TABLE 6
THICKNESS OF EXTRUDED SEMICONDUCTIVE INSULATION SCREEN

millimetres

Calculated diameter over insulation		Average thickness* of extruded screen
Above	Up to and incl.	
—	25	0.8
25	35	1.0
35		1.2

* See Clause 8.2.2 for thickness of thermoplastic insulation screen without outer semiconductive tape and incorporating wire screen.

11 FILLERS, BINDERS, SEPARATION TAPES AND ARMOUR BEDDING.

11.1 Material. Fillers, binders and separation tapes shall be of a substantially non-hygroscopic material.

The armour bedding shall be an extruded impervious layer of non-conductive material.

The above materials shall be compatible with the other materials of the cable with which they are in contact.

11.2 Maximum Operating Temperature. Fillers, binders, separation tapes and bedding shall be capable of operating without being adversely affected, when the cable is maintained at its maximum permitted temperature conditions as specified in Clause 4.

11.3 Armour Bedding Thickness. The thickness of the armour shall be in accordance with Clause 11.5 of AS 3147.

12 ARMOUR.

12.1 Material. Armouring for multicore cables shall be of galvanized mild steel wires, or galvanized interlocked steel tape armour.

Galvanized mild steel wires shall comply with BS 1442.

NOTE: It may be desirable for single-core cables intended for use on a.c. circuits to be armoured with non-magnetic material. In such cases special arrangements should be made between the purchaser and the manufacturer.

12.2 Application. The armour shall be applied over bedding complying with the requirements of Clause 11.

12.3 Dimensions of Wire and Tape. The nominal diameter of the armour wire, and the nominal width (before profiling) and thickness of tape for interlocked steel tape armour shall be not less than the appropriate values given in Tables 3 and 5 in AS 3147.

12.4 Wire Armour. Wire armour shall be closely applied, i.e. with a minimum gap between adjacent wires. Where double-wire armour is used, a separator comprising a single layer of suitable material shall be applied between the concentric layers of armour. For single-wire armour, the direction of lay shall be opposite to that of the cores. For double wire armour, the direction of lay of the innermost layer shall be opposite to that of the cores and the direction of lay of the outermost layer shall be the same as that of the cores.

12.5 Interlocked Steel Tape Armour. Interlocked steel tape armour shall consist of galvanized steel tape applied helically and profiled so that each successive turn interlocks. The steel tape shall have a tensile strength in the range of 300 MPa to 450 MPa. The direction of lay of the tapes shall be opposite to that of the cores.

13 SHEATH.

13.1 Material. The sheath shall consist of a PVC waterproof compound or PE compound or other suitable compound approved by the purchaser that complies with the requirements of Tables 7A and 7B respectively.

NOTE: If a termite barrier is required this may be an extrusion of Nylon 11 or 12 or double copper, brass or stainless steel tapes suitably placed in the cable construction.

13.2 Colour. The preferred colour for sheaths is black.

13.3 Application. The sheath shall be close fitting and be readily removable. For a PVC sheath, applied over a wire screen, a non-hygroscopic barrier tape shall be interposed.

13.4 Criteria. The sheath taken from the finished cable, when subjected to the tests set out in Table 7A or 7B, shall have properties not inferior to the appropriate values specified in Table 7A or 7B.

13.5 Tests. All tests shall be made in the order set down in Table 7A and 7B. The category of each test shall be as specified in Table 7A or 7B.

13.6 Thickness. When determined by the method specified in Clause 2.5 of AS 1660.3, the average thickness of sheath shall be not less than the thickness calculated from the formula given below and the minimum thickness at any point shall not fall below the calculated thickness (t_s) by more than —

15 percent of the thickness (t_s) plus 0.1 mm, i.e. ($0.15t_s + 0.1$ mm)

The thickness of sheath (t_s) shall be calculated from the formula —

$$t_s = 0.035DP + 1.0 \text{ mm}$$

where DP = fictitious diameter under sheath, in millimetres (see Appendix A to AS 3147).

The calculated value of t_s shall then be rounded off to one place of decimals and is subject to a minimum value of 1.4 mm for single-core cables and 1.8 mm for 3-core cables.

13.7 High Voltage Spark Test. The sheath shall be subjected to a spark test in accordance with Table 8, normally during manufacture.

TABLE 7A

TESTS AND CRITERIA FOR OUTER SHEATHS OF PVC MATERIAL

1	2	3	4	5
Test	Criteria	Criteria	Category of test	Reference for test method
	V-75* Sheath	V-90 Sheath		
A. *Mechanical tests without ageing on conditioned specimens*				
1. Tensile strength (Mpa minimum)	12.5	12.5	Type	AS 1660.2.3
2. Elongation at rupture (percent minimum)	150	150	Type	AS 1660.2.3
B. *Mechanical tests after ageing in air oven*				
Duration and temperature of ageing	168 h at 80 ± 2°C	168 h at 100 ± 2°C	Type	AS 1660.2.3
1. Tensile strength (variation percent maximum)†	~~12.5~~ ± 20	~~12.5~~ ± 25		
2. Elongation at rupture (variation percent maximum)†	~~150~~ ± 20	~~150~~ ± 20	Type	AS 1660.2.3
C. *Loss of mass test* Mean loss in mg per cm² of exposed surface of specimen (maximum)	2	2	Type	AS 1660.2.3‡
D. *Thermal deformation test* Reduction in sheath thickness (percent maximum)	40	40	Type	AS 1660.2.3
E. *Heat shock test*	The sheath shall show no sign of cracking either when initially wound on the mandrel or after the test		Special	AS 1660.2.3
F. *Flexibility test*	The sheath shall show no sign of cracking		Special	AS 1660.2.3

* For use with PE insulated cables only.

† Variation percent is the difference between the median value obtained after ageing and the median value obtained without ageing, expressed as a percentage of the latter.

‡ Test method under consideration.

TABLE 7B

TESTS AND CRITERIA FOR OUTER SHEATHS OF LDPE MATERIAL

1	2	3	4
Test	Criteria for LDPE sheath*	Category of test	Reference for test method
Melt flow index (g/600 s)	0.5 (max.) 0.1 (min.)	Type	AS 1049
Tensile strength (MPa minimum)	10	Type	AS 1049
Elongation at rupture (percent minimum)	350	Type	AS 1049
Environmental stress crack resistance hours failure rate	 96 F_0†	Type	Appendix D herein
Polyisobutylene or butyl rubber content (percent maximum)	8	Type	AS 1049
Carbon black content (percent minimum)	2	Type	AS 1049

* For use with PE insulated cables only.

† F_0 is the failure rate for 0 out of 10 samples.

TABLE 8

TESTS — CRITERIA, CATEGORY AND REFERENCE

1	2	3		4	5
Test No	Test	Criteria		Category of test	Reference for test method
1	All appropriate tests conductors taken from the cable	As specified in AS 1125 for the appropriate conductor			
2	All appropriate tests on insulation taken from the cable	As specified in Table 2 herein for the appropriate insulant			
3	All appropriate tests on non-metallic sheath taken from the cable	As specified in Table 7A and 7B herein for the appropriate sheath			
4	Conductor examination and resistance	The conductor dimensions, form, material and resistance shall comply with the appropriate requirements in AS 1125		Routine	AS 1660.3.2
5	The following tests on conductor screen taken from the cable or laboratory prepared samples:				
	(a) Measurement of volume resistivity	Volume resistivity 500 Ω.m max. at maximum normal operation temperature of cable insulation.		Type	Clause 15.4 herein
	(b) Measurement of thickness	As specified in Clause 6.2		Special	AS 1660.3.2
	(c) Elongation at rupture after ageing Duration and temperature of ageing percent minimum	*For cable with PE insulation:* 48 h at 100 ± 2°C 100	*For cable with EPR or XLPE insulation:* 168 h at 100 ± 2°C 100	Type	AS 1660.2
	(d) Projections or irregularities between conductor screen and insulation	The contact surface between the conductor and insulation shall have no projections or irregularities which protrude more than 0.25 mm into the insulation		Special	Appendix G
6	The following tests on insulation taken from the cable				
	(a) Measurement of insulation thickness	The nominal and minimum radial thickness of insulation shall comply with the requirements of Clause 7.3 herein		Special	AS 1660.3.2
	(b) Dimensional stability	The protrusion of the conductor shall not exceed 4 mm at either end of the specimen		Special	Appendix E
	(c) Determination of — size of voids; size of contaminants For PE and XLPE insulation only — size of translucents; number of voids; number of contaminants	Voids ≤ 0.08 mm Contaminants ≤ 0.15 mm Translucents ≤ 1.25 mm Voids ≤ 30 per cm³ Contaminants ≤ 15 per cm³		Special	Appendix G
7	The following tests on extruded semiconductive insulation screen:				
	(a) Measurement of volume resistivity	Volume resistivity 500 Ω.m max. at rated temperature of cable insulation		Type	Clause 15.4 herein
	(b) Strippability for hand-strippable extruded screen	Length of semiconductive material to peel cleanly from insulation 300 mm		Special	
	(c) Adhesion test for hand-strippable extruded screen	Required force to remove 12 mm wide strips shall be not less than 18 N and not more than 90 N for thermoplastic nor more than 125 N for thermoset screens. The screen shall be removable without damaging the insulation, leaving no semiconductive material which cannot be readily removed		Special	Clause 15.4 herein
	(d) Measurement of thickness	As specified in Clause 8.2 herein		Special	AS 1660.3 and to Clause 15.4 herein
8	Measurement of thickness of armour bedding	As specified in Clause 11.3 herein		Special	AS 1660.3

continued

TABLE 8 — *continued*

1	2	3			4	5
Test No	Test	Criteria			Category of test	Reference for test method
9	Measurement of thickness of sheath	As specified in Clause 13.6 herein			Special	AS 1660.3.2
10	A.C. spark test on sheath	The sheath shall withstand the following a.c. voltage (d.c. equivalent voltages may be used): (a) Unarmoured cable, 10 kV/mm sheath thickness with a maximum applied voltage 25 kV (b) Armoured cable, 6 kV/mm sheath thickness			Routine	
11	Insulation resistance measurement of completed cable at room temperature	The insulation resistance constant K_1 at 20°C shall be at least equal to the appropriate value specified below: PE insulant: 36 700 G Ω.m XLPE insulant: 36 700 G Ω.m EPR insulant: 3 670 G Ω.m			Special	AS 1660.3.2
12	Insulation resistance measurement at elevated temperature	The insulation resistance constant K_1 at the maximum normal conductor operating temperature rating of the insulant ± 3°C (as specified below) shall be at least equal to the appropriate value specified below: PE insulant: 3670 G Ω.m XLPE insulant: 36.7 G Ω.m EPR insulant: 3.67 G Ω.m			Type	AS 1660.3.2
13	Partial discharge test	Magnitude of discharge at voltage value given in columns 2 and 3, Table 9 — not more than 20 pC or 5 pC respectively			Routine	Clause 15.5 herein
14	High voltage a.c. test for 1 min, on armour bedding	6 kV per mm of thickness to be applied between the metallic screen and the armour — no breakdown shall occur NOTE: By agreement between purchaser and manufacturer, d.c. equivalent voltages may be used			Routine	
15	High voltage a.c. test for 5 min	No breakdown of the insulation shall occur NOTE: By agreement between purchaser and manufacturer, d.c. equivalent voltages may be used			Routine	Clause 15.6 herein
16	Bending test plus partial discharge test (see Note 1)	At completion of bending test, magnitude of partial discharge at voltage value given in columns 2 and 3, Table 9 — not more than 20 pC or 5 pC respectively			Type	Clause 15.7 herein
17	Tan δ measurement as a function of the voltage and capacitance measurement at ambient temperature (see Note 2): (a) Max. tan δ at U_o (b) Max. increment of tan δ between 0.5 U_o and 2 U_o		*PE*	*XLPE*	*EPR*	Type	Clause 15.8 herein
			10×10^{-4}	40×10^{-4}	200×10^{-4}		
			20×10^{-4}	20×10^{-4}	25×10^{-4}		
18	Tan δ measurement as a function of the temperature at 2 kV (see Note 3): (a) Max. tan δ at ambient temperature (b) Max. tan δ at rated temperature (see Note 4)		*PE*	*XLPE*	*EPR*	Type	Clause 15.9 herein
			10×10^{-4}	40×10^{-4}	200×10^{-4}		
			10×10^{-4}	80×10^{-4}	400×10^{-4}		
19	Heating cycle plus partial discharge test (see Note 5)	At completion of third heating cycle magnitude of partial discharge at voltage value given in columns 2 and 3, Table 9 — not more than 20 pC or 5 pC respectively			Type	Clause 15.10 herein

NOTES: See page 13.

continued

TABLE 8 — *continued*

1	2	3	4	5
Test No	Test	Criteria	Category of test	Reference for test method
20	Impulse withstand test followed by a high voltage a.c. test for 15 min (see Note 6)	No breakdown of the insulation shall occur	Type	Clause 15.11 herein
21	High voltage a.c. test for 4 h	No breakdown of the insulation shall occur	Type — up to and including 3.8/6.6 kV Special — above 3.8/6.6 kV	Clause 15.12 herein
22	High voltage d.c. test after installation	No breakdown of the insulation shall occur	Installation	Clause 17 herein

NOTES:
1. Applicable to PE and XLPE cables of designated voltage above 1.9/3.3 kV and EPR insulated cables of designated voltage above 3.8/6.6 kV.
2. Applicable to cables of designated voltages 6.35/11 kV and above.
3. Applicable to cables of designated voltages 6.35/11 kV and above.
4. The value of maximum normal operation conductor temperature are given in Table 1 herein.
5. Applicable to PE and XLPE cables of designated voltage above 1.9/3.3 kV and EPR insulated cables of designated voltage above 3.8/6.6 kV.
6. Applicable to cables of designated voltage above 3.8/6.6 kV.

14 CABLE MARKING.

14.1 End Markings. The ends of each drum length of 3-core cable shall be —

(a) coloured red, at the end where the core sequence 'one, two, three or red, white, blue' is clockwise; and

(b) coloured green at the end where the core sequence 'one, two, three or red, white, blue' is anticlockwise.

14.2 Cable Identification.

14.2.1 *Information.* The PVC sheath shall be embossed or indented with the manufacturer's identification and the year of manufacture, together with the information shown below, as appropriate:

Voltage designation	*Cable marking*
1.9/3.3 kV	Electric Cable 1.9/3.3 kV
3.8/6.6 kV	Electric Cable 3.8/6.6 kV
6.35/11 kV	Electric Cable 6.35/11 kV
12.7/22 kV	Electric Cable 12.7/22 kV
19/33 kV	Electric Cable 19/33 kV

In addition to the marking specified above, XLPE and EPR insulated cables shall include the temperature rating '90°C'.

The letters and figures shall be raised or recessed and shall consist of upright block characters arranged along two or more lines approximately equally spaced around the circumference of the cable. The size of the letters and numerals shall be not less than 15 percent of the nominal overall diameter of the cable but in no case less than 3 mm or greater than 13 mm. The gap between the end of one set of embossed characters and the beginning of the next shall be not greater than 500 mm.

14.2.2 *Identification tape.* For other than PVC sheathed cables, the information shall be printed on a tape at intervals not greater than 300 mm and included under the sheath throughout the length of the cable.

15 TESTS.

15.1 General. Cable shall comply with the tests specified in this Clause 15.

The tests shall be performed at room temperature unless otherwise specified.

The tests specified for cables manufactured to this standard are listed in column 2 of Table 8. Column 5 of Table 8 gives the reference for the actual test method.

The criteria for each test shall be as specified in column 3 of Table 8.

The category of each test shall be as specified in column 4 of Table 8 (refer to Clause 2 for definitions of 'type', 'routine' and 'special' tests).

Special tests shall be made by agreement between the purchaser and manufacturer (the frequency as in Appendix F herein). Sampling procedures for special tests are specified with test methods in AS 1660.2.

15.2 Selection of Samples. Test numbers 16, 17, 18, 19, 20 and 21 of Table 8 shall be made on the one sample of completed cable at least 5 m in length. If the sample fails during test No 21, a new sample may be taken and submitted to test No 21 provided that it is first submitted to tests No 16 and 19.

15.3 Elongation at Rupture of Semiconductive Extruded Conductor Screen. The method of obtaining the elongation at rupture of the extruded semiconductive conductor screen shall be as specified for insulation materials in the appropriate section of AS 1660.2.

15.4 Tests on Semiconductive Screens.

15.4.1 *Volume resistivity.* Two samples of semiconductive screened core each approximately 250 mm long shall be used to prepare test specimens.

For the conductor screen test, the specimen shall be obtained by longitudinally bisecting the insulations and screens of one core sample, and removing the conductor and one half-section of insulation and screens to provide a single half-section specimen.

The insulation screen test shall be carried out on the outer surface of the remaining complete core sample.

Final preparation of the specimens requires the application of four silver paint band electrodes, to the inside surface of the half section specimen and to the outer surface of the complete core sample. The electrodes shall be not less than 5 mm wide and the two potential electrodes spaced at least 50 mm apart. The current electrodes shall be applied at least 25 mm beyond each potential electrode.

The power of the test circuit shall not exceed 100 mW and the test shall be carried out at a specified temperature using either a.c. or d.c. voltages.

The volume resistivities of the conductor screen (*c*) and the insulation screen (*i*) shall be calculated as follows:

$$\rho_c = \frac{R\,(d_s^2 - d^2)}{25.4L} \qquad (1)$$

$$\rho_i = \frac{R\,(D_s^2 - D^2)}{12.7L} \qquad (2)$$

where ρ_c = the volume resistivity of the conductor screen, in ohm centimetres

ρ_i = the volume resistivity of the insulation screen, in ohm centimetres

R = measured resistance, in ohms

d = diameter over the conductor, in millimetres

d_s = diameter over the conductor screen, in millimetres

D = diameter over the insulation, in millimetres

D_s = diameter over the insulation screen, in millimetres

L = distance between potential electrodes, in millimetres.

The temperature at which the test is made shall be noted.

When a high degree of accuracy is not required, these tests may be carried out with only two electrodes, spaced at least 50 mm apart for each test.

15.4.2 *Strippability test for hand strippable extruded screens not requiring preconditioning.* A sample of semiconductive screened core approximately 400 mm long from the completed cable shall be used for this test which shall be carried out at room temperature as follows:

(a) Cut the semiconductive material at its thickest point longitudinally and radially using a scoring tool having a depth of blade 25 μm less than the specified minimum point thickness of the semiconducting layer of the cable being tested.

(b) Perform a second cut in the same way at least 6 mm from and parallel to the first cut.

(c) For a distance of at least 300 mm, peel a strip from one end of the sample.

The sample is deemed to have passed the test when the strip can be peeled from the insulation without tearing in two and without leaving semiconductive material which cannot be readily removed.

NOTES:

1. The same sample that passes the test may be used for the adhesion test, Clause 15.4.3.
2. For PE and XLPE insulated cables the test is performed on sample at normal ambient temperature and that for an EPR insulated cable the sample may require preconditioning (heating) as agreed between the purchaser and the manufacturer.

15.4.3 *Adhesion test for hand strippable extruded screens not requiring preconditioning.* A sample of semiconductive screened core approximately 400 mm long from the completed cable shall be used for this test which shall be carried out at room temperature as follows:

(a) Cut the semiconductive material longitudinally and radially down to the insulation. Perform a second cut in the same way at a 12 mm separation parallel to the first cut. Remove approximately 50 mm of the 12 mm strip from each end of the cable for attachment to the measuring device.

(b) Measure the tension required to pull the strip away from the cable at a 90 degree angle such that the strip separates from the insulation at a speed of approximately 12 mm/s.

(c) Perform the test at each end of the sample and terminate the test at the centre of the sample.

(d) Repeat steps (a) to (c) on the sample with the second strip spaced 180 degrees from the first. The sample is deemed to have passed the test when in compliance with the criteria specified in Test 7(c) of Table 8.

15.4.4 *Thickness of insulation screen.* The method of measuring the thickness of the extruded semiconductive insulation screen shall be as specified for the measurement of the insulation thickness in AS 1660.3.2.

1660 Cond.

15.5 Partial Discharge Tests.

15.5.1 *Tests.* Tests shall be carried out on each screened core of the cable in accordance with Appendix A. The partial discharge shall not exceed 20 pC at the voltage level in column 2 of Table 9 or 5 pC at the voltage level in column 3 of Table 9.

The voltage levels shown in columns 2 and 3 of Table 9 are 200 percent and 150 percent respectively of the designated voltage U_o rounded to the nearest two significant figures.