

AS/NZS 3198:1996

Australian/New Zealand Standard[®]

**Approval and test specification—
Electric cables—XLPE insulated—
For working voltages up to and
including 0.6/1 kV**

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL/3 on Electric Wires and Cables to supersede AS 3198—1990 and NZS/AS 3198—1990. *Approval and test specification—Electric cables—XLPE insulated—For working voltages up to and including 0.6/1kV.*

This Standard is one of series of Approval and Test Specifications issued by Standards Australia and Standards New Zealand. In Australia, these Standards are to be read in conjunction with AS 3100, *Approval and test specification—General requirements for electrical equipment*. In New Zealand, they are to be read in conjunction with NZS 6200, *Specification for general requirements for electrical apparatus and materials*. The purpose of these Standards is to outline the conditions which must be met to secure approval for the sale and use of electrical equipment. Only safety matters and related conditions are covered.

The objective of this Standard is to specify the construction, dimensions and tests for XLPE insulated cables for working voltages not exceeding 1 kV.

The objective of this revision is to update the 1990 edition and to add cables suitable for a maximum permissible conductor temperature of 110°C.

The nominal cross-sectional areas of the conductors specified herein are taken from AS 1125, *Conductors in insulated electric cables and flexible cords*, and are identical with the values recommended in IEC 228: 1978 *Conductors of insulated cables*.

This Standard differs from the 1990 edition as follows:

- (a) Cables suitable for a maximum permissible conductor temperature of 110°C have been added.
- (b) The Standard has been issued as a Joint Australian/New Zealand Standard.

In the preparation of this Standard, consideration was given to IEC 502 *Extruded solid dielectric insulated power cables for rated voltages from 1 kV to 30 kV* and acknowledgment is made of the assistance received from that source.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard

Approval and test specification—Electric cables—XLPE insulated—
For working voltages up to and including 0.6/1 kV

1 SCOPE This Standard specifies construction, dimensions and tests for cables insulated with three types of cross-linked polyethylene (XLPE), two of which have reduced combustion propagation characteristics. The cables are intended for use in electrical installations at working voltages up to and including 0.6/1 kV.

Except where otherwise specified in tables of construction and dimensions, cables covered by this Standard are suitable for use as underground cables.

This Standard does not apply to specialized XLPE insulated cables for which there are separate Australian, New Zealand or Australian/New Zealand Standards, e.g. concentric wire neutral cables, neutral screened cables, aerial bundled cables and the like.

In addition to providing detailed requirements for cables of the types and sizes in the tables of construction and dimensions, this Standard provides the basis of requirements for other types and sizes in the range of materials covered by this Standard.

NOTE: Purchasing guidelines are contained in Appendix A.

2 REFERENCED DOCUMENTS The following documents are referred to in this Standard:

- AS
1125 Conductors in insulated electric cables and flexible cords
1178 Concentric wire neutral cables—XLPE insulated—For electricity supply at working voltages of 0.6/1 kV
1660 Test methods for electric cables, cords and conductors
2122 Combustion characteristics of plastics
2893 Electric cables—Lead and lead alloy sheaths—Composition
3000 Electrical installations—Buildings, structures and premises (known as the SAA Wiring Rules)
3155 Approval and test specification—Neutral screened cables for working voltages of 0.6/1 kV
3560 Electric cables—XLPE insulated—Aerial bundled—For working voltages up to and including 0.6/1 kV
3863 Galvanized mild steel wire for armouring cables
SAA
MP49 Register of colours of manufacturers' identification threads for electric cables and flexible cords

3 DEFINITIONS For the purposes of this Standard the relevant definitions given in the referenced Standards and those below apply.

3.1 Approximate value—a value which is neither guaranteed nor checked.

3.2 Core (of a cable)—the conductor with its insulation but not including any protective covering.

3.3 Direction of lay—the slope of the helically laid up cores, screen wire or armour wire, armour tape or the like, when the cable is held vertically.

It is right hand when the slope is in the direction of the central part of the letter Z, and left-hand when the slope is in the direction of the central part of the letter S.

3.4 Fictitious values—values calculated according to an equation based only on the cross-sectional area of the conductor, number of cores and specified component dimensions and which ignores conductor shape, degree of compaction of conductors and the possibility of components having dimensions other than specified (see Appendix B).

3.5 Maximum continuous conductor temperature—the maximum temperature at which the conductor of the cable may be operated continuously and which is the temperature resulting from the combined effect of the ambient temperature and the current loading of the conductor.

3.6 Multicore cable—a cable comprising two or more cores.

3.7 Routine tests—tests made by the manufacturer on all completed cable, to demonstrate the integrity of the cable.

3.8 Sample tests—tests made by the manufacturer on samples of completed cable or components taken from completed cable, adequate to verify that the finished product meets the design specification.

3.9 Type tests—tests made by the manufacturer before supplying on a general commercial basis, a type of cable covered by this Standard, in order to demonstrate satisfactory performance characteristics to meet the intended application. These tests are of such a nature that, after they have been made, they need not be repeated, unless changes are made in the cable materials or design, which might change the performance characteristics.

3.10 Voltage designation—for cables for a.c. systems, the rated voltages U_0 and U expressed in the form U_0/U ; or for cables for d.c. systems, the rated voltage U_0 ;

where

U_0 = the r.m.s. power frequency voltage to earth of the supply system or d.c. voltage of the supply system for which the cable is designed; and

U = the r.m.s. power frequency voltage between phases of the supply system and for which the cable is designed.

3.11 Wavelength or length of lay—the axial distance between successive crests of the waveform or turns of the helix formed, as appropriate, e.g. by a core of a multicore cable, wire of a stranded conductor, screen or armour wire, screen or armour tape or the like.

4 VOLTAGE DESIGNATION The rated voltage, U_0/U , recognized for the purposes of this Standard, is 0.6/1 kV.

5 MAXIMUM CONTINUOUS CONDUCTOR TEMPERATURE The maximum permissible continuous conductor temperature of cables shall be as follows:

- (a) Cables insulated with X-90 or X-HF-90 90°C
- (b) Cables insulated with X-IIF-110 110°C

6 CONDUCTORS Conductors shall be of the type specified in the appropriate table of construction and dimensions and shall comply with the appropriate requirements in AS 1125.

Copper conductors may be plain or tinned, but tinned wires taken from the completed cables need not comply with the tinning test in AS 1560.

7 INSULATION

7.1 Materials Insulation shall be one of the following materials:

- (a) **X-90** A compound of cross-linked polyethylene.
- (b) **X-HF-90** A cross-linked halogen free polyolefin compound having characteristics of low smoke emission and low flame propagation properties in fire conditions.
- (c) **X-HF-110** A higher temperature version of (b).

7.2 Application The insulation shall be homogeneous, applied with a close fit but shall not adhere to the conductor.

7.3 Thickness The average thickness of insulation (t_1), determined by the method specified in AS 1660, shall be not less than the thickness specified in the tables of construction and dimensions, and the minimum thickness at any point shall not fall below the specified thickness by more than 10 percent of the specified thickness (t_1) plus 0.1 mm:

$$0.1t_1 + 0.1 \text{ mm}$$

$$90\% \text{ to } 100\%$$

7.4 Tests Tests shall be performed as specified in Table 1.

7.5 Criteria The insulation of completed cable shall comply with Table 1.

7.6 Core identification

7.6.1 Restricted colours Except for yellow printed characters when identifying by figures and words, the colours green and yellow, either alone or in combination with any other colour, shall not be used except as described in Clause 7.6.2.

7.6.2 Method Cores of cables shall be clearly and durably identified by either colours or figures followed by words, in accordance with Clause 7.6.3 or Clause 7.6.4, as appropriate.

Cores intended to be used as earth conductors shall be durably coloured green or with a combination of green and yellow, applied so that in any 15-millimetre length of core one of these colours covers at least 30 percent and not more than 70 percent of the surface of the core, and the other colour covers the remainder of the surface. The mass of the insulation shall be either green or yellow, the other colour may be part of the mass or a surface layer only.

For other than earth conductors, the colouring for identification may be within the mass or at the surface of the core insulation, or where the core is further covered, the covering may be suitably coloured.

7.6.3 Colours The recommended core colours for insulated and further protected cables are as follows:

- (a) Active cores red, white (or uncoloured) and blue.
- (b) Neutral core black.
- (c) Earth core green or green/yellow.

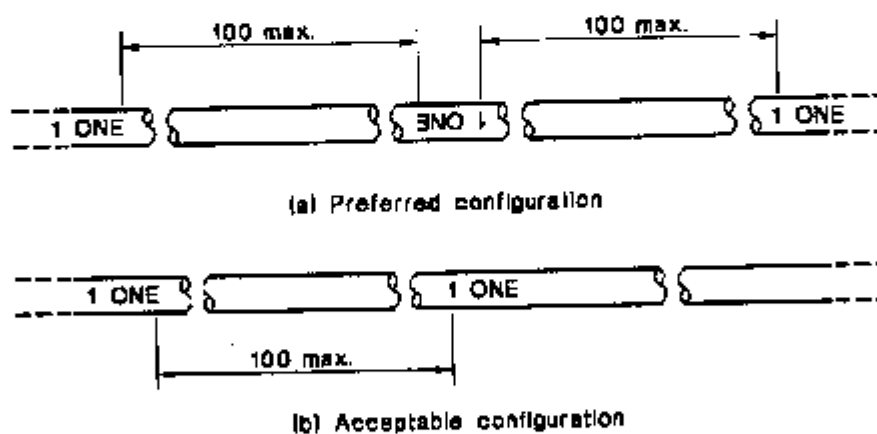
7.6.4 Figures and words Each figure shall be followed by the word that spells that figure (e.g. 1 ONE, 2 TWO, 3 THREE), in accordance with the following requirements:

- (a) The numerals one (1), two (2), three (3) and so forth shall be used to indicate active or neutral cores. If zero (0) is used it shall indicate a neutral core.

(b) Minimum height.

Nominal cross-sectional area of conductor mm ²	Minimum height mm
<70	1.5
≥70	3.0

- (c) Where cores are identified by figures and words, the characters shall be printed in a colour contrasting with that of the core surface (see also Clause 7.6.1).
- (d) Characters shall be printed in line.
- (e) Figures and words shall be spaced so that they are repeated at intervals of not greater than 100 mm (see Figure 1).



DIMENSIONS IN MILLIMETRES

FIGURE 1 EXAMPLES OF CORE IDENTIFICATION

TABLE 1
TESTS AND CRITERIA FOR INSULATION

Test	Criteria			Category of test	Reference for test method
	X-90 insulation	X-HF-90 insulation	X-HF-110 insulation		
A Mechanical tests without ageing on conditioned specimens:				Type	AS 1660
1 Tensile strength, minimum (MPa)	12.5	5.0	5.0		
2 Elongation at rupture, minimum percentage	200	125	125		
B Mechanical tests after ageing in air oven:*				Type	AS 1660
Duration and temperature of ageing	168 h at 135 $\pm$ 3°C	168 h at 135 $\pm$ 3°C	168 h at 150 $\pm$ 3°C		
1 Tensile strength, minimum Percentage of values found in the unaged specimens	75	70	70		
2 Elongation at rupture, minimum Percentage of values found in the unaged specimens	75	70	70		
C Hot set test:				Sample	AS 1660
Duration (min)	15	15	15		
Temperature (°C)	200 $\pm$ 3	200 $\pm$ 3	200 $\pm$ 3		
Load (kPa) (min)	200	200	200		
1 Elongation under load, maximum (percent)	175	175	175		
2 Residual elongation after cooling, maximum (percent)	15	15	15		
D Minimum oxygen concentration percentage	—	28	28	Type	AS 2112
E Acid and corrosive gas emission				Type	AS 1660
1 pH, minimum	—	3.5	3.5		
2 Conductivity, maximum (μ S cm ⁻¹)	—	100	100		
F Electrical characteristics				Type	AS 1660
1 Insulation resistance constant (k_i), at 20°C minimum (G Ω m)	3000	40	40		
2 Insulation resistance constant (k_i) at elevated temperature, minimum (G Ω m)	3.0 at 90°C	0.002 at 90°C	0.002 at 90°C		
G Carbon black content, minimum percentage (Insulated, unprotected single core cables to Table 11 only)	2	—	—	Type	AS 1660

* The test procedure for Thermal Ageing of Elastomers shall be followed.

8 LAY UP OF CORES (MULTICORE CABLES) Cores other than in flat cables and the centre core in circular cables shall be laid up in helical, helical 'SZ' or waveform configuration to impart a degree of flexibility.

9 FILLERS, BARRIER TAPES AND BINDERS When used, fillers, barrier/binder tapes and other binders shall be of suitable non-metallic materials that are compatible with the other materials of the cable with which they are in contact.

10 BEDDING

10.1 General Bedding shall be provided under the armour of all cables and the metal sheath of all multicore cables. It shall also be provided under any other metallic layer (e.g. screen, concentric conductor) of all cables except where the metallic layer is applied in a single core cable or the individual cores of a multicore cable, with the said layer or layers combined meeting the requirements for an earth conductor appropriate for the cable, in which case the bedding may be omitted. In Australia, the earth conductor requirements of AS 3000 apply. Bedding need not be applied under the metal sheath of single core cables.

10.2 Bedding under a metallic layer other than armour

10.2.1 Material The bedding shall comprise extruded or lapped non-metallic materials, as appropriate. These materials shall be compatible with the other materials of the cable with which they are in contact.

10.2.2 Application

10.2.2.1 Lapped bedding Lapped bedding shall be a helically applied continuous layer. For multicore cables comprising circular cores, except cables with more than five cores, the interstices between the cores shall be separately filled.

10.2.2.2 Extruded bedding Extruded bedding shall fit closely over but not adhere to the core assembly or underlying cable component e.g. screen. Any barrier tape or binder may, however, adhere to the bedding. The outer interstices between the cores shall be filled by separate fillers or the bedding.

10.2.3 Thickness The approximate thickness of bedding should be in accordance with Table 2.

TABLE 2
APPROXIMATE THICKNESS OF BEDDING

Electrical diameter under bedding (D_{eff}) (See Appendix A) mm	Approximate thickness of bedding (t_b) mm	
	Extruded	Lapped
≤ 25	1.0	0.4
$>25 \leq 35$	1.2	0.4
$>35 \leq 40$	1.4	0.4
$>40 \leq 45$	1.4	0.6
$>45 \leq 60$	1.6	0.6
$>60 \leq 80$	1.8	0.6
>80	2.0	0.6

10.2.4 Reduced thickness lapped bedding under a metallic screen or concentric conductor of multicore cables Where the metallic screen or concentric conductor to be applied over the laid up cores of a multicore cable comprises metallic tape(s) not greater than 0.08 mm nominal thickness or wires not greater than 0.50 mm nominal diameter, but meeting the requirements for an earth conductor appropriate for the cable, the approximate thickness of the bedding may be reduced to 0.05 mm, if of polyethylene terephthalate tape or equivalent material. In Australia, the earth conductor requirements of AS 3000 apply.

10.3 Bedding under the armour

10.3.1 Material The bedding shall comprise extruded non-metallic material, except that in the case of bedding applied over metal sheath, either extruded or lapped non-metallic material shall be used. Any fibrous lapped bedding such as jute yarn, hessian or other textile tapes shall be impregnated and an additional waterproofing compound shall be applied above and below any fibrous lapped bedding. The bedding materials shall be compatible with the other materials of the cable with which they are in contact.

10.3.2 Additional protection for metal sheathed cables Metal sheathed cables having a bedding of impregnated fibrous materials and which are intended to be laid directly in the ground, drawn into ducts laid direct in the ground, or installed in air out-of-doors, shall have two layers of impregnated paper tape or elastomeric or thermoplastic tape, applied under the remainder of the bedding and satisfying the compatibility requirements of Clause 10.3.1.

10.3.3 Application The requirements specified in Clause 10.2.2 shall apply.

10.3.4 Thickness For extruded bedding, the requirements specified in Clause 10.2.3 apply. For lapped bedding the approximate thickness (t_b) should be 1.5 mm.

11 METALLIC LAYERS For the purpose of this Standard, the following types of metallic layers are considered:

- (a) Metallic screen, surrounding the cores either individually or collectively. Typically this may comprise, but not be restricted to, one or more metallic or metallized tapes, a wire braid or a concentric layer of wires, helically applied or in waveform configuration or a combination of tape and wires.
- (b) Concentric conductor (for cables other than those covered in AS 1178 and AS 3155). Typically this may comprise, but not be restricted to, a concentric layer of wires, helically applied or in waveform configuration.
- (c) Metal sheath (see Clause 14).
- (d) Armour (see Clause 13).

The detailed requirements for (a) and (b) above shall be subject to the relevant regulatory provisions. In Australia, the requirements of AS 3000 apply. See also Appendix A.

Except where the cable is for d.c. application only, any metallic layer applied to single core cable or the individual cores of a multicore cable shall be non-magnetic.

12 SEPARATION SHEATH

12.1 Provision of sheath Where a metal screen and the armour applied over such a screen are of different metals, the two shall be separated by an extruded separation sheath.

12.2 Material and application The separation sheath shall comprise an appropriate material specified in Clause 15.1. and be applied as specified in Clause 15.2.

12.3 Thickness The average thickness of the separation sheath (T_s), determined by the method specified in AS 1660, shall be not less than the value calculated from the following equation and rounded off to the nearest 0.1 mm, subject to a minimum thickness of 1.2 mm:

$$T_s = 0.02D_s + 0.6 \text{ mm} \quad \dots 12.3(1)$$

where

D_s = fictitious diameter under the separation sheath, in millimetres (see Appendix B).

The minimum thickness at any point of the separation sheath shall not fall below the calculated thickness (T_s) by more than—

20 percent of the calculated thickness (T_s) plus 0.2 mm:

$$0.2T_s + 0.2 \text{ mm.}$$

12.4 Tests Tests shall be performed as specified in Table 5.

12.5 Criteria The separation sheath of the completed cable shall comply with Table 5.

13 ARMOUR

13.1 Material Armouring shall be of galvanized low carbon (mild) steel wires or fully galvanized double steel tape.

Galvanized low carbon (mild) steel armour wire shall be in accordance with AS 3863.

13.2 Dimensions of wire and tape The nominal diameter of the armour wire or the nominal thickness of the armour tape shall be not less than the appropriate values given in Tables 3 and 4, respectively.

TABLE 3
DIAMETER OF ARMOUR WIRE

Fictitious diameter under the armour (see Appendix B) mm	Nominal diameter of armour wire (t_a) mm
≤ 8	0.9
$>8 \leq 15$	1.25
$>15 \leq 25$	1.6
$>25 \leq 35$	2.0
$>35 \leq 60$	2.5
>60	3.15

TABLE 4
THICKNESS OF ARMOUR TAPE

Fictitious diameter under the armour (see Appendix B) mm	Nominal thickness of each tape* (t_s) mm
≤ 30	0.2
$>30 \leq 70$	0.5
>70	0.8

* Subject to a tolerance of ± 10 percent.

13.3 Application

13.3.1 General The armour shall be applied over bedding complying with the requirements of Clause 10, or the separation sheath specified in Clause 12 as appropriate.

13.3.2 Wire armour Wire armour shall be applied helically with a minimum gap between adjacent wires.

Where double-wire armour is used, a separator comprising a layer of non-hygroscopic material of approximate thickness 0.5 mm and meeting the requirements of Clause 9 shall be applied between the concentric layers of armour. For single-wire armour, or the inner layer of double-wire armour, the lay direction shall be opposite to the lay direction of helically laid up cores, or left-hand over helical S-Z or waveform laid-up cores. The outer layer of double-wire armour shall be in the opposite direction to the inner layer.

Joints in the armour wires shall be brazed or welded and any surface irregularities shall be removed. A joint in any wire shall not be less than 1 m from the nearest joint in any other wire of an armour layer in the completed cable.

NOTE: For definition of 'non-hygroscopic' see AS 3000.

13.3.3 Tape armour Tape armour shall be applied helically in two layers with the same direction of lay and so that the outer tape is centred approximately over the gap of the inner tape. The gap between adjacent turns of each tape shall not exceed 50 percent of the width of the tape. The steel tape shall have a tensile strength in the range 300 to 450 MPa. The direction of lay shall be opposite to that of the cores in the case of helically laid-up cores, or left-hand in the case of helical S-Z or waveform laid-up cores.

Joints in the tape shall be welded and surface irregularities removed.

14 METAL SHEATH

14.1 Material The metal sheath shall be lead alloy E in accordance with AS 2893.

14.2 Application The metal sheath shall be closely applied by the extrusion process, and readily removable without damage to the insulation. For single core cables it may be applied directly over the core. For multicore cables, it shall be applied over a bedding complying with the requirements of Clause 10.

14.3 Thickness The average thickness of a sheath (T_m), determined by the method specified in AS 1660, shall be not less than the value calculated from the following equation and rounded off to the nearest 0.1 mm, subject to a minimum thickness of 1.0 mm:

$$T_m = 0.025 D_m + 0.7 \text{ mm}$$

where

D_m = fictitious diameter under the metal sheath, in millimetres (see Appendix B)

The minimum thickness at any point shall not fall below the specified thickness by more than—

5 percent of the specified thickness (T_m) plus 0.1 mm:

$$0.05T_m + 0.1 \text{ mm.}$$

15 NON-METALLIC SHEATH

15.1 Material The non-metallic sheath shall have a temperature rating of not less than that of the insulation and be one of the following thermoplastic materials:

- (a) **5V-90** A combination of materials of which the characteristic constituent is the plastomer polyvinyl chloride. The same term also designates compounds containing both polyvinyl chloride and certain of its copolymers. * *
- (b) **HFS-90-TP** A thermoplastic, halogen free polymeric based material (e.g. polyolefin copolymer) having characteristics of low smoke emission and low flame propagation properties in fire conditions.
- (c) **HFS-110-TP** A higher temperature version of (b).

15.2 Application The sheath shall be homogeneous and shall fit closely over but not adhere to the core assembly or underlying cable component, e.g. armour or collective screen. Any barrier tape or binder may however adhere to the sheath.

The outer interstices between the cores shall be filled either by separate fillers or the sheath.