be supplied.

The radial thickness of the outer sheath shall be determined in accordance with the method given in annex D, and the average value shall be not less than the nominal value given in tables 3 to 9. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 15 % of the nominal value.

6.11 Marking

6.11.1 All cables shall be durably and legibly marked with the manufacturer's name, together with the year and month of manufacture, on rubber-proofed or other comparable non-hygroscopic tape or tapes inside the cable. The marking shall be at intervals of not more than 300 mm throughout the length of the cable.

NOTE. The month of manufacture may be indicated by number.

6.11.2 Type 7S cable shall have, in addition to the marking specified in **6.11.1**, an external identifying mark in the form of a blue stripe not less than 12 mm wide applied longitudinally along the cable.

NOTE. At the manufacturer's discretion, the stripe material may be the same as that of the outer sheath, or a similar material compatible with it.

6.12 Tests on cores

6.12.1 *General*

All cores shall be subjected to the spark test specified in **6.12.2**, the voltage test in **6.12.3** and the insulation resistance test in **6.12.4**.

6.12.2 *Spark test*

Cores shall be tested in accordance with the method given in BS 5099, and shall withstand the appropriate test voltage in clause **5** of BS 5099 : 1992.

6.12.3 *Voltage test*

When cores are tested in accordance with the method given in **F.1**, **F.2.1** and **F.2.2**, they shall withstand a test voltage of 3000 V, with the exception of the earth and pilot cores in type 16, which shall withstand 1500 V, and the pilot cores in type 7S, which shall withstand 2500 V.

6.12.4 *Insulation resistance*

When cores are tested in accordance with the method given in **F.1**, **F.2.1** and **F.2.3**, the insulation resistance between the conductor and the water in which the core is immersed shall be not less than the appropriate value given in table 10.

6.13 Tests on completed cable

6.13.1 *Conductor resistance*

The d.c. resistance at 20 °C shall not exceed the appropriate value given in tables 3 to 9.

6.13.2 *Resistance of earth conductor and screens*

For types 7, 7M and 7S, the combined d.c. resistance of the earth conductor and the core screens in parallel at 20 °C shall not exceed the appropriate value given in tables 3 to 5. For types 11, 14, 16 and FS4, the d.c. resistance of the core screens in parallel at 20 °C shall not exceed the appropriate value given in tables 6 to 9.

6.13.3 *Voltage test*

All completed cables shall be subjected to the voltage test in accordance with **F.1** and **F.3.1**. All cores shall withstand a test voltage of 3000 V, with the exception of the earth and pilot cores in type 16, which shall withstand 1500 V, and the pilot cores in type 7S, which shall withstand 2500 V.

6.13.4 *Insulation resistance*

Immediately after completion of the voltage test (see **6.13.3**), the insulation resistance of all cores shall be measured in accordance with **F.1** and **F.3.2**. The insulation resistance shall be not less than the appropriate value given in table 10.

6.13.5 *Test for flame propagation of single cable*

The finished cable shall conform to BS 4066 : Part 1 for tests under fire conditions.

Table 3. Constructional details of type 7 cable

Nominal cross sectional area of conductor (mm^2)	power	16	25	35	50	70	95	120
	earth	16	16	18	25	35	50	50
	pilot	16	16	16	25	35	50	70
Conceptual construction of conductor (mm)	power	126/0.40	196/0.40	276/0.40	396/0.40	360/0.50	475/0.50	608/0.50
	earth[1)]	126/0.40	126/0.40	147/0.40	196/0.40	276/0.40	396/0.40	396/0.40
	pilot	126/0.40	126/0.40	126/0.40	196/0.40	276/0.40	396/0.40	360/0.50
Maximum diameter of wires in conductor (mm)	power	0.41	0.41	0.41	0.41	0.51	0.51	0.51
	earth	0.41	0.41	0.41	0.41	0.41	0.41	0.41
	pilot	0.41	0.41	0.41	0.41	0.41	0.41	0.51
Radial thickness of core insulation (mm)	power	1.5	1.5	1.6	1.7	1.8	2.0	2.2
	pilot[2)]	1.5	1.5	1.5	1.6	1.6	1.7	1.8
Radial thickness of outer sheath (mm)		5.0	5.0	5.0	5.3	5.8	6.4	6.9
Overall diameter of cable (mm)								
minimum		35.8	39.7	43.1	48.5	55.1	62.4	68.0
maximum		38.6	42.9	46.3	51.8	58.8	66.1	72.5
Maximum conductor resistance per 1000 m	power	1.24	0.795	0.565	0.393	0.277	0.210	0.164
of cable at 20 °C (Ω)	pilot	1.24	1.24	1.24	0.795	0.565	0.393	0.277
Maximum resistance of earth and screens in parallel per 1000 m of cable at 20 °C (Ω)	3 screens plus earth conductor in parallel	0.66	0.56	0.54	0.44	0.30	0.26	0.24
Minimum cross-sectional area of earth and screens in parallel (mm^2)[3)]	3 screens plus earth conductor in parallel	41.4	41.4	43.4	58	68	100	100
Area of earth and screens in parallel, expressed as a percentage of the area of the largest current carrying conductor (%)	3 screens plus earth conductor in parallel	258	165	124	116	97	106	83
Minimum conductivity[4)] of earth and screens in parallel, expressed as a percentage of the largest current carrying conductor (%)	3 screens plus earth conductor in parallel	187	141	104	89	92	80	68

[1)] See **6.9.1**.

[2)] See clause **6.3**.

[3)] Design minimum, for information only.

[4)] See annex A.

Table 4. Constructional details of type 7M cable

Nominal cross-sectional area of conductor (mm^2)	power	16	25	35	50	70	95	120
	earth	16	16	18	25	35	50	50
	pilot	16	25	35	50	70	95	120
Conceptual construction of conductor (mm)	power	126/0.40	196/0.40	276/0.40	396/0.40	360/0.50	475/0.50	608/0.50
	earth[1)]	126/0.40	126/0.40	147/0.40	196/0.40	276/0.40	396/0.40	396/0.40
	pilot	126/0.40	196/0.40	276/0.40	396/0.40	360/0.50	475/0.50	608/0.50
Maximum diameter of wires in conductor (mm)	power	0.41	0.41	0.41	0.41	0.51	0.51	0.51
	earth	0.41	0.41	0.41	0.41	0.41	0.41	0.41
	pilot	0.41	0.41	0.41	0.41	0.51	0.51	0.51
Radial thickness of core insulation (mm)	power	1.5	1.6	1.6	1.7	1.8	2.0	2.2
	pilot	1.5	1.6	1.6	1.7	1.8	2.0	2.2
Radial thickness of outer sheath (mm)		5.0	5.0	5.0	5.3	5.8	6.4	6.9
Overall diameter of cable (mm)								
minimum		35.8	39.7	43.1	48.5	55.1	62.4	68.0
maximum		38.6	42.9	46.3	51.8	58.8	66.1	72.5
Maximum conductor resistance per 1000 m of	power	1.24	0.795	0.565	0.393	0.277	0.210	0.164
cable at 20 °C (Ω)	pilot	1.24	0.795	0.565	0.393	0.277	0.210	0.164
Maximum resistance of earth and screens in parallel per 1000 m of cable at 20 °C (Ω)	4 screens plus earth conductor in parallel	0.58	0.47	0.45	0.38	0.27	0.23	0.21
Minimum cross-sectional area of earth and screens in parallel (mm^2)[2)]	4 screens plus earth conductor in parallel	49.9	49.9	62.1	69.1	85.9	117.9	117.9
Area of earth and screens in parallel, expressed as a percentage of the area of the largest current carrying conductor (%)	4 screens plus earth conductor in parallel	321	200	177	138	123	124	98
Minimum conductivity[3)] of earth and screens in parallel, expressed as a percentage of the largest current carrying conductor (%)	4 screens plus earth conductor in parallel	213	169	125	103	102	91	78

[1)] See **6.9.1**.

[2)] Design minimum, for information only.

[3)] See annex A.

Table 5. Constructional details of type 7S cable

Nominal cross-sectional area of conductor (mm^2)	power	50	70	95	120
	earth	25	35	50	50
	pilot	4	6	6	10
Conceptual construction of conductor (mm)	power	396/0.40	360/0.50	475/0.50	608/0.50
	earth[1)]	196/0.40	276/0.40	396/0.40	396/0.40
	pilot	56/0.30	84/0.30	84/0.30	80/0.40
Maximum diameter of wires in conductor (mm)	power	0.41	0.51	0.51	0.51
	earth	0.41	0.41	0.41	0.41
	pilot	0.31	0.31	0.31	0.41
Radial thickness of core insulation (mm)	power	1.7	1.8	2.0	2.2
	pilot	1.4	1.5	1.5	1.5
Radial thickness of outer sheath (mm)		5.3	5.8	6.4	6.9
Overall diameter of cable (mm)					
minimum		48.5	55.1	62.4	68.0
maximum		51.8	58.8	66.1	72.5
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	power	0.393	0.277	0.210	0.164
	pilot	5.47	3.60	3.60	2.09
Maximum resistance of earth and screens in parallel per 1000 m at 20 °C (Ω)	3 screens plus earth conductor in parallel	0.44	0.30	0.26	0.24
Minimum cross-sectional area of earth and screens in parallel (mm^2)[2)]	3 screens plus earth conductor in parallel	58	68	100	100
Area of earth and screens in parallel, expressed as a percentage of the largest current carrying conductor (%)	3 screens plus earth conductor in parallel	116	97.1	105	83.3
Minimum conductivity[3)] of earth and screens in parallel, expressed as a percentage of the largest current carrying conductor (%)	3 screens plus earth conductor in parallel	89	92	80	68

[1)] See **6.9.2**.

[2)] Design minimum, for information only.

[3)] See annex A.

Table 6. Constructional details of type 11 cable		
Nominal cross-sectional area of conductor (mm^2)	power	16
	pilot	16
Conceptual construction of conductor (mm)	power	126/0.40
	pilot	126/0.40
Maximum diameter of wires in conducton (mm)	power	0.41
	pilot	0.41
Radial thickness of core insulation (mm)	power	1.5
	pilot	1.5
Radial thickness of outer sheath (mm)		3.0
Overall diameter of cable (mm)		
minimum		30.9
maximum		33.0
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	power pilot	1.24 1.24
Maximum resistance of screens in parallel per 1000 m of cable at 20 °C (Ω)	4 screens in parallel	1.05
Minimum cross-sectional area of screens in parallel (mm^2)[1)]	4 screens in parallel	33.9
Area of screens in parallel, expressed as a percentage of the area of the largest current carrying conductor (%)	4 screens in parallel	211
Minimum conductivity[2)] of screens in parallel, expressed as a percentage of the largest current carrying conductor (%)	4 screens in parallel	118

[1)] Design minimum, for information only.

[2)] See annex A.

Table 7. Constructional details of type 14 cable[1]						
Nominal cross-sectional area of conductor (mm^2)	power and earth pilot	25 16	35 16	50 25	70 35	95 50
Conceptual construction of conductor (mm)	power and earth pilot	196/0.40 126/0.40	276/0.40 126/0.40	396/0.40 196/0.40	360.0.50 276/0.40	475/0.50 396/0.40
Maximum diameter of wires in conductor (mm)	power and earth pilot	0.41 0.41	0.41 0.41	0.41 0.41	0.51 0.41	0.51 0.41
Radial thickness of core insulation (mm)	power and earth pilot[2]	1.6 1.5	1.6 1.5	1.7 1.6	1.8 1.6	2.0 1.7
Radial thickness of outer sheath (mm)		5.0	5.2	5.7	6.3	7.0
Overall diameter of cable (mm)						
minimum		43.2	47.3	53.7	61.2	69.3
maximum		46.6	50.7	57.6	65.0	73.9
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	power and earth pilot	0.795 1.24	0.565 1.24	0.393 0.795	0.277 0.565	0.210 0.393
Maximum resistance of screens in parallel, per 1000 m of cable at 20 °C (Ω)	3 screens in parallel	1.10	1.20	1.40	0.70	0.85
Minimum cross-sectional area of screens in parallel (mm^2)[3]	3 screens in parallel	25.4	25.4	33	35	53.0
Area of screens in parallel, expressed as a percentage of the area of the largest current carrying conductor (%)	3 screens in parallel	101	72	66	50	55

[1] All cables in this table contain a full size earth conductor.

[2] See **6.3**.

[3] Design minimum, for information only.

Table 8. Constructional details of type 16 cable						
Nominal cross-sectional area of conductor (mm^2)	power earth (2) and pilot	25 10	35 10	50 16	70 25	95 35
Conceptual construction of conductor (mm)	power	196/0.40	276/0.40	396/0.40	360/0.50	475/0.50
	earth and pilot	80/0.40	80/0.40	126/0.40	196/0.40	276/0.40
Maximum diameter of wires in conductor (mm)	power earth and pilot	0.41 0.41	0.41 0.41	0.41 0.41	0.51 0.41	0.51 0.41
Radial thickness of core insulation (mm)	power earth and power	1.6 1.0	1.6 1.0	1.7 1.0	1.8 1.0	2.0 1.0
Radial thickness of outer sheath (mm)		5.0	5.0	5.0	5.4	6.0
Overall diameter of cable (mm)						
minimum		36.5	39.5	43.9	49.6	56.2
maximum		39.2	42.7	47.0	53.3	63.0
Maximum conductor resistance	power	0.795	0.565	0.393	0.277	0.210
per 1000 m of cable at 20 °C (Ω)	earth and pilot	1.95	1.95	1.24	0.795	0.565
Maximum resistance of screens in parallel, per 1000 m of cable at 20 °C (Ω)	3 screens in parallel	1.10	1.20	1.40	0.70	0.85
Minimum cross-sectional area of screens in parallel (mm^2)[1)]	3 screens in parallel	25.4	25.4	33	35	53
Area of screens in parallel, expressed as a percentage of the area of the largest current carrying conductor (%)	3 screens in parallel	101	72	66	50	55
Minimum conductivity[2)] of earth and screens in parallel, expressed as a percentage of the largest current carrying conductor (%)	3 screens plus 2 earth conductors in parallel	152	103	90	107	98

[1)] Design minimum, for information only.

[2)] See annex A.

Table 9. Constructional details of type FS4 cable			
Nominal cross-sectional area of conductor (mm^2)	power and neutral	2.5	4
Conceptual construction of conductor (mm)	power and neutral	50/0.25	56/0.30
Maximum diameter of wires in conductor (mm)	power and neutral	0.26	0.31
Radial thickness of core insulation (mm)	power and neutral	1.0	1.0
Nominal diameter of wires in screen (mm)	power and neutral	0.2	0.2
Number of cores		4	4
Radial thickness of outer sheath		3.8	3.8
Minimum overall dimension of cable (mm)			
major		18.1	32.2
minor		12.4	13.3
Maximum overall dimension of cable (mm)			
major		20.1	34.1
minor		14.4	15.3
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	power and neutral	7.82	4.85
Maximum resistance of one screen per 1000 m of cable at 20 °C (Ω)	1 screen	7.4	8.48
Minimum cross-sectional area of one screen (mm^2)[1)]	1 screen	2.65	2.25
Area of one screen, expressed as a percentage of the largest current carrying conductor (%)	1 screen	106	56
Minimum conductivity[2)] of one screen, expressed as a percentage of the largest current carrying conductor (%)	1 screen	105	57

[1)] Design minimum, for information only.

[2)] See annex A.

Table 10. Insulation resistance

Nominal cross-sectional area of conductor	Minimum insulation resistance for 1000 m at 20 °C	
	FR1[1]	**GP4**[1]
mm^2	MΩ	MΩ
4[2]	600	760
6[2]	530	670
10[2]	440	560
10[3]	320	400
16[3]	250	310
25[3]	200	250
35[3]	170	220
6	390	490
10	440	560
16	350	435
25	300	375
35	260	325
50	230	285
70	210	260
95	200	250
120	200	250

[1] See **6.3**.

[2] Pilot cores for type 7S.

[3] Pilot and earth cores for type 16.

7 Cables with galvanized steel pliable wire armouring, rated voltages up to 1900/3300 V (types 20, 21, 62, 63, 64, 70, 71, 201, 211, 321 and 331)

7.1 Types of cable

Cable types and construction shall be as given in table 11.

Constructional details and dimensions shall be as given in tables 14 to 20.

NOTE. Type 201 cables conforming to this standard are not necessarily suitable for supplying portable equipment because of the absence of an earth conductor.

Table 11. Clause 7 cable types and construction

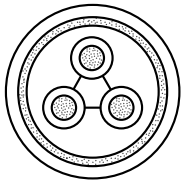
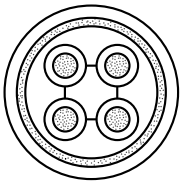
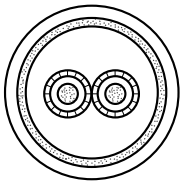
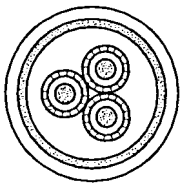
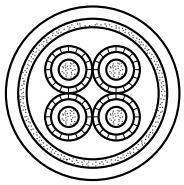
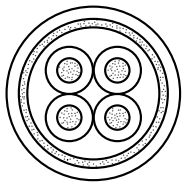
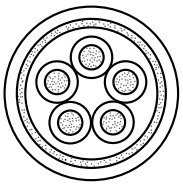
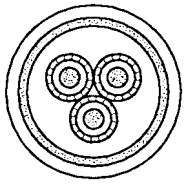
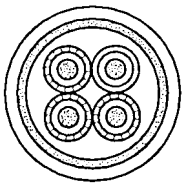
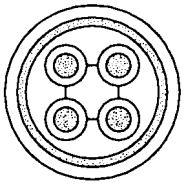
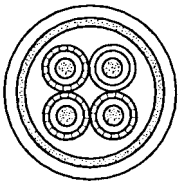
Type	System	Construction	Sectional diagram
20	Single phase a.c. or d.c. 640/1100 V	3-core. Two power cores and one earth core each unscreened, laid around an elastomeric cradle centre, sheathed with ordinary duty compound, galvanized steel strand armoured and heavy duty sheathed overall	
21	3-phase 640/1100 V	4-core. Three power cores and one earth core each unscreened, laid around an elastomeric cradle centre, sheathed with ordinary duty compound, galvanized steel strand armoured and heavy duty sheathed overall	
62	Single phase a.c. and d.c. 640/1100 V	2-core. Two power cores each having a protective metallic screen, laid up, sheathed with ordinary duty compound, galvanized steel strand armoured and heavy duty sheathed overall	
63	Single phase a.c. and d.c. 640/1100 V	3-core. Three power cores each having a protective metallic screen, laid up, sheathed with ordinary duty compound, galvanized steel strand armoured and heavy duty sheathed overall	
64	3-phase a.c. or d.c. 640/1100 V	4-core. Three power cores and one pilot core each having a protective metallic screen, laid around an elastomeric centre sheathed with ordinary duty compound, galvanized steel strand armoured and heavy duty sheathed overall	
70	3-phase 320/550 V	4-core. Three power cores and one earth core each unscreened, laid around an elastomeric centre, sheathed with ordinary duty compound, galvanized steel strand armoured and heavy duty sheathed overall	
71	3-phase 320/550 V	5-core. Three power cores, one pilot core and one earth core each unscreened, laid around an elastomeric centre, sheathed with ordinary duty compound, galvanized steel strand armoured and heavy duty sheathed overall	
201	3-phase 640/1100 V	3-core. Three power cores each having a protective metallic screen, laid around an elastomeric centre, sheathed with ordinary duty compound, galvanized steel strand armoured and heavy duty sheathed overall	

Table 11. Cable types and construction *(continued)*

Type	System	Construction	Sectional diagram
211	3-phase 640/1100 V	4-core. Three power cores each having a protective metallic screen and one unscreened earth core, laid around an elastomeric centre, sheated with ordinary duty compound, galvanized steel strand armoured and heavy duty sheathed overall	
321	3-phase 1900/3300 V	4-core. Three power cores and one earth core each unscreened, laid up around an elastomeric centre, sheathed with ordinary duty compound, galvanized steel strand armoured and heavy duty sheathed overall	
331	3-phase 1900/3300 V	4-core. Three power cores each having a protective metallic screen and one unscreened earth core, laid around an elastomeric centre, sheathed with ordinary duty compound, galvanized steel strand armoured and heavy duty sheathed overall	

7.2 Conductors

The conductors shall be composed of round tinned annealed copper wires conforming to BS 6360 for class 5 conductors and shall be multiple stranded for conductors of 16 mm^2 and larger. Sizes below 16 mm^2 shall be bunched.

Joints made in the single wires forming the conductor shall be brazed, silver soldered or electrically welded. No joint shall be made in the conductor after it has been stranded.

The conceptual construction shall be as given in tables 14 to 20.

NOTE. At the manufacturer's discretion, a film separator of polyethylene terephthalate or other suitable non-hygroscopic tape may be applied over the conductor. Embrittlement or discolouration of this tape after vulcanization of the core may be disregarded.

7.3 Insulation

7.3.1 The core insulation shall fit closely on the conductor without adhering, and shall be as follows for the various types of cable.

a) *Types 20 and 21*

Type GP4 conforming to BS 7655 : Section 1.2.

b) *Types 62, 63, 64, 70 and 71*

Either type FR1 compound conforming to BS 7655 : Section 1.5 or type GP4 conforming to BS 7655 : Section 1.2, except that the tensile stress at 100 % elongation for GP4 shall be 2.0 N/mm^2 minimum.

c) *Types 201 and 211*

Either type FR2 compound conforming to BS 7655 : Section 1.5 or type GP4 conforming to BS 7655 : Section 1.2, except that the tensile stress at 100 % elongation for GP4 shall be 2.0 N/mm^2 minimum.

d) *Types 321 and 331*

Either type FR2 compound conforming to BS 7655 : Section 1.5 or type GP5 conforming to BS 7655 : Section 1.2, except that the tensile stress at 100 % elongation for GP5 shall be 2.0 N/mm^2 minimum.

7.3.2 For type 211 and type 331 cables, an additional layer of insulation shall be applied to the earth core, of a thickness such that the finished outside diameter of the core is the same as that of a screened power core.

NOTE 1. For the earth core, the additional layer of insulation may be separable from the primary insulation, or, alternatively, the insulation may be applied in a homogeneous layer.

NOTE 2. If insulation colouring is used for identification purposes, it may be restricted to the outer layer.

7.4 Thickness of insulation

The radial thickness of core insulation shall be determined in accordance with the method described in annex D, and the average value shall be not less than the nominal value given in tables 14 to 20. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 10 % of the nominal value.

7.5 Core tape

If, at the manufacturer's discretion, a tape is applied over the insulated core, with the identification colouring visible on the outside (see **7.6**), it shall be applied with an overlap and shall consist of either:

a) a tape of closely woven textile approximately 0.15 mm thick, without selvedge, proofed on one side with rubber or comparable material; or

b) a coloured polyethylene terephthalate or other comparable non-hygroscopic tape approximately 0.05 mm thick.

NOTE 1. If untaped cores are used for cable types 62, 63, 64, 70, 71, 201, 211, 321 and 331, the thickness of the inner sheath should be increased by an amount sufficient to conform to the diameter over the inner sheath.

NOTE 2. For cable types 20 and 21 the maximum overall diameters given in tables 16 and 17 are based on taped cores. If untaped cores are used, the overall diameter is reduced by 0.6 mm for 3-core cables and 0.7 mm for 4-core cables.

7.6 Core identification

The insulation of each conductor, or the core tape when used, shall be coloured for identification purposes in accordance with table 12.

Table 12. Core identification

Type	Power core(s)	Earth core
20	brown, blue	green/yellow
21	red, yellow, brown	green/yellow
62	brown, blue	—
63	red, brown, blue	—
64	red, yellow, brown, blue	—
70	red, yellow, brown	green/yellow
71	red, yellow, brown, blue	green/yellow
201	red, yellow brown	—
211	red, yellow, brown	green/yellow
321	red, yellow brown	green/yellow
331	red, yellow, brown	green/yellow

7.7 Protective screen

The form of screen, method of application and materials shall be as given in annex E.

7.8 Central filler or cradle separator

The central filler or cradle separator shall consist of the appropriate elastomeric compound given as follows and may include a textile carrier.

a) *Types 20 and 21*

A cradle separator of heat resisting elastomeric compound shall be used. The cradle separator shall be so that the nominal distance between adjacent cores is 1.5 mm for 2.5 mm^2 and 4 mm^2 sizes of conductor and 2.5 mm for 6 mm^2 and larger: the minimum distance between adjacent cores shall be 70 % of these nominal values. There shall be no noticeable restraint on the relative movement of cores when the cable is flexed.

b) *Types 64, 70, 71, 201 and 211*

A suitable elastomeric compound centre shall be used.

c) *Types 321 and 331*

A centre of elastomeric compound shall be used.

7.9 Laying-up of cores

The cores shall be laid around the appropriate centre or cradle separator specified in **7.8**.

The cores of all cables shall be laid up with a right hand lay and the length of lay shall not exceed the following:

a) 15 times the pitch circle diameter for cores of cross-sectional area up to and including 25 mm^2;

b) 18 times the pitch circle diameter for cores of cross-sectional area larger than 25 mm^2.

The sequence of colours shall be as given in **7.6**.

7.10 Sheath under armour

The assembled cores shall be filled and sheathed in one operation with a compound conforming to BS 7655 : Section 2.1 for a type EM2 sheath.

The minimum radial thickness at any point of the inner sheath when measured in accordance with the method given in annex D shall be not less than 80 % of the nominal value given in tables 14 to 20.

7.11 Armour

7.11.1 *General*

The armour shall consist of the requisite number of wire strands to provide a complete cover. Each strand shall be composed of seven wires of the nominal size given in the appropriate table (see tables 14 to 20). The wires shall be of galvanized steel except that, in certain cases, a number of tinned copper wires shall be included in the strands to ensure electrical conductance of the armour. The number of copper wires employed shall be as given in the appropriate table, and these wires shall be so disposed in the armour that each forms the centre wire of a seven-wire strand.

For cables other than types 62, 63, 64, 70 and 71, the armour shall be applied with a length of lay not less than 4.5 times and not more than 6 times its pitch circle diameter.

For types 62, 63, 64, 70 and 71, the armour shall be applied with a length of lay not less than 4.5 times and not more than 8 times its pitch circle diameter.

The resistance of the armour shall conform to **7.15.3**.

7.11.2 *Galvanized steel wire*

7.11.2.1 *Wire diameter*

When measured in accordance with **G.1**, the average wire diameter shall not fall below the minimum values given in table 13.

Table 13. Minimum wire diameters

Nominal wire diameter mm	Minimum wire diameter mm
0.45	0.42
0.71	0.67
0.90	0.85
1.25	1.18

7.11.2.2 *Mass of zinc coating*

When determined in accordance with **G.2**, the average mass of zinc coating of the wires shall be not less than 75 % of the minimum value given in BS 443 for the appropriate size of wire of tensile strength below 540 N/mm^2.

7.11.2.3 *Mechanical characteristics*

When subjected to the wrapping test in accordance with **G.3**, the mechanical characteristics of the armour wires shall be such that none of the wires shall break.

7.12 Outer sheath

The cable shall be sheathed with a compound conforming to BS 7655 : Section 2.3 for a type RS6 sheath.

NOTE. If no colour is specified in the purchase order, black sheaths should normally be supplied.

The radial thickness of the outer sheath shall be determined in accordance with the method given in annex D, and the average value shall be not less than the nominal value given in tables 14 to 20. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 15 % of the nominal value.

7.13 Marking

7.13.1 All cables shall be durably and legibly marked with the manufacturer's name, together with the year and month of manufacture, on rubber-proofed or other comparable non-hygroscopic tape or tapes inside the cable. The marking shall be at intervals of not more than 300 mm throughout the whole length of the cable.

NOTE. The month of manufacture may be indicated by number.

7.13.2 Cable types 20, 21, 201 and 211 shall have, in addition, an external identifying mark in the form of a yellow stripe not less than 12 mm wide applied longitudinally along the cable. The stripe material shall be similar to that of the outer sheath.

Cable types 321 and 331 shall have, in addition, an external identifying mark in the form of a blue stripe not less than 12 mm wide applied longitudinally along the cable. The stripe material shall be similar to that of the outer sheath.

Table 14. Constructional details of type 20 cable[1)]

Nominal cross-sectional area of conductor (mm^2)	2.5	4	6	10	16	25	35	50	70	95	120	150
Conceptual construction of conductor (mm)	50/0.25	56/0.30	84/0.30	80/040	126/0.40	196/0.40	276/0.40	396/0.40	360/0.50	475/0.50	608/0.50	756/0.50
Maximum diameter of wires in conductor (mm)	0.26	0.31	0.31	0.41	0.41	0.41	0.41	0.41	0.51	0.51	0.51	0.51
Radial thickness of core insulation (mm)	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.7	1.8	2.0	2.2	2.3
Radial thickness of inner sheath (mm)	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3.8	3.8	5.0
Size of armour (mm)	7/0.45	7/0.45	7/0.71	7/0.71	7/0.71	7/0.90	7/0.90	7/0.90	7/0.90	7/0.90	7/0.90	7/1.25
Radial thickness of outer sheath (mm)	2.5	2.5	3.8	3.8	3.8	4.0	4.3	4.7	5.2	5.8	6.2	6.6
Maximum overall diameter of cable (mm)	26.9	28.2	36.5	38.4	40.8	47.0	50.6	56.7	62.7	72.1	77.0	87.3
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	8.21	5.09	3.39	1.95	1.24	0.795	0.565	0.393	0.277	0.210	0.164	0.132
Maximum resistance of armour per 1000 m of cable at 20 °C (Ω)	4.6	4.2	2.2	2.0	1.9	1.3	1.2	1.1	0.94	0.80	0.74	0.45

[1)] All cables in this table contain a full size earth conductor.

Table 15. Constructional details of type 21 cable[1)]

Nominal cross-sectional area of conductor (mm^2)	2.5	4	6	10	16	25	35	50	70	95	120	150
Conceptual construction of conductor (mm)	50/0.25	56/0.30	84/0.30	80/0.40	126/0.40	196/0.40	276/0.40	396/0.40	360/0.50	475/0.50	608/0.50	756/0.50
Maximum diameter of wires in conductor (mm)	0.26	0.31	0.31	0.41	0.41	0.41	0.41	0.41	0.51	0.51	0.51	0.51
Radial thickness of core insulation (mm)	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.7	1.8	2.0	2.2	2.3
Radial thickness of inner sheath (mm)	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	3.8	3.8	5.0	5.0
Size of armour (mm)	7/0.45	7/0.45	7/0.71	7/0.71	7/0.71	7/0.71	7/0.90	7/0.90	7/0.90	7/0.90	7/1.25	7/1.25
Radial thickness of outer sheath (mm)	2.5	2.5	3.8	3.8	3.9	4.3	4.7	5.1	5.7	6.3	6.8	7.3
Maximum overall diameter of cable (mm)	28.6	30.1	38.8	41.0	44.0	49.8	56.1	61.8	71.4	78.6	89.0	95.3
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	8.21	5.09	3.39	1.95	1.24	0.795	0.565	0.393	0.277	0.210	0.164	0.132
Maximum resistance of armour per 1000 m of cable at 20 °C (Ω)	4.2	3.9	2.0	1.9	1.7	1.5	1.1	0.96	0.80	0.73	0.47	0.41

[1)] All cables in this table contain a full size earth conductor.

Table 16. Constructional details of cable types 62, 63, 64, 70 and 71[1)]

		Type 62	Type 63	Type 64	Type 70[1)]	Type 71[1)]
Nominal cross-sectional area of conductor (mm^2)		4	4	4	4	4
Conceptual construction of conductor (mm)		56/0.30	56/0.30	56/0.30	56/0.30	56/0.30
Maximum diameter of wires in conductor (mm)		0.31	0.31	0.31	0.31	0.31
Radial thickness of core insulation (mm)		1.0	1.0	1.0	1.0	1.0
Number of cores		2	3	4	4	5
Radial thickness of inner sheath (mm)		2.0	2.0	2.0	2.0	2.0
Diameter over inner sheath (mm)						
minimum		16.2	17.1	18.7	15.8	17.2
maximum		18.2	19.1	20.7	17.8	19.2
Size of armour (mm)		7/0.45	7/0.45	7/0.45	7/0.45	7/0.45
Radial thickness of outer sheath (mm)		2.5	2.5	2.5	2.5	2.5
Overall diameter of cable (mm)						
minimum		23.9	24.8	26.4	23.5	24.9
maximum		26.4	27.3	28.9	26.0	27.4
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)		5.09	5.09	5.09	5.09	5.09
Maximum resistance of armour per 1000 m of cable at 20 °C (Ω)		4.91	4.63	4.16	5.07	4.63
Maximum resistance of screens in parallel, per 1000 m of cable at 20 °C (Ω)	Screens in parallel	5.5	3.9	2.8	—	—
Minimum conductivity[2)] of screens in parallel, expressed as a percentage of the largest current carrying conductor (%)	Screens in parallel	92	130	181	—	—
Minimum conductivity[2)] of armour, expressed as a percentage of the largest current carrying conductor (%)	Armour	103	109	122	—	—

[1)] Type 70 and 71 cables in this table contain a full size earth conductor.

[2)] See annex A.

7.14 Tests on cores

7.14.1 *General*

All cores shall be subjected to the spark test in **7.14.2**, the voltage test in **7.14.3** and the insulation resistance test in **7.14.4**.

7.14.2 *Spark test*

Cores shall be tested in accordance with the method given in BS 5099, and shall withstand the appropriate test voltage described in clause **5** of BS 5099 : 1992.

7.14.3 *Voltage test*

When cores are tested in accordance with the methods given in **F.1**, **F.2.1** and **F.2.2**, they shall withstand the appropriate test voltage given in table 21.

7.14.4 *Insulation resistance*

When cores are tested in accordance with the methods given in **F.1**, **F.2.1** and **F.2.3**, the insulation resistance between the conductor and the water in which the core is immersed shall be not less than the appropriate value given in table 22.

Table 17. Constructional details of type 201 cable

Nominal cross-sectional area of conductor (mm^2)	power	10	16	25	35	50	70	95	120
Conceptual construction of conductor (mm)	power	80/0.40	126.040	196/0.40	276/0.40	396/0.40	360/0.50	475/0.50	608/0.50
Maximum diameter of wires in conductor (mm)	power	0.41	0.41	0.41	0.41	0.41	0.51	0.51	0.51
Radial thickness of core insulation (mm)	power	1.5	1.5	1.6	1.6	1.6	1.8	2.0	2.2
Number of cores		3	3	3	3	3	3	3	3
Radial thickness of inner sheath (mm)		2.5	2.5	2.5	2.5	2.5	2.5	3.8	3.8
Diameter over inner sheath (mm)									
minimum		25.5	28.7	32.2	35.2	39.5	44.5	52.5	56.6
maximum		27.5	30.7	34.2	37.2	41.5	47.0	55.5	59.6
Size of armour (mm)		7/0.71	7/0.71	7/0.71	7/0.71	7/0.71	7/0.90	7/1.25	7/1.25
Number of tinned copper wires		0	0	4	19	41	36	17	30
Radial thickness of outer sheath (mm)		3.8	3.8	4.1	4.4	4.9	5.4	5.9	6.3
Overall diameter of cable (mm)									
minimum		37.3	40.6	44.6	48.3	53.6	60.7	71.8	76.7
maximum		39.8	43.4	47.4	51.1	57.4	64.5	75.8	81.0
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	power	1.95	1.24	0.795	0.565	0.393	0.277	0.210	0.164
Maximum resistance of armour per 1000 m of cable at 20 °C (Ω)		1.97	1.76	1.45	1.03	0.715	0.504	0.382	0.299
Maximum resistance of screens in parallel, per 1000 m of cable at 20 °C (Ω)	3 screens in parallel	1.33	1.61	1.10	1.20	1.40	0.70	0.85	0.50
Minimum conductivity[1)] of screens in parallel expressed as a percentage of the largest current carrying conductor (%)	3 screens in parallel	245	147	127	102	83	95	80	88

[1)] See annex A.

Table 18. Constructional details of type 211 cable

Nominal cross-sectional area of conductor (mm^2)	power	10	16	25	35	50	70	95	120
	earth	10	16	16	25	35	50	70	70
Conceptual construction of conductor (mm)	power	80/0.40	126/0.40	196/0.40	276/0.40	396/0.40	360/0.50	475/0.50	608/0.50
	earth	80/0.40	126/0.40	126/0.40	196/0.40	276/0.40	396/0.40	360/0.50	360/0.50
Maximum diameter of wires in conductor (mm)	power	0.41	0.41	0.41	0.41	0.41	0.51	0.51	0.51
	earth	0.41	0.41	0.41	0.41	0.41	0.41	0.51	0.51
Radial thickness of core insulation (mm)	power	1.5	1.5	1.6	1.6	1.7	1.8	2.0	2.2
	earth[1)]	1.5	1.5	1.5	1.6	1.6	1.7	1.8	1.8
Number of cores		4	4	4	4	4	4	4	4
Radial thickness of inner sheath (mm)		2.5	2.5	2.5	2.5	2.5	3.8	5.0	5.0
Diameter over inner sheath (mm)									
minimum		27.9	31.6	35.4	38.8	43.7	51.8	60.3	64.9
maximum		29.9	33.6	37.4	40.8	46.2	54.8	63.3	67.9
Size of armour (mm)		7/0.71	7/0.71	7/0.71	7/0.71	7/0.90	7/0.90	7/1.25	7/1.25
Number of tinned copper wires		0	0	0	15	13	29	11	24
Radial thickness of outer sheath (mm)		3.8	4.1	4.4	4.8	5.3	5.8	6.4	6.9
Overall diameter of cable (mm)									
minimum		39.8	44.0	48.5	52.7	59.7	68.8	80.6	86.2
maximum		42.3	46.8	51.3	56.5	63.5	72.8	84.9	90.5
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	power	1.95	1.24	0.795	0.565	0.393	0.277	0.210	0.164
	earth	1.95	1.24	1.24	0.795	0.565	0.393	0.277	0.277
Maximum resistance of armour per 1000 m of cable at 20 °C (Ω)		1.81	1.63	1.45	1.03	0.715	0.504	0.382	0.299
Maximum resistance of screens in parallel, per 1000 m of cable at 20 °C (Ω)	3 screens in parallel	1.33	1.61	1.10	1.20	1.40	0.70	0.85	0.50
Minimum conductivity[2)] of earth and screens in parallel, expressed as a percentage of the largest current carrying conductor (%)	3 screens in parallel	247	178	136	118	> 100	110	101	> 100

[1)] See **7.3.2**.
[2)] See annex A.

Table 19. Constructional details of type 321 cable[1)]						
Nominal cross-sectional area of conductor (mm^2)		35	50	70	95	120
Conceptual construction of conductor (mm)	power and earth	276/0.40	396/0.40	360/0.50	475/0.50	608/0.50
Maximum diameter of wires in conductor (mm)	power and earth	0.41	0.41	0.51	0.51	0.51
Radial thickness of core insulation (mm)	power and earth	3.0	3.0	3.0	3.0	3.0
Number of cores	power and earth	4	4	4	4	4
Radial thickness of inner sheath (mm)		2.5	3.8	3.8	5.0	5.0
Diameter over inner sheath (mm)						
minimum		40.8	47.7	52.8	60.3	63.9
maximum		43.3	50.2	55.8	63.3	66.9
Size of armour (mm)		7/0.90	7/0.90	7/0.90	7/1.25	7/1.25
Number of tinned copper wires		0	6	24	9	21
Radial thickness of outer sheath (mm)		5.0	5.4	5.9	6.4	6.8
Overall diameter of cable (mm)						
minimum		56.2	63.9	70.0	80.6	85.0
maximum		60.0	67.7	74.0	84.9	89.3
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)		0.565	0.393	0.277	0.210	0.164
Maximum resistance of armour per 1000 m of cable at 20 °C (Ω)	power and earth	0.99	0.76	0.53	0.40	0.32

[1)] All cables in this table contain a full size earth conductor.

Table 20. Constructional details of type 331 cable

Nominal cross-sectional area of conductor $(mm)^2$	power earth	25 16	35 16	50 35	70 50	95 70	120 70
Conceptual construction of conductor (mm)	power earth	196/0.40 126/0.40	276/0.40 126/0.40	396/0.40 276/0.40	360/0.50 396/0.40	475/0.50 360/0.50	608/0.50 360/0.50
Maximum diameter of wires in conductor (mm)	power earth	0.41 0.41	0.41 0.41	0.41 0.41	0.51 0.41	0.51 0.51	0.51 0.51
Radial thickness of core insulation (mm)	power earth[1)]	3.0 3.0	3.0 3.0	3.0 3.0	3.0 3.0	3.0 3.0	3.0 3.0
Number of cores		4	4	4	4	4	4
Radial thickness of inner sheath (mm)		2.5	3.8	3.8	5.0	5.0	5.0
Diameter over inner sheath (mm)							
minimum		42.2	48.2	52.5	60.0	65.1	68.8
maximum		44.7	50.7	55.6	63.0	68.9	72.6
Size of armour (mm)		7/0.90	7/0.90	7/0.90	7/1.25	7/1.25	7/1.25
Number of tinned copper wires		0	0	5	0	8	22
Radial thickness of outer sheath (mm)		5.1	5.5	5.9	6.4	6.9	7.3
Overall diameter of cable (mm)							
minimum		57.8	64.6	69.8	80.3	86.4	90.9
maximum		61.6	68.4	73.8	84.6	90.7	95.2
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	power earth	0.795 1.24	0.565 0.795	0.393 0.565	0.277 0.393	0.210 0.277	0.164 0.277
Maximum resistance of armour per 1000 m of cable at 20 °C (Ω)		0.965	0.844	0.715	0.488	0.382	0.299
Maximum resistance of screens in parallel, per 1000 m of cable at 20 °C (Ω)	3 screens in parallel	1.35	0.80	0.70	0.69	0.84	0.55
Minimum conductivity[2)] of earth and screens in parallel, expressed as a percentage of the largest current carrying conductor (%)	3 screens in parallel and earth	123	142	126	111	101	89

[1)] See 7.3.2.
[2)] See annex A.

Table 21. Test voltage on core

Type	Test voltage V
70, 71	1500
62, 63, 64	2500
20, 21, 201, 211	3000
321, 331	7500

Table 22. Insulation resistance

Nominal cross-sectional area of conductor	Minimum insulation resistance for 1000 m at 20 °C			
	320/550 V and 640/1100 V cables		1900/3300 V cable	
	FR1[1)]	GP4[1)]	FR2[1)]	GP5[1)]
mm^2	MΩ	MΩ	MΩ	MΩ
2.5	—	910	—	—
4				
Types 20, 2	—	760	—	—
Types 62, 63, 64, 70, 71	470	590	—	—
6	—	670	—	—
10	440	560	—	—
16	350	435	1150	1500
25	300	375	980	1250
35	260	325	850	1100
50	230	285	740	950
70	210	260	630	820
95	200	250	550	720
120	200	250	510	660
150	—	240	—	—

[1)] See **7.3**.

Table 23. Test voltage on completed cable

Type	Test voltage V
70, 71	1500
62, 63, 64	2500
20, 21, 201, 211	3000
321, 331	7500

7.15 Tests on completed cable

7.15.1 ***Conductor resistance***

The d.c. resistance of the conductor at 20 °C shall not exceed the appropriate value given in tables 14 to 20.

7.15.2 ***Resistance of screens***

For cable types with screened cores, the d.c. resistance of the screens at 20 °C shall not exceed the appropriate value given in tables 16, 17, 18 and 20.

7.15.3 ***Resistance of armour***

The d.c. resistance of the armour at 20 °C shall not exceed the appropriate value given in tables 14 to 20.

7.15.4 ***Voltage test***

All completed cables shall be subjected to the voltage test in accordance with **F.1** and **F.3.1**. All cores shall withstand the appropriate voltage given in table 23.

7.15.5 ***Insulation resistance***

Immediately after completion of the voltage test (see **7.15.4**), the insulation resistance of all cores shall be measured in accordance with **F.1** and **F.3.2**. The insulation resistance shall be not less than the appropriate value given in table 22.

7.15.6 ***Test for flame propagation of single cable***

The finished cable shall conform to BS 4066 : Part 1 for tests under fire conditions.

8 Cables with galvanized steel pliable wire armouring having up to 24 individual screened cores, rated voltage 320/550 V (types 506, 512, 518 and 524)

8.1 Types of cable

Constructional details and dimensions shall be as given in table 24.

Cables shall have galvanized steel pliable wire armouring with up to 24 individual screened cores and a rated voltage 320/550 V.

NOTE 1. The cable dimensions are such that they should fit double seal compression glands of the type identified as British Coal gland reference No. 19.

NOTE 2. The cable is intended for use on large mining machines (external to the machine) to provide interconnection between machine sections or machine sections and associated auxiliary equipment.

8.2 Construction

The cables shall have screened ETFE insulated cores, laid up and sheathed with ordinary duty compound, galvanized steel strand armoured and heavy duty sheathed overall.

8.3 Conductors

The conductors shall be composed of stranded round tinned annealed copper wires conforming to BS 6360.

Joints made in the single wires forming the conductor shall be brazed, silver soldered or electrically welded. No joint shall be made in the conductor after it has been stranded.

The number and nominal and maximum diameter of the wires in the conductor shall be as given in table 24.

8.4 Insulation

The ETFE insulation shall fit closely on the conductor without adhering. When tested in accordance with BS EN 60811-1-1, the insulation shall conform to the following.

a) *Unaged pieces*

Minimum tensile strength: 17 N/mm^2;

Minimum elongation at break: 125 %.

b) *After accelerated ageing in air over 10 d at (190 ± 5) °C*

Minimum tensile strength: 80 % of unaged value;

Minimum elongation at break: 80 % of unaged value.

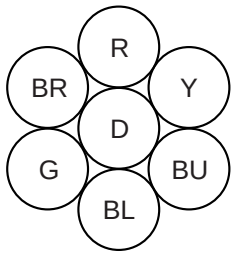
8.5 Thickness of insulation

The nominal radial thickness of core insulation shall be as given in table 24. The minimum thickness at any point of the insulation, determined in accordance with the method described in annex D, shall be not less than 0.33 mm.

8.6 Core identification

The cores shall be coloured for identification purposes as shown in figures 1, 2, 3 and 4.

NOTE. The figures illustrate the sequence of colours in each layer only and do not represent an actual design.



Key	no. of cores
R) red	1
Y) yellow	1
BU) blue	1
BL) black	1
G) green	1
BR) brown	1
D) dummy	1

Figure 1. Core identification: type 506 cable

8.7 Protective screen

The form of screen, method of application and materials shall be as given in annex E.

8.8 Central filler

For cable types 506 and 518 (see **8.9**), the central filler shall consist of non-hygroscopic textile or PCP compound, that may include a textile carrier.

8.9 Laying-up of cores

The cores shall be laid up as follows.

a) *Type 506*

Six cores shall be laid around a centre as specified in **8.8** (see figure 1).

b) *Type 512*

Cores shall be laid up in two layers; one of three cores and one of nine cores (see figure 2).

c) *Type 518*

Cores shall be laid up in two layers; one of six cores and one of 12 cores, around a centre as specified in **8.8** (see figure 3).

d) *Type 524*

Cores shall be laid up in three layers; one of two cores, one of eight cores and one of 14 cores (see figure 4).

The direction of lay of the cores for cable type 506 shall be right hand.

The direction of lay of the cores for cable types 512, 518 and 524 shall be right hand for all layers, or right hand for the first layer, with subsequent layers alternately left hand and right hand.

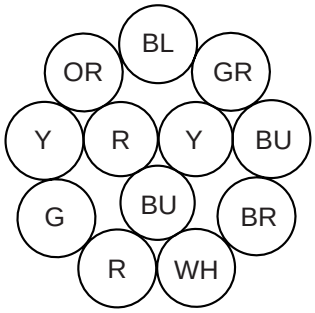
For all cable types, the length of lay of the cores shall be not greater than 12.5 times the pitch circle diameter.

Table 24. Constructional details of cable types 506, 512, 518 and 524

	Type 506	Type 512	Type 518	Type 524
Nominal cross-sectional area of conductor (mm^2)	1.34	1.34	1.34	0.93
Conceptual construction of conductor (mm)	19/0.3	19/0.3	19/0.3	19/0.25
Maximum diameter of wires in conductor (mm)	0.31	0.31	0.31	0.26
Radial thickness of core insulation (mm)	0.4	0.4	0.4	0.4
Number of cores	6	12	18	24
Radial thickness of inner sheath (mm)	3.5	1.8	1.5	1.5
Diameter over inner sheath (mm)				
minimum	14.8	14.8	16.5	17.9
maximum	16.8	16.8	18.5	19.9
Size of armour (mm)	7/0.45	7/0.45	7/0.45	7/0.45
Radial thickness of outer sheath (mm)	1.8	1.8	1.8	1.8
Overall diameter of cable (mm)[1)]				
minimum	22.1	22.1	22.8	24.2
maximum	23.6	23.6	25.3	26.7
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	15.4	15.4	15.4	22.1
Maximum resistance of armour per 1000 m of cable at 20 °C (Ω)	5.40	5.40	4.76	4.50
Maximum resistance of screens in parallel, per 1000 m of cable at 20 °C (Ω)	37.3	37.3	37.3	44.7
Minimum conductivity[2)] of armour, expressed as a percentage of the largest current carrying conductor (%)	285	285	324	491

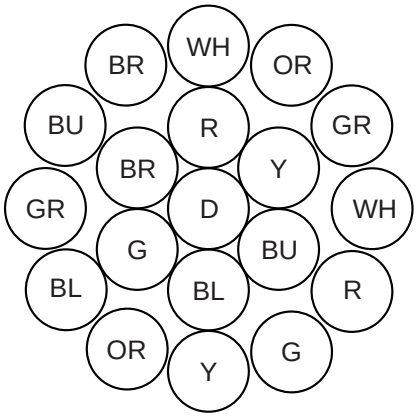
[1)] These values have been calculated so as to enable a cable to fit a double seal compression gland of the type identified as British Coal gland reference No. 19.

[2)] See annex A.



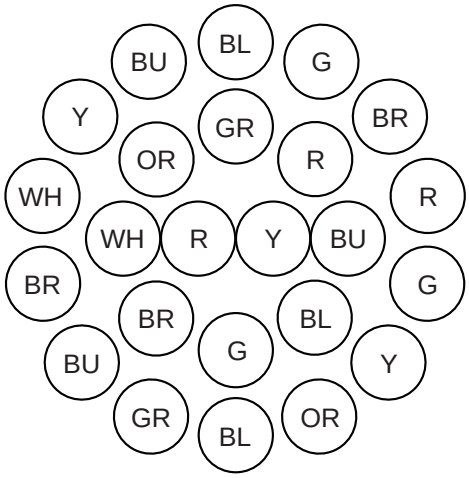
Key	no. of cores
R) red	2
Y) yellow	2
BU) blue	2
BL) black	1
G) green	1
BR) brown	1
WH) white	1
OR) orange	1
GR) grey	1

Figure 2. Core identification: type 512 cable



key	no. of cores
R) red	2
Y) yellow	2
BU) blue	2
BL) black	2
G) green	2
BR) brown	2
WH) white	2
OR) orange	2
GR) grey	2
D) dummy	1

Figure 3. Core identification: type 518 cable



key	no. of cores
R) red	3
Y) yellow	3
BU) blue	3
BL) black	3
G) green	3
BR) brown	3
WH) white	2
OR) orange	2
GR) grey	2

Figure 4. Core identification: type 524 cable

A binder tape of polyethylene terephthalate or other comparable non-hygroscopic material shall be applied over the laid-up cores, with an overlap of not less than 15 %. The direction of lay of the tape shall be opposed to that of the outer layer of cores.

NOTE. A separator tape between the layers of cores may be included at the option of the manufacturer.

8.10 Sheath under armour

The assembled cores shall be sheathed with a compound conforming to BS 7655 : Section 2.1 for a type EM2 sheath.

The minimum radial thickness at any point of the sheath, when determined by the method given in annex D, shall be not less than 80 % of the nominal value given in table 24.

8.11 Armour

8.11.1 *General*

The armour shall consist of the requisite number of galvanized steel wire strands to provide a complete cover. Each strand shall be composed of seven wires of the nominal size given in table 24.

The armour shall be applied with a length of lay not less than 4.5 times and not more than 8 times its pitch circle diameter.

The total cross-sectional area of the armour shall be not less than 14.2 mm^2.

The resistance of the armour shall conform to **8.15.1**.

8.11.2 *Galvanized steel wire*

The galvanized steel wire (see **8.11.1**) shall conform to **7.11.2**.

8.12 Outer sheath

The cable shall be sheathed with a compound conforming to BS 7655 : Section 2.3 for type RS6 sheath.

NOTE. If no colour is specified in the purchase order, black sheaths should normally be supplied.

The radial thickness of the outer sheath shall be determined in accordance with the method given in annex D, and the average value shall be not less than the nominal value given in table 24. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 15 % of the nominal value.

8.13 Marking

All cables shall be durably and legibly marked with the manufacturer's name, together with the year and month of manufacture, on a rubber-proofed or other comparable non-hygroscopic tape or tapes inside the cable. The marking shall be at intervals of not more than 300 mm throughout the length of the cable.

NOTE. The month of manufacture may be indicated by number.

8.14 Tests on core

8.14.1 *General*

All cores shall be subjected to the spark test in **8.14.2**, the voltage test in **8.14.3** and the insulation resistance test in **8.14.4**.

8.14.2 *Spark test*

Cores shall be tested in accordance with BS 5099 : 1992, and shall withstand the appropriate test voltage in clause **5** of BS 5099 : 1992.

8.14.3 *Voltage test*

When cores are tested in accordance with the methods given in **F.1**, **F.2.1** and **F.2.2**, they shall withstand a test voltage of 1500 V.

8.14.4 *Insulation resistance*

When cores are tested in accordance with the methods given in **F.1, F.2.1** and **F.2.3**, the insulation resistance between the conductor and the water in which the core is immersed shall be not less than 1500 MΩ for 1000 m at 20 °C.

8.15 Tests on completed cable

8.15.1 *Conductor, screen and armour resistance*

Completed cables shall be subjected to resistance tests.

The d.c. resistance at 20 °C shall not exceed the appropriate value given in table 24.

8.15.2 *Voltage test*

The completed cable shall be subjected to the voltage test in accordance with **F.1** and **F.3.1**. All cores shall withstand a test voltage of 1500 V.

8.15.3 *Insulation resistance*

Immediately after completion of the voltage test (see **8.15.2**), the insulation resistance of all cores shall be measured in accordance with **F.1** and **F.3.2**. The insulation resistance shall be not less than 1500 M for 1000 m at 20 °C.

8.15.4 *Test for flame propagation of single cable*

The finished cable shall conform to BS 4066 : Part 1 for tests under fire conditions.

9 Cables with galvanized steel pliable wire armouring having individual metallic screened or unscreened cores, rated voltage 3800/6600 V (types 621, 630 and 631)

9.1 Types of cables

Cable types and construction shall be as given in table 25.

Constructional details and dimensions shall be as given in tables 26 to 28 as appropriate.

9.2 Conductors

The conductors shall be composed of round tinned annealed copper wires conforming to BS 6360 for class 5 conductors and shall be multiple stranded.

Joints made in the single wires forming the conductor shall be brazed, silver soldered or electrically welded. No joint shall be made in the conductor after it has been stranded.

The conceptual construction shall be as given in tables 26 to 28.

A semiconducting layer shall be applied immediately over the conductor and shall consist of one of the following:

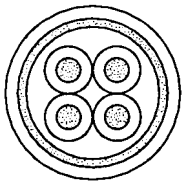
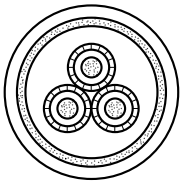
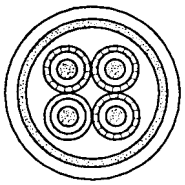
a) a semiconducting tape;

b) a layer of extruded semiconducting elastomeric compound;

c) a combination of a) and b) with the tape applied next to the conductor.

If the semiconducting elastomeric compound is used, it shall be extruded simultaneously with the insulation.

Table 25. Clause 9 cable types and construction

Type	System	Construction	Sectional diagram
621	3-phase	4-core. Three power cores unscreened and one unscreened earth core, laid around a centre, sheathed, galvanized steel strand armoured and sheathed overall	
630	3-phase	3-core. Three power cores each having a protective metallic screen, laid around an elastomeric centre, sheathed, galvanized steel strand armoured and sheathed overall	
631	3-phase	4-core. Three power cores each having a protective metallic screen and one unscreened earth core, laid around a centre, sheathed, galvanized steel strand armoured and sheathed overall.	

9.3 Insulation

The core insulation shall be either type FR2 conforming to BS 7655 : Section 1.5 or type GP5 conforming to BS 7655 : Section 1.2

For type 631 cable, an additional layer of insulation shall be applied to the earth core of a thickness such that the finished outside diameter of the core is the same as that of a screened power core.

NOTE. For the earth core, the additional layer of insulation may be separable from the primary insulation, or, alternatively, the complete insulation may be applied in a homogeneous layer.

9.4 Thickness of insulation

The thickness of the insulation shall be determined in accordance with the method given in annex D, and the average value shall be not less than the nominal value given in tables 26 to 28. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 10 % of the nominal value.

9.5 Core tape

The insulated core shall be lapped with tape applied with an overlap and with the identification colouring (see **9.6**) visible on the outside. It shall consist of either:

a) a tape of closely woven textile approximately 0.15 mm thick, without selvedge, proofed on one side with rubber or comparable material; or

b) a coloured polyethylene terephthalate or other comparable non-hygroscopic tape approximately 0.05 mm thick.

9.6 Core identification

The core tape shall be coloured for identification purposes as follows:

a) power cores: red, yellow, brown;

b) earth core: green/yellow.

9.7 Protective screen

The form of screen, method of application and materials shall be as given in annex E.

9.8 Central filler

The central filler shall consist of elastomeric compound and may include a textile carrier.

9.9 Laying-up of cores

The cores shall be laid around the centre specified in **9.8**.

The cores of all cables shall be laid up with a right hand lay and the length of lay shall not exceed 18 times the pitch circle diameter.

The sequence of colours shall be as given in **9.6**.

9.10 Sheath under armour

The assembled cores shall be sheathed in one operation with a compound conforming to BS 7655 : Section 2.1 for a type EM2 sheath.

The minimum radial thickness at any point of the sheath when determined by the method given in annex D shall be not less than 80 % of the nominal value given in tables 26 to 28.

Table 26. Constructional details of type 621 cable[1)]

Nominal cross-sectional area of conductor (mm^2)	35	50	70	95	120	150
Conceptual construction of conductor (mm)	276/0.40	396/0.40	360/0.50	475/0.50	608/0.50	756/0.50
Maximum diameter of wires in conductor (mm)	0.41	0.41	0.51	0.51	0.51	0.51
Radial thickness of core insulation (mm)	5.0	5.0	5.0	5.0	5.0	5.0
Number of cores	4	4	4	4	4	4
Radial thickness of inner sheath (mm)	3.8	5.0	5.0	5.0	5.0	5.0
Diameter over inner sheath (mm)						
minimum	53.8	60.5	65.6	70.7	74.3	79.2
maximum	56.8	63.5	69.4	74.5	78.1	83.2
Size of armour (mm)	7/0.90	7/1.25	7/1.25	7/1.25	7/1.25	7/1.25
Radial thickness of outer sheath (mm)	6.0	6.3	7.0	7.5	7.8	8.3
Overall diameter of cable (mm)						
minimum	71.2	81.0	87.1	93.2	97.4	103.3
maximum	75.2	85.3	91.4	97.5	101.7	107.6
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	0.565	0.393	0.277	0.210	0.164	0.132
Maximum resistance of armour per 1000 m of cable at 20 °C (Ω)	0.73	0.45	0.43	0.39	0.38	0.35

[1)] All cables in this table contain a full size earth conductor.

Table 27. Constructional details of type 630 cable							
Nominal cross-sectional area of conductor (mm^2)		35	50	70	95	120	150
Conceptual construction of conductor (mm)		276/0.40	396/0.40	360/0.50	475/0.50	608/0.50	756/0.50
Maximum diameter of wires in conductor (mm)		0.41	0.41	0.51	0.51	0.51	0.51
Radial thickness of core insulation (mm)		5.0	5.0	5.0	5.0	5.0	5.0
Number of cores		3	3	3	3	3	3
Radial thickness of inner sheath (mm)		3.8	3.8	5.0	5.0	5.0	5.0
Diameter over inner sheath (mm)							
minimum		53.1	57.0	64.0	68.5	71.7	76.1
maximum		56.1	60.0	67.0	72.3	75.5	80.0
Size of armour (mm)		7/0.9	7/0.9	7/1.25	7/1.25	7/1.25	7/1.25
Radial thickness of outer sheath (mm)		6.0	6.3	6.8	7.3	7.6	8.0
Overall diameter of cable (mm)							
minimum		70.5	75.0	85.1	90.6	94.4	99.6
maximum		74.5	79.3	89.4	94.9	98.7	103.9
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)		0.565	0.393	0.277	0.210	0.164	0.132
Maximum resistance of armour per 1000 m of cable at 20 °C (Ω)		0.76	0.71	0.46	0.43	0.41	0.39
Maximum resistance of screens in parallel, per 1000 m of cable at 20 °C (Ω)	3 screens in parallel	0.1	0.88	0.72	0.78	0.62	0.67
Minimum cross-sectional area of screens in parallel (mm^2)[1)]	3 screens in parallel	50.8	50.8	50.8	50.8	66	75
Area of screens in parallel, expressed as a percentage of the area of the largest current carrying conductor (%)	3 screens in parallel	145	101	72	53	55	50
Minimum conductivity[2)] of screens in parallel, expressed as a percentage of the largest current carrying conductor (%)	3 screens in parallel	144	100	99	76	66	54

[1)] Design minimum, for information only.

[2)] See annex A.

9.11 Armour

9.11.1 *General*

The armour shall consist of the requisite number of galvanized steel strands to provide a complete cover. Each strand shall be composed of seven wires of the appropriate nominal size given in tables 24 to 26.

The armour shall be applied with a length of lay not less than 4.5 times and not more than 6 times its pitch circle diameter.

The resistance of the armour shall conform to **9.15.2**.

9.11.2 *Galvanized steel wire*

The galvanized steel wire (see **9.11.1**) shall conform to **7.11.2**.

9.12 Outer sheath

The cable shall be sheathed with a compound conforming to BS 7655 : Section 2.3 for type RS6 sheath.

NOTE. If no colour is specified in the purchase order, black sheaths should normally be supplied.

The radial thickness of the outer sheath shall be determined in accordance with the method given in annex D, and the average value shall be not less than the nominal value given in tables 26 to 28. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 15 % of the nominal value.

9.13 Marking

9.13.1 All cables shall be durably and legibly marked with the manufacturer's name, together with the year and month of manufacture, on a rubber-proofed or other comparable non-hygroscopic tape or tapes inside the cable. The marking shall be at intervals of not more than 300 mm throughout the length of the cable.

NOTE. The month of manufacture may be indicated by number.

9.13.2 The cables shall have, in addition, an external identifying mark in the form of a red stripe not less than 12 mm wide applied longitudinally along the cable. The stripe material shall be similar to that of the outer sheath.

Table 28. Constructional details of type 631 cable			
Nominal cross-sectional area	power	50	70
of conductor (mm^2)	earth	35	50
Conceptual construction of conductor (mm)	power	396/0.40	360/0.50
	earth	276/0.40	396/0.40
Maximum diameter of wires in conductor (mm)	power	0.41	0.51
	earth	0.41	0.41
Radial thickness of core insulation (mm)	power	5.0	5.0
	earth	5.0	5.0
Number of cores		4	4
Radial thickness of inner sheath (mm)		5.0	5.0
Diameter over inner sheath (mm)			
minimum		65.4	70.5
maximum		69.2	74.3
Size of armour (mm)		7/1.25	7/1.25
Radial thickness of outer sheath (mm)		6.9	7.4
Overall diameter of cable (mm)			
minimum		86.7	92.8
maximum		91.0	97.1
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	power	0.393	0.277
	earth	0.565	0.393
Maximum resistance of armour per 1000 m of cable at 20 °C (Ω)		0.45	0.42
Maximum resistance of screens in parallel, per 1000 m of cable at 20 °C (Ω)	3 screens in parallel	0.40	0.40
Minimum conductivity[1)] of earth and screens in parallel, expressed as a percentage of the largest current carrying conductor (%)	3 screens in parallel and earth	> 140	> 128

[1)] See annex A.

9.14 Tests on cores

9.14.1 *General*

All cores shall be subjected to the following tests:

a) voltage test (see **9.14.2**);

b) insulation resistance test (see **9.14.3**).

9.14.2 *Voltage test*

When cores are tested in accordance with the methods given in **F.1**, **F.2.1** and **F.2.2**, they shall withstand a test voltage of 15000 V.

9.14.3 *Insulation resistance*

When cores are tested in accordance with the methods given in **F.1**, **F.2.1** and **F.2.3**, the insulation resistance between the conductor and the water in which the core is immersed shall be not less than the appropriate value given in table 29.

9.15 Tests on completed cable

9.15.1 *Conductor resistance*

The d.c. resistance at 20 °C shall not exceed the appropriate value given in tables 26 to 28.

9.15.2 *Resistance of screen and armour*

The d.c. resistance at 20 °C of the armour in cable type 621, and of the screens and armour in cable types 630 and 631, shall not exceed the appropriate value given in tables 26 to 28.

9.15.3 *Voltage test*

Completed cables shall be subjected to the voltage test in accordance with **F.1** and **F.3.1**. All cores shall withstand a test voltage of 15000 V.

9.15.4 *Insulation resistance*

Immediately after completion of the voltage test (see **9.15.3**) the insulation resistance of all cores shall be measured in accordance with **F.1** and **F.3.2**. The insulation resistance shall be not less than the appropriate value given in table 29.

9.15.5 *Test for flame propagation of single cable*

The finished cable shall conform to BS 4066 : Part 1 for tests under fire conditions.

Table 29. Insulation resistance		
Nominal cross-sectional area of conductor	**Minimum insulation resistance for 1000 m at 20 °C**	
	FR2[1)]	**GP5**[1)]
mm^2	MΩ	MΩ
35	1250	1600
50	1100	1400
70	950	1200
95	840	1100
120	780	1000
150	710	920

[1)] See clause **9.3**.

10 Cable with individual metallic screens, rated voltage 600/1000 V, for use with drills (type 44)

10.1 Type of cable

Cable type and construction shall be as given in table 30.

Constructional details and dimensions shall be as given in table 31.

NOTE. This cable is intended for use with hand-held shot-hole drilling machines, for which the normal voltage in British mines is 125 V between phases, and with the neutral point earthed so that the voltage is limited to 72 V.

10.2 Conductors

The conductors shall be composed of stranded round tinned annealed copper wires conforming to BS 6360 for class 5 conductors.

Joints made in the single wires forming the conductor shall be brazed, silver soldered or electrically welded. No joint shall be made in the conductor after it has been stranded.

The conceptual construction shall be as given in table 31.

NOTE. At the manufacturer's discretion, a film separator of polyethylene terephthalate or other suitable non-hygroscopic tape may be applied over the conductor. Embrittlement or discoloration of this tape after vulcanization of the core may be disregarded.

10.3 Insulation

The core insulation shall be either type FR1 conforming to BS 7655 : Section 1.5 or type GP4 conforming to BS 7655 : Section 1.2, except that the tensile stress at 100 % elongation for GP4 shall be 2.0 N/mm^2 minimum.

An additional layer of insulation shall be applied to the earth core and pilot core, of a thickness such that the finished outside diameter of the core is the same as that of a screened power core.

NOTE. The additional insulation may be applied in a homogeneous layer.

10.4 Thickness of insulation

The thickness of the insulation shall be determined in accordance with the method given in annex D, and the average value shall be not less than the nominal value of 1.0 mm given in table 31.

The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 10 % of the nominal value.

10.5 Core tape

The insulated core shall be lapped with tape applied with an overlap and with the identification colouring (see **10.6**) visible on the outside. It shall consist of either:

a) a tape of closely woven textile approximately 0.15 mm thick, without selvedge, proofed on one side with rubber or comparable material; or

b) a coloured polyethylene terephthalate or other comparable non-hygroscopic tape approximately 0.05 mm thick.

10.6 Core identification

The core tape shall be coloured for identification purposes as follows:

a) power cores: red, yellow, brown;

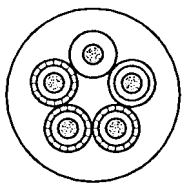
b) pilot core: blue;

c) earth core; green/yellow.

10.7 Protective screen

The form of screen, method of application and materials shall be as given in annex E.

The screened cores shall each be lapped with polyethylene terephthalate tape approximately 0.025 mm thick with an overlap of not less than 15 %.

Table 30. Clause 10 cable type and construction			
Type	**System**	**Construction**	**Sectional diagram**
44	3-phase 125/72 V	5-core. Three power cores each having a protective metallic screen, one unscreened earth core and one unscreened pilot core, laid around an elastomeric centre, sheathed overall	

10.8 Laying-up of cores

The cores shall be laid around a centre of elastomeric compound that may include a textile carrier, with right hand lay in the following colour sequence: red, yellow, brown (power); green/yellow (earth); blue (pilot).

The length of lay shall not exceed 10 times the pitch circle diameter. There shall be provisions for allowing relative movement of cores when the cable is flexed.

10.9 Outer sheath

The assembled cores shall be filled and sheathed in one operation with a compound conforming to BS 7655 : Section 2.3 for a type RS6 sheath.

NOTE. If no colour is specified in the purchase order, black sheaths should normally be supplied.

The radial thickness of the outer sheath shall be determined in accordance with the method given in annex D, and the average value shall be not less than the nominal value of 3.0 mm given in table 31. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 15 % of the nominal value.

10.10 Marking

All cables shall be durably and legibly marked with the manufacturer's name together with the year and month of manufacture, either:

a) on rubber-proofed or other comparable non-hygroscopic tape or tapes inside the cable; or

b) on one or more of the insulated cores.

NOTE. The month of manufacture may be indicated by number.

10.11 Tests on cores

10.11.1 *General*

All cores shall be subjected to the spark test in **10.11.2**, the voltage test in **10.11.3** and the insulation resistance test in **10.11.4**.

10.11.2 *Spark test*

Cores shall be tested in accordance with the method given in BS 5099, and shall withstand the appropriate test voltage in clause **5** of BS 5099 : 1992.

10.11.3 *Voltage test*

When cores are tested in accordance with the methods given in **F.1**, **F.2.1** and **F.2.2**, they shall withstand a test voltage of 1500 V.

10.11.4 *Insulation resistance*

When cores are tested in accordance with the methods given in **F.1**, **F.2.1** and **F.2.3**, the insulation resistance between the conductor and the water in which the core is immersed shall be not less than:

a) for FR1 insulation: 350 M for 1000 m at 20 °C;

b) for GP4 insulation: 490 M for 1000 m at 20 °C.

10.12 Tests on completed cable

10.12.1 *Conductor resistance*

The d.c. resistance at 20 °C shall not exceed the value given in table 31.

10.12.2 *Resistance of screens*

The d.c. resistance of each screen at 20 °C shall not exceed the value given in table 31.

10.12.3 *Voltage test*

All completed cables shall be subjected to the voltage test in accordance with **F.1** and **F.3.1**. All cores shall withstand a test voltage of 1500 V.

10.12.4 *Insulation resistance*

Immediately after completion of the voltage test (see **10.12.3**), the insulation resistance of all cores shall be measured in accordance with **F.1** and **F.3.2**.

The insulation resistance shall be not less than:

a) for FR1 insulation: 350 M for 1000 m at 20 °C;

b) for GP4 insulation: 490 M for 1000 m at 20 °C.

10.12.5 *Test for flame propagation of single cable*

The finished cable shall conform to BS 4066 : Part 1 for tests under fire conditions.

Table 31. Constructional details for type 44 cable[1)]

Nominal cross-sectional area of conductor (mm^2)	6
Conceptual construction of conductor (mm)	84/0.30
Maximum diameter of wires in conductor (mm)	0.31
Radial thickness of core insulation (mm)	1.0
Radial thickness of outer sheath (mm)	3.0
Overall diameter of cable (mm)	
minimum	24.7
maximum	26.7
Maximum conductor resistance (3 screens in parallel) per 1000 m of cable at 20 °C (Ω)	3.48
Maximum screen resistance (3 screens in parallel) per 1000 m of cable at 20 °C (Ω)	11

[1)] This cable contains a full size earth conductor.

11 Cable with individual non-metallic screens, rated voltage 600/1000 V, for use with drills (type 43)

11.1 Type of cable

Cable type and construction shall be as given in table 32.

Constructional details and dimensions shall be as given in table 33.

NOTE. This cable is intended for use with hand-held shot-hole drilling machines, for which the normal voltage in British mines is 125 V between phases, and with the neutral point earthed so that the voltage to earth is limited to 72 V.

11.2 Conductors

The conductors shall be composed of round tinned annealed copper wires conforming to BS 6360 for class **5** conductors.

Joints made in the single wires forming the conductor shall be brazed, silver soldered or electrically welded. No joint shall be made in the conductor after it has been stranded.

The nominal number and nominal and maximum diameter of the wires in the conductor shall be as given in table 33.

NOTE. At the manufacturer's discretion, a film separator of polyethylene terephthalate or other suitable non-hygroscopic tape may be applied over the conductor. Embrittlement or discoloration of this tape after vulcanization of the core may be disregarded.

11.3 Insulation

The core insulation shall be either type FR1 conforming to BS 7655 : Section 1.5 or type GP4 conforming to BS 7655 : Section 1.2, except that the tensile stress at 100 % elongation for GP4 shall be 2.0 N/mm^2.

When, at the manufacturer's discretion, a core identification tape is applied over the power and pilot cores (see **11.6**), it shall be applied with an overlap and with the identification colouring visible on the outside. It shall consist of either:

a) a tape of closely woven textile approximately 0.15 mm thick, without selvedge, proofed on one side with rubber or comparable material; or

b) a coloured polyethylene terephthalate or other comparable non-hygroscopic tape approximately 0.05 mm thick.

11.4 Conducting elastomeric screen

The material forming the covering on the earth conductor, the preformed cradle separator and the screen over laid-up cores shall consist of conducting elastomeric compound such that the completed cable conforms to **11.14**.

11.5 Thickness of insulation and covering

The thickness of insulation on the power cores, pilot core or the covering on the earth conductor shall be determined in accordance with the method given in annex D, and the average value shall be not less than the nominal value of 1.0 mm given in table 33. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 10 % of the nominal value.

11.6 Core identification

The insulation or covering of each conductor or the core tape, when used, shall be coloured for identification purposes as follows:

a) power cores: red, yellow, brown;

b) pilot core: blue;

c) earth core: black.

11.7 Cradle separator

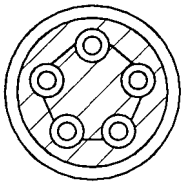
The cradle separator shall be of preformed conducting elastomeric compound and may include a textile carrier. The cradle separator shall be formed so that the nominal distance between adjacent cores is 1.5 mm, the minimum distance between adjacent cores being 70 % of the nominal value.

11.8 Laying-up of cores

The cores shall be laid around the cradle separator with right hand lay in the following colour sequence: red, yellow, brown (power); black (earth); blue (pilot).

The length of lay shall be not less than eight times and not more than 10 times the pitch circle diameter. There shall be provision for allowing relative movement of cores when the cable is flexed.

Table 32. Clause 11 cable type and construction

Type	System	Construction	Sectional diagram
43	3-phase 125/72 V	5-core. Three unscreened power cores, one unscreened earth core and one unscreened pilot core, laid around a conducting elastomeric cradle separator with a lay of between eight and ten times the pitch circle diameter, covered with a conducting elastomeric screen in direct contact with the earthing conductor, and heavy duty sheathed overall.	

11.9 Screen over laid-up cores

The laid-up cores shall be filled and sheathed in one operation with a layer of black conducting elastomeric compound having a nominal thickness of 1.5 mm.

The thickness of the conducting elastomeric screen shall be measured on a representative sample taken from the cable, not less than 150 mm from the end of a manufacturing length, by a method in which the error of determination does not exceed 0.025 mm.

NOTE. It is necessary to take measurements at several positions around the perimeter, to ensure that any point of minimum thickness is located and recorded.

The minimum thickness shall not fall below the nominal value by an amount more than 20 % plus 0.2 mm.

11.10 Outer sheath

The screened cable shall be sheathed with a closely fitting material conforming to BS 7655 : Section 2.3 for a type RS6 sheath.

NOTE. If no colour is specified in the purchase order, black sheaths should normally be supplied.

The radial thickness of the outer sheath shall be determined in accordance with the method given in annex D, and the average value shall be not less than the nominal value of 2.5 mm given in table 33. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 15 % of the nominal value.

11.11 Marking

11.11.1 The cable shall be durably and legibly marked with the manufacturer's name, together with the year and month of manufacture, either:

a) on rubber-proofed or other comparable non-hygroscopic tape or tapes inside the cable; or

b) on one or more of the insulated cores.

NOTE. The month may be indicated by number.

11.11.2 The cable shall have, in addition, an external identifying mark in the form of a yellow stripe not less than 12 mm wide, applied longitudinally along the cable or spiralled with any pitch.

NOTE. The stripe may be in the form of printed ink, paint or any other suitable material. It is not expected for the marking to remain distinguishable along the complete length of the cable through its service life.

11.12 Tests on cores

11.12.1 *General*

All power and pilot cores shall be subjected, at the place of manufacture, to the spark test in **11.12.2**, and shall pass the voltage test specified in **11.12.3** and the insulation resistance test specified in **11.12.4**.

11.12.2 *Spark test*

Cores shall be tested in accordance with the method given in BS 5099, and shall withstand the appropriate test voltage in clause **5** of BS 5099 : 1992.

11.12.3 *Voltage test*

When cores are tested in accordance with the method given in **F.1**, **F.2.1** and **F.2.2**, they shall withstand a test voltage of 1500 V.

11.12.4 *Insulation resistance*

When cores are tested in accordance with the method given in **F.1**, **F.2.1** and **F.2.3**, the insulation resistance between the conductor and the water in which the core is immersed shall be not less than:

a) for FR1 insulation: 350 MΩ for 1000 m at 20 °C;

b) for GP4 insulation: 490 MΩ for 1000 m at 20 °C.

11.13 Tests on completed cable

11.13.1 *Conductor resistance*

The d.c. resistance at 20 °C shall not exceed the value given in table 33.

11.13.2 *Voltage test*

All completed cables shall be subjected to the voltage test in accordance with **F.1** and **F.3.1**. All cores shall withstand a test voltage of 1500 V.

11.13.3 *Insulation resistance*

Immediately after completion of the voltage test (see **11.3.2**), the insulation resistance of all cores shall be measured in accordance with **F.1** and **F.3.2**. The insulation resistance shall be not less than:

a) for FR1 insulation: 350 MΩ for 1000 m at 20 °C;

b) for GP4 insulation: 490 MΩ for 1000 m at 20 °C.

11.13.4 *Test for flame propagation of single cable*

The finished cable shall conform to BS 4066 : Part 1 for tests under fire conditions.

11.14 Electrical test on conducting elastomeric screen

When tested in accordance with annex H, the conducting elastomeric screen shall be deemed to have passed the electrical test if either of the following applies:

a) the leakage current created by the fault reaches a minimum value of 125 mA r.m.s. within 10 ms, either from the instant the needle makes contact with the power conductor, or from the instant the voltage is switched on (see **H.2**), and does not fall below 125 mA r.m.s. within 200 ms from that instant; or

b) if the flow of leakage current from any one core does not conform to a), the current flow produced by each of the three cores subjected to the additional tests (see **H.2**) conforms to a).

Table 33. Constructional details for type 43 cable[1)]	
Nominal cross-sectional area of conductor (mm)^2	6
Conceptual construction of conductor (mm)	84/0.30
Maximum diameter of wires in conductor (mm)	0.31
Radial thickness of core insulation or covering (mm)	1.0
Radial thickness of conducting elastomeric sheath (mm)	1.5
Radial thickness of outer sheath (mm)	2.5
Overall diameter of cable (mm)	
minimum	25.6[2)]
maximum	27.6[2)]
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	3.48

[1)] This cable contains a full size earth conductor.

[2)] These values allow for the use of taped cores. With untaped cores the diameters are approximately 0.8 mm less.

12 Cable with individual metallic screened cores, non-armoured, rated voltage 3800/6600 V (type 730)

12.1 Type of cable

Cable type and construction shall be as given in table 34.

Constructional details and dimensions shall be as given in table 35.

12.2 Conductors

The conductors shall be composed of round tinned annealed copper wires conforming to BS 6360 for class 5 conductors.

Joints made in the single wires forming the conductor shall be brazed, silver soldered or electrically welded. No joint shall be made in the conductor after it has been stranded.

The conceptual construction shall be as given in table 35.

A non-metallic screen shall be applied immediately over the conductor and shall consist of one of the following:

a) a semiconducting tape;

b) a layer of extruded semiconducting elastomeric compound;

c) a combination of a) and b) with the tape applied next to the conductor.

If semiconducting elastomeric compound is used, it shall be extruded simultaneously with the insulation.

12.3 Insulation

The core insulation shall be either type FR2 conforming to BS 7655 : Section 1.5 or type GP5 conforming to BS 7655 : Section 1.2.

12.4 Thickness of insulation

The thickness of the insulation shall be determined in accordance with the method given in annex D, and the average value shall be not less than the nominal value given in table 35. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 10 % of the nominal value.

12.5 Core tape

The insulated core shall be lapped with a tape applied with an overlap and with the identification colouring (see **12.6**) visible on the outside. It shall consist of either:

a) a tape of closely woven textile approximately 0.15 mm thick, without selvedge, proofed on one side with coloured rubber or comparable material; or

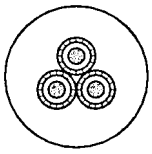
b) a coloured polyethylene terephthalate or other comparable non-hygroscopic tape approximately 0.05 mm thick.

12.6 Core identification

The three core tapes specified in **12.5** shall be coloured one red, one yellow and one brown.

12.7 Protective screen

The form of screen, method of application and materials shall be as given in annex E.

Table 34. Clause 12 cable type and construction			
Type	**Section**	**Construction**	**Sectional diagram**
730	3-phase 3800/6600 V	3-core. Three power cores each having a protective metallic screen, laid around an elastomeric centre or bare earth conductor, sheathed overall	

12.8 Central filler/central earth conductor

The central filler shall consist of one of the following:

a) elastomeric compound that may include a textile carrier; or

b) a 16.0 mm^2 conductor, composed of round tinned annealed copper wire conforming to BS 6360 for class 5 conductors, with right hand direction of lay.

12.9 Laying-up of cores

The cores of the 35 mm^2, 50 mm^2, 70 mm^2 and 90 mm^2 cable shall be laid around the elastometric central filler specified in **12.8**a.

The cores of the 120 mm^2 and 150 mm^2 cable shall be laid around the bare central earth conductor specified in **12.8**b.

12.10 Outer sheath

The cable shall be sheathed with a compound conforming to BS 7655 : Section 2.3 for type RS6 sheath.

NOTE. If no colour is specified in the purchase order, black sheaths should normally be supplied.

The radial thickness of the outer sheath shall be determined in accordance with the method given in annex D, and the average value shall be not less than the appropriate nominal value given in table 35. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 15 % of the nominal value.

12.11 Marking

The cables shall be durably and legibly marked with the manufacturer's name, together with the year and month of manufacture, on a rubber-proofed or other comparable non-hygroscopic tape or tapes inside the cable. The marking shall be at intervals of not more than 300 mm throughout the length of the cable.

NOTE. The month of manufacture may be indicated by number.

12.12 Tests on cores

12.12.1 *General*

All cores shall be subjected to the following tests:

a) voltage test (see **12.12.2**);

b) insulation resistance test (see **12.12.3**).

12.12.2 *Voltage test*

When cores are tested in accordance with the methods given in **F.1**, **F.2.1** and **F.2.2**, they shall withstand a test voltage of 15000 V.

12.12.3 *Insulation resistance*

When cores are tested in accordance with the methods given in **F.1, F.2.1** and **F.2.3**, the insulation resistance between the conductor and the water in which the core is immersed shall be not less than the appropriate value given in table 36.

12.13 Tests on completed cable

12.13.1 *Conductor resistance*

The d.c. resistance at 20 °C shall not exceed the appropriate value given in table 35.

12.13.2 *Resistance of earth screens*

The d.c. resistance of the screens at 20 °C shall not exceed the appropriate value given in table 35.

12.13.3 *Voltage test*

All completed cables shall be subjected to the voltage test in accordance with **F.1** and **F.3.1**. All cores shall withstand a test voltage of 15000 V.

12.13.4 *Insulation resistance*

Immediately after completion of the voltage test (see **12.13.3**), the insulation resistance of all cores shall be measured in accordance with **F.1** and **F.3.2**. The insulation resistance shall be not less than the appropriate value given in table 36.

12.13.5 *Test for flame propagation of single cable*

The finished cable shall conform to BS 4066 : Part 1 for tests under fire conditions.

13 Cable with metallic screened cores, non-armoured, rated voltage 6350/11000 V (type 830)

13.1 Type of cable

Cable type and construction shall be as given in table 37.

Constructional details and dimensions shall be as given in table 38.

13.2 Conductors

The conductors shall be composed of round tinned annealed copper wire conforming to BS 6360 for class 5 conductors.

Joints made in the single wires forming the conductor shall be brazed, silver soldered or electrically welded. No joint shall be made in the conductor after it has been stranded.

The conceptual construction shall be as given in table 38.

A non-metallic screen shall be applied immediately over the conductor and shall consist of one of the following:

a) a semiconductor tape; or

b) a layer of extruded semiconducting elastomeric compound; or

c) a combination of a) and b) with the tape applied next to the conductor.

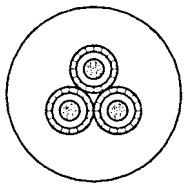
When semiconducting elastomeric compound is used, it shall be extruded simultaneously with the insulation.

Table 35. Constructional details of type 730 cable							
Nominal cross-sectional area of	power	35	50	70	95	120	150
conductor (mm^2)	earth	—	—	—	—	16	16
Conceptual construction of conductor (mm)	power	276/0.40	396/0.40	360/0.50	475/0.50	608/0.50	756/0.50
	earth	—	—	—	—	126/0.40	126/0.40
Maximum diameter of wires in conductor (mm)	power	0.41	0.41	0.51	0.51	0.51	0.51
	earth	—	—	—	—	0.41	0.41
Radial thickness of core insulation (mm)	power	5.0	5.0	5.0	5.0	5.0	5.0
Number of cores		3	3	3	3	3	3
Radial thickness of outer sheath (mm)		6.0	6.3	6.8	7.3	7.6	8.0
Overall diameter of cable (mm)							
minimum		57.5	62.0	67.5	73.1	76.9	82.1
maximum		60.5	65.0	71.4	76.9	80.9	86.1
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	power	0.565	0.393	0.277	0.210	0.164	0.132
Maximum resistance of earth (when specified) and screens in parallel, per 1000 m of cable at 20 °C (Ω)	3 screens and earth (when specified) in parallel	0.81	0.78	0.55	0.42	0.32	0.26
Minimum cross-sectional area of earth (when specified) and screens in parallel (mm^2)[1)]	3 screens and earth (when specified) in parallel	50.8	50.8	50.8	50.8	82	87
Area of earth (when specified) and screens in parallel, expressed as a percentage of the area of the largest current carrying conductor (%)	3 screens and earth (when specified) in parallel	145	101	72	53	68	58
Minimum conductivity[2)] of earth (when specified) and screens in parallel, expressed as a percentage of the largest current carrying conductor (%)	3 screens and earth (when specified) in parallel	70	50	50	50	51	51

[1)] Design minimum, for information only.

[2)] See annex A.

Table 36. Insulation resistance		
Nominal cross-section area of conductor	**Minimum insulation resistance for 1000 m at 20 °C**	
	FR2[1)]	**GP5**[1)]
mm^2	MΩ	MΩ
35	1250	1600
50	1100	1400
70	950	1200
95	840	1100
120	780	1000
150	710	920
[1)] See **12.3**.		

Table 37. Clause 13 cable type and construction			
Type	**System**	**Construction**	**Sectional drawing**
830	3-phase 6350/11000 V	3-core. Three power cores each having a protective metallic screen, laid around an elastomeric centre or bare earth conductor, sheathed overall	

13.3 Insulation

The core insulation shall be either type FR2 conforming to BS 7655 : Section 1.5 or type GP5 conforming to BS 7655 : Section 1.2.

13.4 Thickness of insulation

The thickness of the insulation shall be determined in accordance with the method given in annex D, and the average value shall be not less than the nominal value given in table 38. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 10 % of the nominal value.

13.5 Core tape

The insulated core shall be lapped with a tape applied with an overlap and with the identification colouring (see **13.6**) visible on the outside. It shall consist of either:

a) a tape of closely woven textile approximately 0.15 mm thick, without selvedge, proofed on one side with coloured rubber or comparable material; or

b) a coloured polyethylene terephthalate or other comparable non-hygroscopic tape approximately 0.05 mm thick.

13.6 Core identification

The three core tapes (see **13.5**) shall be coloured one red, one yellow and one brown.

13.7 Protective screen

The form of screen, method of application and materials shall be as given in annex E.

13.8 Central filler/central earth conductor

The central filler shall consist of one of the following, as specified in **13.9**:

a) elastomeric compound that may include a textile carrier; or

b) a 16.0 mm^2 conductor, composed of round tinned annealed copper wire conforming to BS 6360 for class 5 conductors, with right hand direction of lay.

13.9 Laying-up of cores

The cores of the 50 mm^2, 70 mm^2 and 95 mm^2 cable shall be laid around the elastomeric central filler specified in **13.8**a.

The cores of the 120 mm^2 and 150 mm^2 cable shall be laid around the bare central earth conductor specified in **13.8**b.

13.10 Outer sheath

The cable shall be sheathed with a compound conforming to BS 7655 : Section 2.3 for type RS6 sheath.

NOTE. If no colour is specified in the purchase order, black sheaths should normally be supplied.

The radial thickness of the outer sheath shall be determined in accordance with the method given in annex D, and the average value shall be not less than the nominal value given in table 38. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 15 % of the nominal value.

13.11 Marking

The cables shall be durably and legibly marked with the manufacturer's name, together with the year and month of manufacture, on a rubber-proofed or other comparable non-hygroscopic tape or tapes inside the cable. The marking shall be at intervals of not more than 300 mm throughout the length of the cable.

NOTE. The month of manufacture may be indicated by number.

13.12 Tests on cores

13.12.1 *General*

All cores shall be subjected to the following tests:

a) voltage test (see **13.12.2**);

b) insulation resistance test (see **13.12.3**).

13.12.2 *Voltage test*

When cores are tested in accordance with the method given in **F.1**, **F.2.1** and **F.2.2**, they shall withstand a test voltage of 25000 V.

13.12.3 *Insulation resistance*

When cores are tested in accordance with the method given in **F.1, F.2.1** and **F.2.3**, the insulation resistance between the conductor and the water in which the core is immersed shall be not less than the appropriate value given in table 39.

13.13 Tests on completed cable

13.13.1 *Conductor resistance*

The d.c. resistance at 20 °C shall not exceed the appropriate value given in table 38.

13.13.2 *Resistance of earth conductor and screens*

The combined d.c. resistance of the earth conductor (when specified) and core screen in parallel at 20 °C shall not exceed the appropriate value given in table 38.

13.13.3 *Voltage test*

All completed cables shall be subjected to the voltage test in accordance with **F.1** and **F.2.1**. All cores shall withstand a test voltage of 25000 V.

13.13.4 *Insulation resistance*

Immediately after completion of the voltage test (see **13.13.3**), the insulation resistance of all cores shall be measured in accordance with **F.1** and **F.3.2**. The insulation resistance shall be not less than the appropriate value given in table 39.

13.13.5 *Test for flame propagation of single cable*

The finished cable shall conform to BS 4066 : Part 1 for tests under fire conditions.

Table 38. Constructional details of type 830 cable

Nominal cross-sectional area of conductor (mm^2)	power earth	50 —	70 —	95 —	120 16	150 16
Conceptual construction of conductor (mm)	power earth	396/0.40 —	360/0.50 —	475/0.50 —	608/0.50 126/0.40	756/0.50 126/0.40
Maximum diameter of wires in conductor (mm)	power earth	0.41 —	0.51 —	0.51 —	0.51 0.41	0.51 0.41
Radial thickness of core insulation (mm)	power	7.5	7.5	7.5	7.5	7.5
Number of cores		3	3	3	3	3
Radial thickness of outer sheath (mm)		7.4	7.9	8.3	8.7	9.1
Overall diameter of cable (mm)						
minimum		75.0	80.6	85.9	89.9	93.3
maximum		83.0	86.0	91.0	96.5	103.0
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	power	0.393	0.277	0.210	0.164	0.132
Maximum resistance of earth (when specified) and screens in parallel, per 1000 m of cable at 20 °C (Ω)	3 screens and earth (when specified) in parallel	0.68	0.55	0.42	0.32	0.26
Minimum cross-sectional area of earth (when specified) and screens in parallel (mm^2)	3 screens and earth (when specified) in parallel	66	66	66	76	92
Area of earth (when specified) and screens in parallel, expressed as a percentage of the area of the largest current-carrying conductor (%)	3 screens and earth (when specified) in parallel	132	94	69	63	61
Minimum conductivity[2)] of earth (when specified) and screens in parallel, expressed as a percentage of the largest current-carrying conductor (%)	3 screens and earth (when specified) in parallel	58	50	50	51	51

[1)] Design minimum, for information only.

[2)] See annex A.

Table 39. Insulation resistance

Nominal cross-sectional area of conductor	**Minimum insulation resistance for 1000 m at 20 °C**	
	FR2[1)]	**GP5**[1)]
mm^2	MΩ	MΩ
50	1400	1800
70	1200	1600
95	1100	1400
120	1000	1300
150	880	1200

[1)] See **13.3**.

14 Cables with individual metallic screens, rated voltage 1900/3300V, for use with coalface cutters and for similar purposes (types 307, 307M and 307S)

14.1 Type of cable

Cable type and construction shall be as given in table 40.

Constructional details and dimensions shall be as given in tables 41 to 43.

14.2 Conductors

The conductors shall be composed of round tinned annealed copper wire conforming to BS 6360 for class 5 conductors.

Joints made in the single wires forming the conductor shall be brazed, silver soldered or electrically welded. No joints shall be made in the conductor after it has been stranded.

The conceptual construction shall be as given in tables 41 to 43.

NOTE. At the manufacturer's discretion, a film separator of polyethylene terephthalate or other suitable non-hygroscopic tape may be applied over the conductor. Embrittlement or discoloration of this tape after vulcanization of the core may be disregarded.

14.3 Insulation

The core insulation shall form a close fit on the conductor without adhering. It shall be either type FR 2 conforming to BS 7655 : Section 1.5 or type GP 5 compound conforming to BS 7655 : Section 1.2. The insulation for the pilot cores of cable type 307S shall be either type FR 1 conforming to BS 7655 : Section 1.5 or type GP 4 compound conforming to BS 7655 : Section 1.2. The tensile stress at 100 % elongation for GP4 and GP5 shall be 2.0 N/mm^2 minimum.

For cable type 307, an additional layer of insulation shall be applied to the pilot core of a thickness such that the finished outside diameter of the core is the same as that of a screened power core. This additional layer of insulation shall be readily separable from the primary insulation.

NOTE. If the insulation colouring is used for identification purposes, it may be restricted to the outside layer.

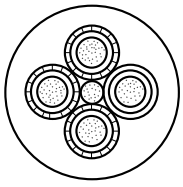
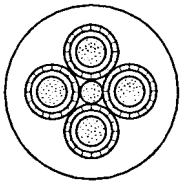
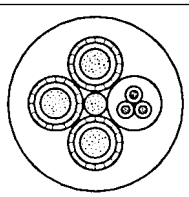
14.4 Thickness of insulation

The radial thickness of the insulation shall be determined in accordance with the method given in annex D, and the average value shall be not less than the nominal value given in tables 41 to 43. The smallest of the measured values shall not fall below the nominal value by more than 0.1 mm plus 10 % of the nominal value.

14.5 Core tape

The insulation of each conductor or sheathed pilot unit shall be lapped with a tape of closely woven textile, approximately 0.15 mm thick, without selvedge, proofed on one side with rubber or comparable material. The tape shall be applied with an overlap. The proofed side of the tape shall be coloured for identification purposes (see **14.6**) and shall be visible on the outside.

Table 40. Clause 14 cable types and construction

Type	System	Construction	Sectional diagram
307	3-phase	5-core. Three power cores each having a protective metallic screen and one pilot core unscreened. Laid around a bare earth conductor with which the screens are in electrical contact, sheathed overall.	
307M	3-phase	5-core. Three power cores and one pilot core having the same nominal cross-sectional area, each having a protective metallic screen, laid around a bare earth conductor with which the screens are in electrical contact, sheathed overall.	
307S	3-phase	7-core. Three power cores each having a protective metallic screen, and one unscreened sheathed pilot unit containing three pilot cores, laid around a bare earth conductor with which the screens are in electrical contact, sheathed overall.	

14.6 Core identification

14.6.1 *General*

The core tapes (see **14.5**) shall be coloured for identification purposes as follows:

a) power cores: red, yellow and brown;
b) pilot cores (except type 307S, see **14.6.2**): blue.

14.6.2 *Type 307S pilot unit and pilot cores*

The pilot unit core tape (see **14.5**) shall be coloured blue.

The pilot cores shall be identified either by the application of a coloured core tape in accordance with **14.5** or by the colour of the insulation in accordance with **14.3**. The identifying colours shall be one black, one white and one blue.

14.7 Protective screen

The form of screen, method of application and materials shall be as given in annex E.

14.8 Laying up of cores

14.8.1 *Types 307 and 307M*

The cores shall be laid around a bare earth conductor with a length of lay that permits the screens enclosing each power core to make electrical contact with the bare central earth conductor. The lay of the earth conductor strands shall be in the same direction as that of the laid-up cores, i.e. right hand.

14.8.2 *Type 307S*

The three pilot cores of the pilot unit shall be laid up with a right hand direction of lay with the length of lay not exceeding nine times the pitch circle diameter.

The power cores and the pilot unit shall be laid around a bare earth conductor with a length of lay that permits the screens enclosing each power core to make electrical contact with the bare central earth conductor. The lay of the earth conductor strands shall be in the same direction as that of the laid-up cores, i.e. right hand.

14.8.3 *Length and direction of lay*

The cores of all types of cables, with the exception of the pilot cores of cable types 307S (see **14.8.2**) shall be laid up with a right hand direction of lay not exceeding 15 times the pitch circle diameter.

14.8.4 *Sequence of colours*

The laid-up cores/units shall be in the following sequence: red, yellow, brown (power); blue (pilot).

14.9 Sheath of pilot unit and outer sheath

14.9.1 *Sheath of pilot unit (type 307S)*

The assembled cores of the pilot unit shall be sheathed with a black compound conforming to BS 7655 : Section 2.1 for type EM 2. The sheath shall be of such a thickness that the diameter of the taped sheath is the same as that of a screened power core.

14.9.2 *Outer sheath*

The assembled cores/unit shall be filled and sheathed in one operation with a compound conforming to BS 7655 : Section 2.3 for RS6 sheath.

NOTE. If no colour is specified in the purchase order, black sheaths should normally be supplied.

14.10 Marking

All cables shall be durably and legibly marked with the manufacturer's name, together with the year and month of manufacture, on rubber-proofed or other comparable non-hygroscopic tapes inside the cable. The marking shall be at intervals of not more than 300 mm throughout the length of the cable.

All cables shall have, in addition, an external identifying mark in the form of a red stripe not less than 12 mm wide applied longitudinally along the length of the cable. The stripe material shall be similar to that of the outer sheath.

14.11 Test on cores

14.11.1 *General*

All cores shall be subjected to the spark test in **14.11.2**, the voltage test in **14.11.3** and the insulation resistance test in **14.11.4**.

14.11.2 *Spark test*

Cores shall be tested in accordance with the method given in BS 5099, and shall withstand the appropriate test voltages in clause **5** of BS 5099 : 1992.

14.11.3 *Voltage test*

When cores are tested in accordance with the methods given in **F.1**, **F.2.1** and **F.2.2**, they shall withstand a test voltage of 7500 V, with the exception of the pilot cores in type 307S, which shall withstand 2500 V.

14.11.4 *Insulation resistance*

When cores are tested in accordance with the methods given in **F.1**, **F.2.1** and **F.2.3**, the insulation resistance between the conductor and the water in which the core is immersed shall be not less than the appropriate value given in table 44.

14.12 Tests on complete cable

14.12.1 *Conductor resistance*

The d.c. resistance at 20 °C shall not exceed the appropriate value given in tables 41 to 43.

14.12.2 *Resistance of earth conductor and screens*

The combined d.c. resistance of the earth conductor and the core screens in parallel at 20 °C shall not exceed the appropriate value given in table 44.

14.12.3 ***Voltage test***

All completed cables shall be subjected to the voltage test in accordance with **F.1** and **F.3.1**. All cores shall withstand a test voltage of 7500 V, with the exception of the pilot cores in type 307S, which shall withstand 2500 V.

14.12.4 ***Insulation resistance***

Immediately after completion of the voltage test (see **14.12.3**), the insulation resistance of all cores shall be measured in accordance with **F.1** and **F.3.2**. The insulation resistance shall be not less than the appropriate value given in table 44.

14.12.5 ***Test for flame propagation of single cable***

The finished cable shall conform to BS 4066 : Part 1 for tests under fire conditions.

Table 41. Constructional details of type 307 cable

Nominal cross-sectional area of conductor (mm^2)	power	25	35	50	70	95	120
	earth	25	35	35	50	50	70
	pilot	16	16	25	35	50	70
Conceptual number and diameter of wires in conductor (no./mm)	power	196/0.40	276/0.40	396/0.40	360/0.50	475/0.50	608/0.50
	earth[1)]	196/0.40	276/0.40	276/0.40	396/0.40	396/0.40	396/0.50
	pilot	126/0.40	126/0.40	196/0.40	276/0.40	396/0.40	396/0.50
Maximum diameter of wires in conductor (mm)	power	0.41	0.41	0.41	0.51	0.51	0.51
	earth	0.41	0.41	0.41	0.41	0.41	0.41
	pilot	0.41	0.41	0.41	0.41	0.41	0.51
Radial thickness of insulation (mm)	power	3.0	3.0	3.0	3.0	3.0	3.0
	pilot[2)]	3.0	3.0	3.0	3.0	3.0	3.0
Radial thickness of sheath (mm)		5.1	5.5	5.9	6.4	6.9	7.3
Overall diameter (mm)	min.	47.4	51.6	56.8	62.8	68.9	73.4
	max.	49.9	54.6	59.8	65.8	72.7	77.2
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	power	0.795	0.565	0.393	0.277	0.21	0.164
	pilot	1.24	1.24	0.795	0.565	0.393	0.277
Maximum resistance of earth and screens in parallel, per 1000 m of cable at 20 °C (Ω)	3 screens plus earth conductor in parallel	0.5	0.5	0.35	0.35	0.28	0.28
Minimum cross-sectional area of earth and screens in parallel (mm^2)[3)]	3 screens plus earth conductor in parallel	60	70	88	98	103	123
Area of earth and screens in parallel, expressed as a percentage of the largest current-carrying conductor (%)	3 screens plus earth conductor in parallel	240	200	175	140	108	103
Minimum conductivity[4)] of earth and screens in parallel, expressed as a percentage of the largest current-carrying conductor (%)	3 screens plus earth conductor in parallel	159	142	112	97	75	75

[1)] See **14.8.1**.

[2)] See **14.3**.

[3)] Design minimum, for information only.

[4)] See annex A.

Table 42. Constructional details of type 307M cable

Nominal cross-sectional area of conductor (mm^2)	power	25	35	50	70	95	120
	earth	25	25	35	50	50	70
	pilot	25	35	50	70	95	120
Conceptual number and (no./mm) diameter of wires in conductor	power	196/0.40	276/0.40	396/0.40	360/0.50	475/0.50	608/0.50
	earth[1)]	196/0.40	276/0.40	276/0.40	396/0.40	396/0.50	396/0.50
	pilot	196/0.40	276/0.40	396/0.40	360/0.50	475/0.50	608/0.50
Maximum diameter of wires (mm) in conductor	power	0.41	0.41	0.41	0.51	0.51	0.51
	earth	0.41	0.41	0.41	0.41	0.41	0.41
	pilot	0.41	0.41	0.41	0.51	0.51	0.51
Radial thickness of insulation (mm)	power	3.0	3.0	3.0	3.0	3.0	3.0
	pilot	3.0	3.0	3.0	3.0	3.0	3.0
Radial thickness of sheath (mm)		5.1	5.5	5.9	6.4	6.9	7.3
Overall diameter (mm)	min.	47.4	51.6	56.8	62.8	68.9	73.4
	max.	49.9	54.6	59.8	65.8	72.7	77.2
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	power	0.795	0.565	0.393	0.277	0.21	0.164
	pilot	0.795	0.565	0.393	0.277	0.21	0.164
Maximum resistance of earth and screens in parallel, per 1000 m of cable at 20 °C (Ω)	4 screens plus earth conductor in parallel	0.45	0.45	0.31	0.31	0.25	0.25
Minimum cross-sectional area of earth and screens in parallel (mm^2)[2)]	4 screens plus earth conductor in parallel	72	82	106	121	121	141
Area of earth and screens in parallel, expressed as a percentage of the largest current-carrying conductor (%)	4 screens plus earth conductor in parallel	288	243	212	173	127	117
Minimum conductivity[3)] of earth and screens in parallel, expressed as a percentage of the largest current-carrying conductor (%)	4 screens plus earth conductor in parallel	176	155	126	106	84	81

[1)] See **14.8.2**.

[2)] Design minimum, for information only.

[3)] See annex A.

Table 43. Constructional details of type 307S cable

Nominal cross-sectional area of conductor (mm^2)	power	50	70	95	120
	earth	50	50	50	70
	pilot	4	6	6	6
Conceptual number and diameter of wires in conductor (no./mm)	power	396/0.40	360/0.50	475/0.50	608/0.50
	earth[1)]	276/0.40	396/0.40	396/0.40	396/0.50
	pilot	56/0.30	84/0.30	84/0.30	80/0.40
Maximum diameter of wires in conductor (mm)	power	0.41	0.51	0.51	0.51
	earth	0.41	0.41	0.41	0.41
	pilot	0.31	0.31	0.31	0.41
Radial thickness of insulation (mm)	power	3.0	3.0	3.0	3.0
	pilot	1.4	1.5	1.5	1.5
Radial thickness of sheath (mm)		5.9	6.4	6.9	7.3
Overall diameter (mm)	min.	56.8	62.8	68.9	73.4
	max.	59.8	65.8	72.7	77.2
Maximum conductor resistance per 1000 m of cable at 20 °C (Ω)	power	0.393	0.277	0.21	0.164
	pilot	5.09	3.39	3.39	1.95
Maximum resistance of earth and screens in parallel, per 1000 m of cable at 20 °C (Ω)	3 screens plus earth conductor in parallel	0.35	0.35	0.28	0.28
Minimum cross-sectional area of earth and screens in parallel (mm^2)[2)]	3 screens plus earth conductor in parallel	88	103	103	123
Area of earth and screens in parallel, expressed as a percentage of the largest current-carrying conductor (%)	3 screens plus earth conductor in parallel	175	147	108	103
Minimum conductivity[3)] of earth and screens in parallel, expressed as a percentage of the largest current-carrying conductor (%)	3 screens plus earth conductor in parallel	112	97	75	75

[1)] See **14.8.2**.

[2)] Design minimum, for information only.

[3)] See annex A.

Table 44. Insulation resistance

Nominal cross-sectional area of conductor	Minimum insulation resistance per 1000 m at 20 °C			
	Pilot cores		Power cores	
	FR1	GP4	FR2	GP5
mm^2	MΩ	MΩ	MΩ	MΩ
4[1)]	600	760	—	—
6[1)]	530	670	—	—
10[1)]	440	560	—	—
16	575	750	1150	1500
25	490	625	980	1250
35	425	550	850	1100
50	370	475	740	950
70	315	410	630	820
95	275	360	550	720
120	255	330	510	660

[1)] Pilot cores for type 307S.

Annexes

Annex A (informative)

Approved codes of practice and conductivities

The conductivity (expressed as a percentage) of earthing or reference conductors in flexible cables should be not less than that of the largest conductor in the cable (100 %). The exception to this is that for cables operating in power systems where the maximum fault current is restricted, a lower conductivity may be utilized, providing that safety is not less than if an equivalent unrestricted system is in operation. However, the lower conductivity should be a minimum of 50 %.

For more details on conductivities of earthing or referencing conductors in flexible cables, refer to the approved codes of practice, *The use of electricity in mines* (COP 34) [2] and *The use of electricity at quarries* (COP 35) [3], and tables 3 to 9, 14 to 20, 24, 26 to 28, 31, 33, 35, 38 and 41 to 43.

The cables listed in table A.1 have conductivities of between 50 % and 99 % made up as indicated; all other cables have conductivities equal to or in excess of 100 %.

Annex B (informative)

Recommended current ratings

Recommended current ratings are given in tables B.1 and B.2

The recommended current ratings are based on the following:

a) an ambient temperature of not greater than 25 °C;

b) intermittent ratings assuming the conditions of load are not more severe than in the following sequence:

1) full current for 40 min;

2) no current for 10 min to 15 min;

3) half current for 40 min;

4) no current for 10 min to 15 min;

5) the above cycle (items 1) to 4)) repeated.

NOTE 1. Voltage drop considerations and protection systems may require use of a larger size conductor.

NOTE 2. The ratings are not applicable to cables wound on drums or to cables in a coiled or partly coiled configuration. In all such cases the cable manufacturer should be consulted.

Examples of the effect of voltage drop are given in table B.4. With the current given, the voltage drop may be large, e.g. for a type 506 cable carrying 16 A in a single phase circuit, the voltage drop is 0.55 V/m. A drop of 1 V every 2 m may be acceptable with short cable runs but with longer runs and with low voltage circuits the voltage drop may be the critical parameter.

Table A.1 Cables with conductivities of between 50 % and 99 %

Cable type	Construction	Nominal cross-sectional area mm^2
7	3 screens plus reduced earth	50, 70, 95 and 120
7M	4 screens plus reduced earth	95 and 120
7S	3 screens plus reduced earth	50, 70, 95 and 120
16	3 screens plus 2 reduced earth	50 and 95
FS4	1 screen	4
201	3 screens plus GSS armour	50, 70, 95 and 120
307	3 screens plus reduced earth	70, 95 and 120
307M	3 screens plus reduced earth	95 and 120
307S	3 screens plus reduced earth	70, 95 and 120
630	3 screens plus GSS armour	70, 95, 120 and 150
730	3 screens plus earth	50, 70, 95, 120 and 150
830	3 screens plus earth	50, 70, 95, 120 and 150

NOTE. Reference should be made to the Health and Safety Executive and the relevant code of practice if any of the above cables are used, as a special installation procedure may be required.

Table B.1 Current ratings of cables of clauses 6, 7, 9, 10, 11, 12, 13 and 14

Nominal area of conductor	**Current rating of cables of type**						
	Continuous					**Intermittent**	
	7, **7M**, **7S**, **11**, **14**, **16**, **FS4** (clause **6**), **307**, **307M**, **307S** (clause **14**)	**62**, **63**, **64**, **70**, **71** (clause **7**)	**20**, **21**, **201**, **211**, **321**, **331** (clause **7**)	**621**, **630**, **631**, **730**, **830**[1] (clauses **9, 12** and **13**)	**43**, **44**[2] (clauses **10** and **11**)	**7**, **7M**, **7S**, **11**, **14**, **16**, **FS4** (clause **6**), **307**, **307M**, **307S** (clause **14**)	
						0.6/1.0 kV	**1.9/3.3 kV**
mm^2	A	A	A	A	A	A	A
2.5	28	—	28	—	—	—	—
4	37	28	37	—	—	—	—
6	46	—	46	—	46	—	—
	63	—	63	—	—	—	—
16	85	—	85	—	—	96	—
25	110	—	110	—	—	125	130
35	135	—	135	135	—	150	155
50	170	—	170	170	—	200	210
70	205	—	205	205	—	250	255
95	250	—	250	250	—	310	315
120	295	—	295	295	—	355	360
150	—	—	320	320	—	—	—

[1] 3-phase a.c.

[2] Maximum conductor temperature 75 °C.

NOTE. For higher ambient temperatures, the ratings should be reduced by the factors given in table B.3.

Table B.2 Current ratings for cables of clause 8

Cable type	**Nominal area of conductor** mm^2	**Continuous current rating**[1] A
506	1.34	16
512	1.34	13
518	1.34	11
524	0.93	8

[1] Maximum conductor temperature 75 °C.

Table B.3 Current de-rating factors

Ambient temperature °C	**De-rating factor**
30	0.93
35	0.87
40	0.80
45	0.73
50	0.66
55	0.57
60	0.48

Table B.4 Voltage drop and current rating

Cable type	**Current rating at 24 V** A	**Voltage drop per metre, d.c. or single phase a.c.** mV/A	**Voltage drop per metre, 3-phase a.c.** mV/A
506	16	34	30
512	13	34	30
518	11	34	30
524	8	50	43

Annex C (informative)

Short circuit current carrying capability of flexible cable screens

Examples of short circuit current ratings with earth fault path are given in table C.1. The basis for the calculations is given in IEC 724 : 1984. All conductor area values are nominal and screen area values are tabulated whole numbers. Temperature limits for conductors are 75 °C to 250 °C and for screens 65 °C to 200 °C.

Table C.1 Short circuit current ratings

Cable type	Conductor area mm^2	Screen area mm^2	1 s short circuit A
Types 7, 7S	16	41.4	2420[1)]
3-screens and earth	25	41.4	3780[1)]
	35	43.4	5300[1)]
	50	58	7560[1)]
	70	68	9350
	95	100	13600
	120	100	13600
Type 7M	16	49.9	2420[1)]
4-screens and earth	25	49.9	3780[1)]
	35	62.1	5300[1)]
	50	69.1	7560[1)]
	70	85.9	10600[1)]
	95	117.9	14350[1)]
	120	117.9	16250
Type 11	16	33.9	2420[1)]
4-screens			
Types 14, 16	25	25.4	3450
3-screens	35	25.4	3450
	50	33	4550
	70	35	4820
	95	53	7300
Type 44	6	11	908[1)]
3-screens			
Type 62	4	7.5	605[1)]
2-screens			
Type 63	4	11.2	605[1)]
3-screens			
Type 64	4	15	605[1)]
4-screens			
Types 201, 211	10	17.8	1510[1)]
3-screens	16	25.4	2420[1)]
	25	25.4	3500
	35	25.4	3500
	50	33	4550
	70	33	4550
	95	50	6890
	120	50	6890
Type 331	25	25.4	3500[1)]
3-screens	35	25.4	3500
	50	33	4550
	70	33	4500
	95	50	6890
	120	50	6890

Table C.1 Short circuit current ratings *(continued)*

Cable type	**Conductor area** mm^2	**Screen area** mm^2	**1 s short circuit** A
Types 630	35	50.8	5300[1)]
3-screens	50	50.8	7000
	70	50.8	7000
	95	50.8	7000
	120	66	9100
	150	75	10340
Type 730	35	50.8	5300[1)]
3-screens and earth	50	50.8	7000
(when specified)	70	50.8	7000
	95	50.8	7000
	120	82	11300
	150	91	12540
Type 631	50	50.8	7000
3-screens	70	50.8	7000
Type 830	50	66	7560[1)]
3-screens and earth	70	66	9100
(when specified)	95	66	9100
	120	76	10480
	150	92	12680
Type FS4	2.5	10.6	378[1)]
4-screens	4	9.2	605[1)]
307	25	60	3780[1)]
	35	60	5295[1)]
	50	88	7560[1)]
	70	88	10590[1)]
	95	103	14200
	120	103	14200
307M	25	72	3780[1)]
	35	72	5295[1)]
	50	106	7560[1)]
	70	106	10590[1)]
	95	121	14370[1)]
	120	121	16685
307S	50	88	7560[1)]
	70	88	10590[1)]
	95	103	14200
	120	103	14200

[1)] Rating is limited by the capacity of the conductor.

Annex D (normative)

Measurement of insulation and sheath thickness

D.1 Measurement of insulation thickness

Take a 300 mm length of core, not less than 300 mm from the end of a manufacturing length, and obtain three samples from this, separated by at least 80 mm.

Cut the insulation with a sharp knife along a plane perpendicular to its axis and place it under a measuring microscope or in a profile enlarger of at least × 10 magnification, the plane of the cross section being perpendicular to the optical axis.

Use measurements taken with a microscope accurate to within 0.01 mm as the reference method in case of dispute.

Make six measurements of radial thickness on each piece of insulation at places where the insulation is thin, i.e. between the ridges caused by the strands, and as far as possible at equally-spaced intervals around the circumference. In all cases, make the first measurement at the place where the insulation is thinnest (see figure D.1).

In order to eliminate the influence of any irregularities in the outer surface that may be due to the presence of proofed tape, position the point of intersection of the cross-wires of the measuring microscope as shown in figure D.2.

Take the mean of the 18 values obtained on the three pieces of insulation, calculated to two decimal places and rounded off to one, as the mean value of insulation thickness. (That is, round off 1.74 to 1.7 and 1.75 to 1.8, etc.)

Regard the smallest of the 18 values obtained as the minimum thickness of insulation at any one place.

D.2 Measurement of sheath thickness

Remove a 300 mm length of sheath not less than 300 mm from the end of a manufacturing length and take three samples from this, separated by at least 80 mm.

Cut the sheath with a sharp knife along a plane perpendicular to the axis of the cable and place it under a measuring microscope or in a profile enlarger of at least × 10 magnification, the plane of the cross-section being perpendicular to the optical axis.

Use measurements taken with a microscope accurate to within 0.01 mm as the reference method in case of dispute.

If the sheath shows grooves caused by the cores, take the measurements in as many places as there are cores, at places where the sheath is thin, i.e. at the deepest part of the grooves (see figure D.3). If the sheath has no grooves, take six measurements, as far as possible equally spaced around the circumference. In either case, take the first measurement at the place where the sheath is thinnest.

For type FS4 cable, make two measurements approximately parallel to the minor axis at the position of each of the cores where the insulation is thinnest, and one measurement approximately parallel to the major axis at the position of each of the outer cores where the insulation is thinnest (see figure D.4).

Eliminate the influence of any unevenness, e.g. caused by tape, by positioning the cross-wires of the microscope as shown in figure D.5.

Take the mean of the 18 values obtained on the three pieces of insulation, calculated to two decimal places and rounded as in **D.1**, as the mean value of insulation thickness.

Regard the smallest of all the values obtained as the minimum thickness of the sheath at any one place.

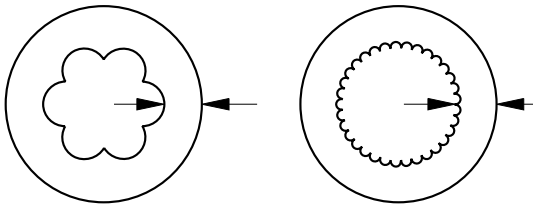


Figure D.1 Position for first measurement of insulation thickness

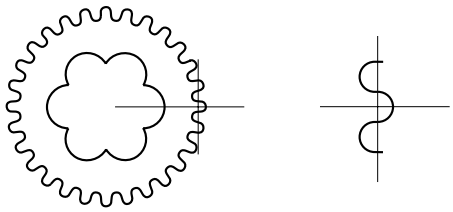


Figure D.2 Positions of point of intersection of the cross-wires of the measuring microscope

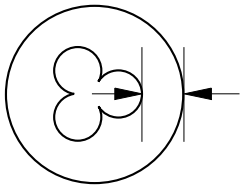


Figure D.3 Position for measurement of sheath thickness

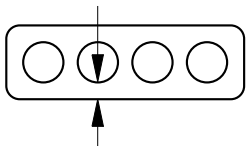


Figure D.4 Position for measurement of sheath thickness for type FS4 cable

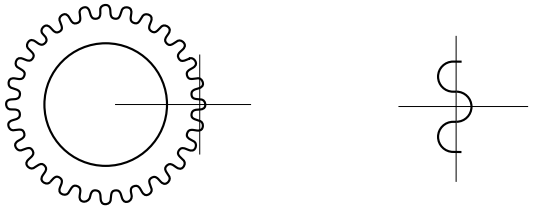


Figure D.5 Position of point of intersection of the cross-wires of the measuring microscope

Annex E (normative)

Protective screens: form, method of application and material

E.1 Wire and synthetic fibre braids

E.1.1 ***Cable types: 7, 7M, 7S, 11, 14, 16, 201, 211, 331, 630, 631, 730, 830, 307, 307M, 307S***

The screen shall consist of a number of strands of 15/0.30 mm, 13/0.30 mm, 10/0.30 mm or 7/0.30 mm tinned annealed copper wires, as follows:

a) the 15/0.30 mm strands shall be bunched with a lay length not exceeding 180 mm;

b) the 13/0.30 mm strands shall be bunched with a lay length not exceeding 120 mm;

c) the 10/0.30 mm strands shall be bunched with a lay length not exceeding 90 mm;

d) the 7/0.30 mm strands shall be bunched or stranded, with a lay length not exceeding 40 mm.

E.1.2 ***Cable types 44, 62, 63, 64 and FS4***

The screen shall consist of a number of strands of 10/0.20 mm tinned annealed copper wires. The strands shall be bunched with a lay length not exceeding 40 mm.

E.1.3 ***Application***

The screen strands shall be applied in the form of a braid in which all the copper strands are applied from spindles rotating in the same direction. In the opposite direction and from an equal number of spindles, synthetic fibre yarns of either polyamide or polyethylene terephthalate shall be applied.

Each of the fibrous members shall be not less than 210 denier 6 ends yarn or equivalent. The copper strands shall be applied with a right hand lay or left hand lay at the manufacturer's discretion. The lay ratio of the braid (length of lay divided by pitch diameter) shall be within the limits of 2 and 4.5.

For the copper components of the braid, the number of spindles and the strands per spindle shall be chosen in order to provide a filling factor of not less than 0.8, where:

$$\text{Filling factor} = \frac{mnd}{\pi D}\left(1 + \frac{\pi^2 D^2}{L^2}\right)^{\frac{1}{2}}$$

where

D is the mean diameter of braid (in millimetres);

d is the effective width of strand (in millimetres);

L is the length of lay of braid (in millimetres);

m is the number of spindles (copper only);

n is the number of screen strands per spindle.

There shall be no joints in the completed braid. If renewal of spindles is necessary, the ends shall be brought out of, and cut off flush with, the braid. There shall be not more than one spindle renewal in any metre length of core.

NOTE. The effective width and radial thickness of the braids are given in table E.1.

E.2 All wire braids for cable types 506, 512, 518 and 524

The screen shall consist of tinned annealed copper wire of 0.1 mm diameter. The number of spindles and ends per spindle shall be chosen so as to provide a filling factor of not less than 0.50, where:

$$\text{Filling factor} = \frac{mnd_{\text{w}}}{2\pi D}\left(1 + \frac{\pi^2 D^2}{L^2}\right)^{\frac{1}{2}}$$

where

D is the mean diameter of braid (in millimetres);

d_{w} is the diameter of braiding wire (in millimetres);

L is the length of the lay of braid (in millimetres);

m is the total number of spindles;

n is the number of ends per spindle.

The lay length of the braiding wires shall be not greater than $9D$ and not less than $6D$.

There shall be no joints in the completed braid. If renewal of spindles is necessary, the ends shall be brought out of, and cut off flush with, the braid. There shall be not more than one spindle renewal in any 300 mm length of core.

Table E.1 Protective screen braid thickness and width				
Clause reference	**Cable type**	**Stranding** mm	**Effective width** mm	**Radial thickness** mm
6	7, 7M,	15/0.30	2.1	1.0
	7S, 11,	13/0.30	1.8	1.0
	14, 16	10/0.30	1.4	1.0
		7/0.30	0.9	1.0
	FS4	10/0.20	0.9	0.6
3	62, 63	10/0.20	0.9	0.6
	64			
	201, 211,	15/0.30	2.1	1.0
	331	13/0.30	1.8	1.0
		10/0.30	1.4	1.0
		7/0.30	0.9	1.0
9	630, 631	15/0.30	2.1	1.0
		13/0.30	1.8	1.0
		10/0.30	1.4	1.0
		7/0.30	0.9	1.0
10	44	10/0.20	0.9	0.6
12	730	15/0.30	2.1	1.0
		13/0.30	1.8	1.0
		10/0.30	1.4	1.0
		7/0.30	0.9	1.0
13	830	15/0.30	2.1	1.0
		13/0.30	1.8	1.0
		10/0.30	1.4	1.0
		7/0.30	0.9	1.0
14	307,	15/0.30	2.1	1.0
	307M,	13/0.30	1.8	1.0
	307S	10/0.30	1.4	1.0
		7/0.30	0.9	1.0

Annex F (normative)
Voltage and insulation resistance tests

F.1 General

Carry out the voltage tests at room temperature, with alternating voltage at a frequency in the range 49 Hz to 61 Hz, and a waveform approximating to a sine curve, the ratio of peak value/r.m.s. value at $\sqrt{2}$ with a tolerance of $\pm$ 7 %.

F.2 Tests on cores

F.2.1 *General*

Carry out the voltage test after the core has been immersed in water for not less than 12 h and immediately follow the test with the insulation resistance test. Carry out both tests while the core is still immersed.

F.2.2 *Voltage test*

Apply the specified test voltage between the conductor and the water, which is earthed and in which the core is immersed. Gradually increase the voltage and maintain it at the full value for 5 min without breakdown of the insulation.

F.2.3 *Insulation resistance test*

Immediately after completion of the voltage test described in **F.2.2**, measure the insulation resistance between the conductor and the water in which the core is immersed. In cases of dispute, control the temperature of the water in which the core is immersed at (20 $\pm$ 1) °C.

Measure the insulation resistance after electrification for 1 min with direct current, at between 300 V and 500 V.

F.3 Tests on complete cables

F.3.1 ***Voltage test***

Subject each conductor of a completed cable to a test at the specified voltage, without immersion in water.

Apply the test voltage between each insulated conductor and each other conductor in the cable, bonded to earth, and then the screens and armour, bonded to earth.

F.3.2 ***Insulation resistance test***

Immediately on completion of the voltage test (**F.3.1**), measure the insulation resistance between each insulated conductor and each other conductor in the cable, and the screens and armour, all bonded to earth.

Make the measurement of insulation resistance after electrification for 1 min with direct current between 300 V and 500 V.

Annex G (normative)

Tests for galvanized steel wire taken from completed cables

G.1 Armour wire diameter

Take ten wires or 10 % of the total number of wires, whichever is the smaller, at random from one sample of completed cable. Determine the diameter of each wire with a micrometer by taking two measurements at right angles to each other. Take the average of all the measurements as the wire diameter.

G.2 Mass of zinc coating

Take ten wires or 10 % of the total number of wires, whichever is the smaller, at random from one sample of completed cable. Determine the mass of zinc coating of the wires using either the gravimetric or gas volumetric method described in clause **8** of BS 443 : 1982. Take the average of all the measurements as the mass of coating.

G.3 Wrapping test

Take ten wires or 10 % of the total number of wires, whichever is the smaller, at random from one sample of completed cable. Wrap each wire round a cylindrical mandrel for one complete turn. The ratio of the mandrel diameter to wire diameter shall be four.

Annex H (normative)

Electrical test for conducting elastomeric screen for type 43 cable

H.1 General

Take a sample of cable at least 300 mm from the end of a manufacturing length. Apply a test voltage of 70 V a.c. between a power conductor and the earth conductor with a series resistance of 225 Ω connected in the test circuit. The test voltage shall have a frequency in the range 49 Hz to 61 Hz and a waveform approximating to a sine curve, the ratio of peak value/r.m.s. value at $\sqrt{2}$ with a tolerance of $\pm$ 7 %.

Create a fault by inserting a 0.9 mm bare steel needle through the outer sheath of the cable, through the conducting elastomeric screen and into each power conductor in turn. Record the leakage current created by each fault, either:

a) from the instant the needle makes contact with the power conductor; or

b) if the needle is inserted before the test voltage is applied, from the instant the voltage is switched on.

H.2 Additional tests

If the results obtained in accordance with **H.1** do not conform to **11.14**a, carry out two further tests on each of the three cores at approximately 150 mm and 300 mm from the point of original measurement.

List of references (see clause 2)

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 443 : 1982	*Specification for testing zinc coatings on steel wire and for quality requirements*
BS 4066 :	*Tests on electric cables under fire conditions*
BS 4066 : Part 1 : 1980	*Method of test on a single vertical insulated wire or cable*
BS 4727 :	*Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms*
BS 5099 : 1992	*Specification for spark testing of electric cables*
BS 6360 : 1991	*Specification for conductors in insulated cables and cords*
BS 7655 :	*Specification for insulating and sheathing materials for cables*
BS 7655 : Part 1 :	*Elastomeric insulating compounds*
BS 7655 : Section 1.2 : 1993	*General 90 °C application*
BS 7655 : Section 1.5 : 1993	*Flame retardant composites*
BS 7655 : Part 2 :	*Elastomeric sheathing compounds*
BS 7655 : Section 2.1 : 1993	*Harmonized types*
BS 7655 : Section 2.3 : 1993	*General application*
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