

Australian/New Zealand Standard™

**Electric cables—Reeling and trailing—
For mining and general use (other than
underground coal mining)**

AS/NZS 2802:2000

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee EL-003, Electric Wires and Cables. It was approved on behalf of the Council of Standards Australia on 28 April 2000 and on behalf of the Council of Standards New Zealand on 24 April 2000. It was published on 19 June 2000.

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Australian Industry Group
Department of Defence, Australia
Department of Mineral Resources, N.S.W.
Electrical Contractors Association of New Zealand
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Australian/New Zealand Standard™

Electric cables—Reeling and trailing— For mining and general use (other than underground coal mining)

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PREFACE

This Standard was prepared by the Standards Australia/Standards New Zealand Committee EL-003, Electric Wires and Cables, to supersede AS 2802—1992 and NZS/AS 2802—1992.

This Standard incorporates Amendment No. 1 (December 2003). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.

The objective of the Standard is to specify requirements for construction, dimensions and tests of reeling and trailing cables for mining (other than underground coal mining) and general use for voltages 1.1 kV up to 33 kV.

The Standard specifies two classes of cables for reeling and trailing cables for mining and general use, and defines cable structures developed to satisfy particular industry requirements. For high voltage applications, cables with a rationalized range of conductor sizes are specified to provide an optimum range to meet most applications.

Improvements made in manufacturing techniques and quality control, together with availability of cable materials with improved electrical and mechanical properties, permit the production of a high class of cable.

The cables specified in this Standard have been designed to meet the special requirements of the Australian surface mining industry and also to comply with the requirements of AS 3007, *Electrical installations—Surface mines and associated processing plant* (all parts).

Although surface mining was a significant factor in determining the cables to be incorporated in this Standard, it is recognized that many of these cables will be equally applicable to other installations, e.g. underground metalliferous mines, ship loaders, travelling cranes, reclaimers at loading stations and other large materials handling plant.

A number of cables specified in this Standard might also meet the requirements for underground coal mines; however, reeling and trailing cables for coalmines are the subject of AS/NZS 1802, *Electric cables—Reeling and trailing—For underground coal mining purposes*.

This Standard differs from the 1992 edition as follows:

- (a) It is published as a Joint Australian/New Zealand Standard.
- (b) Two additional Class 1 cables, Types 451 and 455 have been included.
- (c) The tests and criteria for insulation and sheathing materials have been deleted and reference made to AS/NZS 3808.
- (d) A number of test methods have been deleted and reference made to AS/NZS 1660.
- (e) The direction of lay of wires and bunches or strands for power and earth conductors (other than composite earth screens) is no longer specified.
- (f) The definition of voltage designation has been modified.

In the preparation of this Standard consideration was also given to the following publications and acknowledgment is made of the assistance received therefrom:

AEIC No. CS 6, *Ethylene propylene rubber insulated shielded power cables rated 5 through 69 kV*

NEMA No. WC 8 ICEA Publication No. S-68-516, *Ethylene-propylene-rubber-insulated wire and cable for the transmission and distribution of electrical energy*

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.

Statements expressed in mandatory terms in notes to tables and figures are deemed to be requirements of this Standard

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FOREWORD

This Standard specifies two classes of reeling and trailing cables, as follows:

- (a) *Class 1* Cables, rated 3.3/3.3 kV and above, having high grade insulation and sheath materials which permit applications with reduced insulation radial thickness.
- (b) *Class 2* Cables, rated 1.1/1.1 kV and above, designed for application of insulation and sheath materials with greater radial thickness insulation than equivalent rated Class 1 cables.

The cable constructions are defined in detail to satisfy the particular requirements of the industry and the sizes have been rationalized to provide an optimum range to meet most applications.

Cable users will be assisted in making the appropriate cable selection by reference to the descriptive tables of cable types in this Standard. A number of cables manufactured in accordance with AS/NZS 1802 for underground coalmining may be suitable for use in surface mining or other underground mining. Advice on suitability of these cables should be sought from the cable supplier.

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

The dimensions specified for Class 1 cable insulation and sheath radial thicknesses are based on ICEA Pub No S-68-516 for non-effectively earthed systems. The dimensions adopted for Class 2 cables maintain the greater radial thicknesses specified in AS/NZS 1802.

The test requirements specified for Class 1 cables are generally higher than those specified in previous Standards because of developments in cable materials and manufacturing techniques in recent years. Where the method of testing differs from or has not yet been included in the AS/NZS 1660 series, *Test methods for electric cables, cords and conductors*, the test method has been included in Clause 26 and in appendices to this Standard.

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard**Electric cables—Reeling and trailing—For mining and general use
(other than underground coal mining)****1 SCOPE**

This Standard specifies requirements for two classes of multicore elastomer insulated and sheathed flexible reeling and trailing cables for surface mining, underground mining (other than coal mining) and general use, where plant requires electricity supply at system voltages from 1.1/1.1 kV up to and including 33/33 kV.

The Class 1 cables are insulated with a high grade ethylene propylene rubber (XR-EP-90) which permits a reduced radial thickness for the insulation compared with equivalent rated Class 2 cables. The cable sheath is extra-heavy duty chlorosulphonated polyethylene, or chlorinated polyethylene (XHD-90-CSP, or CPE), or polychloroprene (XHD-85-PCP).

The Class 2 cables are designed for manufacture using standard R-EP-90 insulation and HD-90-CSP, HD-90-CPE or HD-85-PCP sheath. The greater insulation radial thickness required for these cables provides a more robust cable.

It is not intended that the use of other types of cables should be precluded and regulatory authorities may give approval to new types as they are developed. Appropriate requirements for new types and sizes will eventually be included in this Standard as the need arises.

This Standard also provides the basis of requirements for construction of other sizes in the range of materials covered by this Standard.

2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS	
1125	Conductors in insulated electric cables and flexible cords
1931	High-voltage test techniques
1931.1	Part 1: General definitions and test requirements
3007	Electrical installations—Surface mines and associated processing plant (all parts)
3863	Galvanized mild steel wire for armouring cables
AS/NZS	
1660	Test methods for electric cables, cords and conductors (all parts)
1802	Electric cables—Reeling and trailing—For underground coal mining purposes
3808	Insulating and sheathing materials for electric cables
5000	Electric cables—Polymeric insulated
5000.1	Part 1: For working voltages up to and including 0.6/1 kV
IEC	
60287	Electric cables—Calculation of the current rating
ISO	
1139	Textiles—Designation of yarns

3 DEFINITIONS

For the purpose 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 Bunch

A number of wires all of which are twisted together in the same direction and with the same length of lay throughout.

3.3 Centre filler

A section of elastomeric material that fills the centre interstice of the core assembly of a multicore cable.

3.4 Composite screen

A screen comprising stranded or bunched copper wires applied in one direction and interwoven in the opposite direction with polyethylene terephthalate yarn, or its equivalent.

3.5 Conductor covering

Elastomeric insulation of a specified radial thickness which differs from that required by the voltage designation of the cable.

3.6 Conductor screen

A layer of non-metallic semiconductive material applied directly over the conductor.

3.7 Cradle separator

A shaped section of elastomeric material, designed to support the core assembly, fill the centre interstice and provide a specified separation between individual power cores.

3.8 Direction of lay

The slope direction of the conductor wire, bunch, core, screen or armour strands when the stranded conductor or 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.

3.9 Earth conductor

A conductor laid up in the cable for the purpose of providing earth continuity.

3.10 Fictitious diameter

Diameter calculated according to a formula based only on cross-sectional area of conductor, number of cores and specified component dimensions and which ignores conductor make-up and the possibility of components having dimensions other than as specified.

The fictitious value is only used to determine the mechanical protective coverings of the cable, i.e. inner and outer sheath and pliable armour strand size.

3.11 Insulation screen

A screen applied directly over insulation as follows:

- (a) A non-metallic semiconductive material.
- (b) A combination of (a) and composite screen.

A1

3.12 Length of lay

The axial length of one complete turn of the helix formed by a cable component, e.g.—

- (a) a bunch of a multiple stranded conductor;
- (b) a core of a laid-up core assembly; or
- (c) the strands of pliable armour in a cable.

3.13 Maximum continuous conductor temperature

The maximum temperature at which the conductor may be operated continuously. It is the temperature resulting from the combined effect of the ambient temperature and the current loading on the conductor.

3.14 Multiple-stranded conductor

A group of bunches or strands laid up helically and symmetrically such that within any one layer the length of lay of bunches or strands is uniform.

3.15 Pilot/Control core

A conductor with a covering of insulating material for use in conjunction with a pilot protection or other control system.

3.16 Pitch circle diameter

The diameter of a circle which passes through the midpoints of like cable components, e.g.

- (a) a given layer of bunches or strands in a multiple stranded conductor, or the laid-up cores of a multicore circular cable; or
- (b) the composite screen of a core or strands of pliable armour in a circular cable.

3.17 Power core

A power conductor with insulation of the appropriate voltage grade including, where applicable, semiconductive and composite screens.

3.18 Reeling and trailing cables

Cables having flexible conductors, insulation incorporating conductor and insulation screens where appropriate, filling, reinforcement where appropriate, one or more protective coverings, and being specially designed to provide flexible electrical connections between portable or mobile equipment and a point of supply.

3.19 Routine tests

Tests made by the manufacturer on all completed cable to demonstrate the integrity of the cable.

3.20 Sample tests

Tests made by the manufacturer on samples of completed cables or components taken from completed cables so as to verify that the finished product meets the design specification.

3.21 Strand

An assembly of wires laid up helically in one or more layers.

3.22 Triple extrusion

The simultaneous extrusion of conductor screen, insulation and semiconductive insulation screen over a power conductor.

3.23 Type tests

Tests required to be made before supplying on a general commercial basis a type of cable covered by this Standard, to demonstrate performance characteristics to satisfy the intended application. These tests are such that after they have been made, they need not be repeated, unless changes are made in the cable materials or design that might change the performance characteristics.

4 VOLTAGE DESIGNATION

Due to common usage in the mining industry, cables in this Standard have voltages designated using 'phase voltage'/'phase voltage'. However, although the cables specified for use with a.c. in this Standard are suitable in non-effectively earthed systems they are not intended for continuous operation with one phase earthed.

The voltage designation takes into consideration that the system voltage may vary up to 9.1 percent from the rated voltage.

5 CABLE CLASS, TYPE AND APPLICATION

All cables are classified in terms of their construction and use as follows:

- (a) *Class 1 cables* Flexible cables having voltage designations of 3.3/3.3 kV and above, and using an insulation material that allows higher voltage stress levels, which permit reduction of insulation and sheath thickness compared with Class 2 cables. This class of cable is designed for slow reeling or trailing applications with optimum flexibility, drum capacity and mass.
- (b) *Class 2 cables* Flexible cables having voltage designations of 1.1/1.1 kV and above. Those cables rated at 3.3/3.3 kV and above are constructed with a greater radial thickness of insulation and sheath than Class 1 cables, to provide a more robust cable. These cables are suitable for trailing and most reeling applications.

Cables within the above two classes are designated by type number. The type number incorporates reference to the voltage designation, e.g. Type 441.3 indicates Type 441 cable rated at 3.3 kV.

Cable type numbers are listed in Column 2 of Table 1. Column 3 provides a description of the cable, Column 4 refers to the range of voltage designations and Column 5 lists figures and tables containing constructional details and dimensions.

NOTE: For the cables specified in this Standard, for use in other than underground coalmining, the first digit of the type number is 4. For cables specified in AS/NZS 1802, for use in underground coal mines, the first digit of the type number is 2. These initial numerals have been chosen so that for cables of like construction (e.g. as in the case of Types 209 and 409), the possibility of mistaken identity is reduced, even after the cable has been worn or damaged. For guidance on current ratings, refer to Appendix A.

6 MAXIMUM CONDUCTOR TEMPERATURE

The maximum conductor temperature of cables is specified in Table 2.

The emergency operation temperature (indicated in Column 2 of Table 2) is applicable for an average, over several years, of not more than one period per year. No period shall exceed 36 h and there shall not be more than three periods in any 12 consecutive months. The service life of cables may be reduced if flexed or reeled during emergency operation.

TABLE 1
TYPES OF CABLES

1	2	3	4	5
Cable class	Type No.	Description	Voltage designation kV	Details of construction and dimensions
Class 1	441	Semiconductive screened three-core cable with three interstitial earth conductors and a central pilot core	3.3/3.3 to 22/22	Figure 7 and Table 16
	450	Composite screened three-core cable with two interstitial earth conductors and one interstitial pilot core	3.3/3.3 to 33/33	Figure 8 and Table 17
	451	Composite screened three-core cable with two interstitial earth conductors and one reduced interstitial pilot core	3.3/3.3 to 33/33	Figure 9 and Table 18
	455	Semiconductive screened three-core cable with two interstitial earth conductors and one interstitial pilot core	3.3/3.3 to 11/11	Figure 10 and Table 19
Class 2	409	Composite screened three-core cable with a central pilot core	1.1/1.1 to 22/22	Figure 3 and Table 12
	412	Unscreened pliable armoured three-core cable with three interstitial earth cores (no pilot)	1.1/1.1 only	Figure 4 and Table 13
	440	Composite screened three-core cable with three interstitial pilot cores	1.1/1.1 to 22/22	Figure 5 and Table 14
	441.1	Semiconductive screened three-core cable with three interstitial earth conductors and a central pilot core	1.1/1.1 only	Figure 6 and Table 15

TABLE 2
MAXIMUM CONDUCTOR TEMPERATURE

1	2	3
Normal operation	Emergency operation	Short-circuit operation (5 s maximum duration)
°C	°C	°C
90	130	250*

* Account should be taken of the possibility that, at 250°C, the tinning of the power conductor might melt.

7 POWER AND EARTH CONDUCTORS (other than composite earth screens)

7.1 General

Power and earth conductors shall consist of tinned annealed copper wires complying with the appropriate requirements of AS 1125, except that the wires taken from the completed cable need not comply with the tinning test specified in AS/NZS 1660. Additionally, the conductors shall comply with Table 3.

Power conductors of nominal cross-sectional area 6 mm² or larger and all interstitial conductors shall be multiple stranded. Tables 13 to 19 specify the standard interstitial conductors appropriate for a given cable.

Notwithstanding the above, the conductors may consist of a larger number of smaller diameter wires provided that the individual wires are not less than 0.19 mm or 50 percent of the specified diameter for a given conductor size, whichever is the greater, and provided that the conductor is of equal cross-sectional area to the standard conductor.

TABLE 3
CONDUCTORS OTHER THAN INTERSTITIAL AND CENTRAL
PILOT AND EARTH CONDUCTORS

1	2	3	4
Nominal cross-sectional area mm ²	Number and nominal diameter of wires No./mm	Number of bunches × number of wires per bunch in multiple stranded conductors	Number of bunches in layers (from centre of conductor outward) for multiple stranded conductors
1.5	30/0.25	—	—
2.5	50/0.25	—	—
4*	56/0.30	—	—
6	84/0.30	7 × 12	1, 6
10	77/0.40	7 × 11	1, 6
16	126/0.40	7 × 18	1, 6
25	209/0.40	19 × 11	1, 6, 12
35	285/0.40	19 × 15	1, 6, 12
50	380/0.40	19 × 20	1, 6, 12
70	203/0.67	29 × 7	4, 9, 16
95	259/0.67	37 × 7	1, 6, 12, 18
120	336/0.67	48 × 7	3, 9, 15, 21
150	427/0.67	61 × 7	1, 6, 12, 18, 24
185	518/0.67	37 × 14	1, 6, 12, 18
240	672/0.67	48 × 14	3, 9, 15, 21
300	854/0.67	61 × 14	1, 6, 12, 18, 24
400*	1159/0.67	61 × 19	1, 6, 12, 18, 24

* The 4 mm² and 400 mm² conductors are not, presently, specified in the range of cables covered in Tables 12 to 19 but have been incorporated for information only.

7.2 Joints

Joints shall comply with the appropriate requirements of AS 1125, except that in the case of interstitial conductors comprising fewer than seven bunches, joints are permitted in individual wires only.

7.3 Direction of lay

The direction of lay of wires and of bunches or strands shall be such as to minimize cable distortion in service.

7.4 Length of lay of bunches for interstitial conductors

The bunches (as distinct from wires in the bunches) forming interstitial conductors shall be laid up with a length of lay not exceeding nine times the pitch-circle diameter of the interstitial conductor.

7.5 Resistance of earth conductors

The resistance of earth conductors shall be as follows:

- (a) For cable Types 412, 441, 450, 451 and 455 the interstitial earth conductors shall be of equal size. Except where a specific resistance value applies as is specified in Item (ii), the electrical d.c. resistance of the respective earth conductors combined, when expressed as a ratio to the maximum permissible resistance of one associated power conductor (see AS 1125), shall not exceed the following values:
 - (i) For cables with power conductors up to and including 16 mm^2 , the ratio 1.0.
 - (ii) For cables with power conductors above 16 mm^2 up to and including 35 mm^2 , the value 1.24 ohm/km.
 - (iii) For cables with power conductors above 35 mm^2 , the ratio 2.0.
- (b) For Type 440 cable, except where a specific resistance value applies as is specified in Item (ii), the electrical d.c. resistance of the three pilot conductors combined, when expressed as a ratio to the maximum permissible resistance of one associated power conductor (see AS 1125), shall not exceed the following values:
 - (i) For cables with conductors up to and including 70 mm^2 , the ratio 2.0.
 - (ii) For cables with power conductors larger than 70 mm^2 , the ratio or value 3.0 or 0.547 ohm/km, whichever is the lesser.

NOTE: In certain situations, touch voltage consideration might require lower resistance for earth conductors.

8 PILOT CORE (Types 409 and 441 only)

8.1 Conductor material and resistance

For Types 409 and 441, the central pilot conductor shall consist of tinned, annealed copper wires complying with the appropriate requirements of AS 1125, except that the wires taken from the completed cable need not comply with the tinning test specified in AS/NZS 1660. The conductor resistance shall not exceed the following values:

- (a) For cables having power conductors of nominal cross-sectional area up to and including 35 mm^2 3 Ω /100 m length of conductor.
- (b) For cables having power conductors of nominal cross-sectional area above 35 mm^2 2 Ω /100 m length of conductor.

NOTE: When selecting a cable and when specifying the central pilot core, consideration should be taken of the mandatory regulations for earth loop resistance.

8.2 Extensibility of pilot conductor

The central pilot conductor shall meet the requirements of Test 6 in Table 7.

8.3 Joints in central pilot conductors

No joint shall be made in the central pilot conductor of any completed cable. However, individual wires may be joined in accordance with AS 1125.

8.4 Material and radial thickness of covering

Central pilot conductors shall have a covering of R-EP-90 compound complying with the relevant requirements specified in Clause 10. The thickness of covering on the central pilot conductor shall be not less than 0.5 mm at any point.

8.5 Location

The pilot core shall be centrally located in the cradle separator (see Clause 15).

9 CONDUCTOR SCREEN

9.1 General

All cables with a voltage designation of 3.3/3.3 kV and above shall have a semiconductive screen applied directly over each power conductor. The screen shall be applied by taping or extrusion, or both. It shall comply with Table 7.

9.2 Material

Class 2 cables rated 22/22 kV and all Class 1 cables shall have an extruded semiconductive screen consisting of cross-linked polymeric material. A semiconductive tape may be used directly on the conductor prior to the extrusion of the semiconductive conductor screen.

Class 2 cables rated 3.3/3.3 kV up to and including 11/11 kV shall have a taped screen comprising textile-reinforced semiconductive tape or extruded semiconductive screen, or a combination of the two.

9.3 Application

9.3.1 *Extruded screen*

The extruded material shall bond to the insulation material such that it is not possible to separate the two materials without damage to their interface and, for Class 1 cables rated 6.6/6.6 kV and above, shall be applied as part of a triple extrusion process.

9.3.2 *Taped screen*

One or more tapes shall be applied free of creases. Where one tape only is used, it shall be applied with an overlap of 50 percent of the tape width.

9.3.3 *Combined taped and extruded screen*

The tape shall be applied directly onto the conductor followed by the extruded screen which shall bond to the insulation and, in the case of Class 1 cables rated 6.6/6.6 kV and above, be applied as part of a triple extrusion process.

9.4 Thickness of extruded screen or combined taped and extruded screen

The screen thickness, determined by the method specified for measurement of insulation thickness in AS/NZS 1660, shall be not less than 0.3 mm at any point of the extruded or combined taped and extruded screen.

9.5 Removal from conductor

The conductor screen shall be such as to facilitate removal from the conductor using standard practices.

10 INSULATION OR COVERING ON CONDUCTORS (other than semiconductive elastomer covering on earth conductors)

10.1 Material

10.1.1 *General*

The insulation or covering on conductors shall be one of the appropriate cross-linked compounds set out in Clauses 10.1.2 and 10.1.3. It shall comply with AS/NZS 3808.

10.1.2 *Power cores*

The insulation shall be as follows:

- (a) *For Class 1 cables* XR-EP-90 compound shall be used (see AS/NZS 3808).
- (b) *For Class 2 cables* R-EP-90 compound shall be used (see AS/NZS 3808).

For Class 2 cables, a manufacturer may elect to use the XR-EP-90 insulation material.

10.1.3 Earth and pilot cores

The insulation or covering shall be either R-EP-90 or XR-EP-90 for both classes of cable.

10.2 Application

The application of insulation or covering shall be as follows:

- (a) *For 1.1/1.1 kV rated cables* The insulation or covering shall fit closely on, but not adhere to, the conductor. The insulation or covering shall be homogeneous and be removable using standard practices.

At the discretion of the manufacturer, a separator tape may be applied immediately over the conductor. Any separator tape shall be coloured or opaque if it does not adhere to the insulation.

- (b) *For cables rated 3.3/3.3 kV and above* The insulation shall be bonded to the conductor screen. The insulation shall be homogeneous and, in the case of Class 1 cables rated 6.6/6.6 kV and above, shall be applied as part of a triple extrusion process.

10.3 Thickness

The thickness of insulation or covering on conductors, other than the central pilot conductor, determined in accordance with the procedure specified in AS/NZS 1660 and Clause 26.2, shall be not less than the thickness specified in Tables 12 to 19, as appropriate.

Except for the interstitial pilot conductor of Type 450, the minimum thickness of insulation or covering at any point shall not fall below the specified thickness (t_i) by more than 10 percent of the specified thickness (t_i) plus 0.1 mm, i.e. ($0.1t_i + 0.1$ mm).

NOTES:

- 1 See Clause 7 for requirements for covering on central pilot conductor.
- 2 See Table 17 for requirements for interstitial pilot conductor covering in Type 450.

11 TAPE OVER INSULATION OR COVERING, OTHER THAN SEMICONDUCTIVE TAPE (Types 409, 412 and 440 only)

11.1 Material

For Types 409, 412 and 440, the tape shall comprise a textile fabric and shall be compatible with the insulation on the power or pilot conductors, as appropriate.

11.2 Application

The tape shall be applied with an overlap of not less than 10 percent of the tape width or 2 mm, whichever is the greater.

For Types 409.1 and 440.1, the tape shall be applied directly over the insulation of each power core.

For Type 440 (every voltage designation), the tape shall be applied over the covering of all interstitial cores.

For Type 412, the tape may be applied over insulation or covering of the cores.

The tape shall be removable by hand without damage to the insulation.

12 INSULATION SCREEN (non-metallic and composite)

12.1 General

The insulation screen shall comprise the following:

- (a) *For Types 441 and 455*—semiconductive elastomer only.

- (b) *For Types 409 and 440 (rated 3.3/3.3 kV up to and including 11/11 kV) and for Type 450 (rated 3.3/3.3 kV only)*—semiconductive elastomer or semiconductive tape, or a combination of the two, followed by a composite screen.
- (c) *For Types 450 and 451 (rated 6.6/6.6 kV and above) and Types 409 and 440 (rated 22/22 kV)*—semiconductive elastomer followed by a composite screen.

NOTE: A suitable semiconductive tape may be applied over the elastomer screen specified in Item (c).

12.2 Semiconductive elastomer screen

12.2.1 Material

The material shall comprise a layer of cross-linked semiconductive elastomer which shall be compatible with the insulation. It shall comply with the requirements of Table 7.

12.2.2 Application

The semiconductive elastomer shall be applied directly over the insulation of each power core. It shall be capable of being removed by hand without damage to the insulation.

12.2.3 Thickness of semiconductive screen

The average thickness of the screen, determined by the method specified for measurement of insulation thickness in AS/NZS 1660, shall be not less than 0.8 mm.

The thickness at any point shall be not less than 80 percent of the specified thickness.

12.3 Textile reinforced semiconductive tape screen

12.3.1 General

As an alternative to an elastomeric non-metallic screen, a textile-reinforced semiconductive tape screen may be applied over the insulation of the power cores of 3.3/3.3 kV Type 450 and 451 (Class 1) and 3.3/3.3 kV up to and including 11/11 kV Types 409 and 440 (Class 2).

12.3.2 Material

The semiconductive tape shall comprise a textile fabric, coated with a semiconductive elastomer and having a continuous print on one side identifying it as being semiconductive. It shall be compatible with the insulation of the power cores.

The volume resistivity of the tape shall comply with the requirements of Table 7.

12.3.3 Application

The semiconductive tape shall be applied immediately over the insulation with a minimum thickness of 0.2 mm.

The tape shall be capable of being removed by hand without damage to the insulation.

Where a tape is applied in combination with a semiconductive elastomer screen, the tape shall be outermost, with the printed side of the tape facing outward.

12.4 Composite screen (Types 409, 440, 450 and 451)

12.4.1 Construction

Composite screen construction shall be as follows:

- (a) *Types 409 and 440* Composite screens shall consist of copper strands interwoven with polyethylene terephthalate yarn (or yarn of equivalent mechanical strength).

The copper strands shall be applied with a right-hand direction of lay and shall be interwoven in the left-hand direction with the yarn thus forming a braid. Each of the textile fibrous members shall be not less than R60 tex (see ISO 1139).

Each strand shall consist of seven tinned, annealed copper wires, each having a nominal diameter within the limits of 0.25 mm and 0.50 mm inclusive. The recommended strand size for each cable is shown in Table 12 or 14, as appropriate.

NOTE: A suitable semiconductive tape may be applied over the composite screen.

- (b) *Types 450 and 451* Composite screens shall consist of groups of tinned annealed copper wires interwoven with polyethylene terephthalate yarn (or yarn of equivalent mechanical strength).

The individual wires and groups of wires shall be laid flat and parallel. The yarn and groups of yarn shall be laid flat and parallel.

The wires shall be applied with a right-hand direction of lay and shall be interwoven in the left-hand direction with the yarn thus forming a braid. Each of the textile fibrous members shall be not less than R60 tex (see ISO 1139).

The nominal diameter of the wires shall be not less than the following values:

- (i) For up to and including 15 mm calculated diameter under the screen... 0.25 mm.
- (ii) For calculated diameters under the screen above 15 mm and up to 20 mm inclusive..... 0.30 mm.
- (iii) For calculated diameters under the screen above 20 mm and up to 30 mm inclusive..... 0.40 mm.
- (iv) For calculated diameters under the screen above 30 mm..... 0.50 mm.

The recommended wire size for each cable is given in Table 17.

12.4.2 Joints

There shall be no joints in the complete braid. Where renewal of spindles is necessary, the ends shall be silver-soldered as follows:

- (a) *For Types 409 and 440* The individual copper strands of a spindle shall be butt-soldered.
- (b) *For Types 450 and 451* The ends of the individual copper wires of a spindle shall be twisted into one or more groups of wires, trimmed flush and butt-soldered.

Such butt-soldered screen strands or wires shall be free from sharp edges, solder lumps or similar imperfections.

The breaking strength of a butt-soldered joint shall be not less than 80 percent of a strand or wire not containing a joint.

There shall be not more than one spindle renewal in any 1 m length of core.

12.4.3 Length of lay

The length of lay, expressed as a multiple of the pitch circle diameter of the screen, shall not exceed four and a half times.

12.4.4 Coverage

The coverage by the copper shall be not less than 80 percent when derived from the following equation:

$$\text{Percentage covering} = \frac{W}{m} \times 100 \quad \dots (1)$$

where

W = number of strands $\times$ diameter of single strand for Types 409 and 440; or

$$\begin{aligned}
 &= \text{number of wires} \times \text{diameter of single wire for Types 450 and 451, in millimetres} \\
 m &= \frac{L\pi d}{\sqrt{[(\pi d)^2 + L^2]}} \quad \dots (2) \\
 L &= \text{axial length or pitch of one complete turn of a screen strand or wire, in millimetres} \\
 d &= \text{pitch diameter of screen strands or wires, in millimetres, taken as the nominal diameter under composite screen plus the diameter of one strand or wire together with an allowance for increased thickness due to opposite weave yarn.}
 \end{aligned}$$

12.4.5 Resistance (Types 409 and 440 only)

Except where a specific resistance value applies as is specified in Item (b), the electrical d.c. resistance of the three screens combined, when expressed as a ratio to the maximum permissible resistance of one associated power conductor (see AS 1125), shall not exceed the following values:

- (i) For all cables with power conductors up to and including 16 mm² nominal cross-sectional, the ratio..... 1.0.
- (ii) For cables with power conductors above 16 mm² and up to and including 35 mm² nominal cross-sectional area, the value 1.24 Ω/km.
- (iii) For all cables with power conductors above 35 mm² nominal cross-sectional area, the ratio..... 2.0.

NOTE: In certain situations, the above resistances for earth screens may have to be reduced due to consideration of voltage drop during faults and fault currents.

13 SEMICONDUCTIVE TAPE OVER COMPOSITE SCREEN (Types 450 and 451)

The tape applied over the composite screen shall be a semiconductive tape having a nominal thickness not less than 0.1 mm and shall be helically applied with an overlap not less than 10 percent of tape width or 2 mm, whichever is the greater. These tapes provide for mechanical protection between cores.

14 IDENTIFICATION OF CORES

14.1 General

Insulated and covered conductors shall be distinctly and durably identified in accordance with the requirements of Clauses 14.2 and 14.3.

14.2 Identification method

The identification method used shall be as indicated in Tables 4 and 5.

TABLE 4
CORE IDENTIFICATION METHOD

1	2	3	4	5
Type No.	Voltage designation, kV			
	≤ 1.1/1.1		≥ 3.3/3.3	
	Power cores	Covered conductor(s)	Power cores	Covered conductor
409	(a) or (b) or (d)	(a)	(a) or (c) or (d)	(a)
412	(a) or (b)	(a) or (b)	—	—
440	(a) or (b) or (d)	(a)	(a) or (c) or (d)	(a) or (b)
441	(a) or (e)	—	(a) or (e)	(a)
450	—	—	(c) or (d) or (f)	(a)
451	—	—	(c) or (d) or (f)	(a)
455	—	—	(e)	(a)

LEGEND:

- (a) = colour-coded insulation or covering.
- (b) = colour-coded or continuously numbered proofed tape over the insulation or covering.
- (c) = colour-coded or continuously numbered semiconductive tape over the insulation.
- (d) = colour-coded yarn in composite screen.
- (e) = Type 441 and 455—colour-coded or numbered semiconductive elastomer insulation screen, identifiable at intervals not greater than 300 mm.
- (f) = Type 450 and 451—colour-coded or continuously numbered semiconductive tape over the composite screen.

14.3 Identification and rotational sequence

14.3.1 Identification by colours

Where identification is achieved by the use of colours, the colours and rotational sequence shall be in accordance with Table 5.

Where earth conductor insulation material is bicoloured green/yellow, green shall be the predominant colour. Where bicolouring cannot be achieved by extrusion, the yellow colour may be applied to the green insulation material by a process such as printing the surface of the insulation.

Where colouring of power cores is not practicable, Clause 14.3.2 shall apply.

TABLE 5
COLOURS AND ROTATIONAL SEQUENCE

Type No.	Rotational sequence of core colours
409	Red, white, blue. The central pilot core is grey
412	Red, green/yellow, white, green/yellow, blue, green/yellow
440	Red, grey, white, grey, blue, grey
441*	Red, black, white, black, blue, black. The central pilot core is grey
450*	Red, black, white, black, blue, grey
451*	Red, black, white, black, blue, grey
455	Red, black, white, black, blue, grey

- * The earth conductors are covered with semiconductive elastomer which is inherently black, hence it is not possible to assign the normal (green/yellow) earth colour identification to these conductors.

14.3.2 Identification by numbers

Where identification of power cores is achieved by numbering, the core colours shall be replaced by numbers, in the sequence specified in Clause 14.3.1, as follows: