

## Equipment Technical Specification

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# Earthing cables

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## Equipment Technical Specification

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|------------------------|------------------------------------------------------------------------------|-----------------------------------------------|
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**ETS 0089     Earthing cables**

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**1.0 PURPOSE**

To specify the technical requirements for earthing cables for use on Endeavour Energy's electrical network.

**2.0 SCOPE**

This specification covers the design, engineering, manufacture, testing, supply and delivery of earthing cables installed as part of Endeavour Energy's electrical network.

This specification is not applicable for:

- earthing cables used for portable earthing and short circuiting equipment. Refer to Equipment Technical Specification ETS 0020 - Portable earthing and short circuiting equipment; or
- aerial earth cables including under slung earth wires. Refer to Equipment Technical Specification ETS 0064 - Bare overhead conductors

**3.0 REFERENCES**

- Board Policy 4.0 - Environment
- Company Policy 9.2.5 - Network Asset Design
- Company Policy 9.2.10 - Network Asset Ratings
- Company Policy 9.7.1 - Network Asset Construction
- Company Policy 9.8.3 – Network Operations
- Company Policy – 9.9.1 Network Asset Maintenance
- Company Procedure GSY 1066 - Worksite Hazard and Risk Assessment
- Equipment Technical Specification ETS 0020 - Portable earthing and short circuiting equipment
- Equipment Technical Specification ETS 0056 - Heat shrink end caps for distribution cables
- Equipment Technical Specification ETS 0064 - Bare overhead conductors
- Electrical Safety Rules
- Network Management Plan December 2013 Review
- ENA National Electricity Network Safety Code (Doc 01-2008)
- AS/NZS 1125:2001 Conductors in insulated electric cables and flexible cords
- AS/NZS 1574:1996 Copper and copper alloys – Wire for electrical purposes
- AS/NZS 1660 series Test methods for electric cables, cords and conductors
- AS/NZS 1995:2003 Welding cables
- AS 2848.1:1998 Aluminium and aluminium alloys – Compositions and designations – Wrought products
- AS 2857:1996 Timber drums for insulated electric cables and bare conductors
- AS/NZS 3808:2000 Insulating and sheathing materials for electric cables
- AS 3983:1991 Metal drums for insulated electric cables and bare conductors
- AS/NZS 4026:2008 Electric cables – For underground residential distribution systems
- AS/NZS 5000.1:2005 Electric cables – Polymeric insulated – For working voltages up to and including 0.6/1 (1.2) kV
- AS/NZS ISO 9001:2008 Quality management systems – Requirements
- AS/NZS ISO 14001:2004 Environmental management systems – Requirements with guidance for use

**4.0 DEFINITIONS AND ABBREVIATIONS****AS**

Australian Standard

**ASP**

Accredited Service Provider

**ECC**

earth continuity cable

**NATA**

National Association of Testing Authorities

**NZS**

New Zealand Standard

**PVC**

poly vinyl chloride

**Routine tests**

Tests made by the manufacturer on each manufactured length of cable to check that each length meets specified requirements.

**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.

**SDI**

single core double insulated

**Type test**

Tests made before supplying on a general commercial basis a type of cable covered by this Specification, to demonstrate satisfactory performance characteristics that meet the intended application.

**U**

r.m.s. power frequency voltage between phases of the supply system

**U<sub>0</sub>**

r.m.s power frequency voltage between phase conductor and earth of the supply system

**V-90**

Insulation material V-90- A combination of materials, of which the base constituent is thermoplastic polyvinyl chloride, suitable for up to 90<sup>0</sup> C maximum continuous operating temperature.

**XLPE**

cross linked polyethylene

**X-90**

Insulation material X-90- A compound of cross-linked polyethylene, suitable for up to 90<sup>0</sup> C maximum continuous operating temperature.

**X-110**

Insulation material X-110- A compound of cross-linked polyethylene, suitable for up to 110<sup>0</sup> C maximum continuous operating temperature.

**X-HF-110**

Insulation material X-HF-110- a cross-linked halogen-free polyolefin compound having characteristics of reduced smoke emission and reduced flame propagation properties in fire conditions, suitable for up to 110<sup>0</sup> C maximum continuous operating temperature.

## 5V-90

Sheathing material 5V-90- a combination of materials, of which the base constituent is thermoplastic polyvinyl chloride, suitable for up to 90<sup>0</sup> C maximum continuous operating temperature.

## HFS-110-TP

Sheathing material HFS-110-TP – a thermoplastic, halogen-free polymeric based material (for example, polyolefin copolymer) having characteristics of reduced smoke emission and reduced flame propagation properties in fire conditions, suitable for up to 110<sup>0</sup> C maximum continuous operating temperature.

## 5.0 Earthing cables

The earthing cables covered in this specification are listed in Table 1.

**Table 1: List of earth cables**

| ITEM | Stock Code- Short Description                                   | Description                                                                                                                                                           | Mostly used as                                                       |
|------|-----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|
| 1    | SZ13771-70mm <sup>2</sup> bare Cu                               | CABLE SINGLE CORE BARE 70MM <sup>2</sup> 19/2.14 ANNEALED CIRCULAR STRANDED COPPER CONDUCTOR (CLASS 2-AS1125 )                                                        | Distribution earthing system- connecting electrodes. Direct buried.  |
| 2    | 1564228 95mm <sup>2</sup> Al SDI black                          | CABLE SDI 95MM <sup>2</sup> 19/2.45 CIRCULAR COMPACTED ALUMINIUM CONDUCTOR (CLASS 2-AS1125) 0.6-1kv X-90 INSULATED 5V-90 OVER SHEATHED BLACK CABLE.                   | Down leads on poles. Above ground use.                               |
| 3    | SZ12880-70mm <sup>2</sup> Cu Ins Green/yellow                   | CABLE SINGLE CORE 70MM <sup>2</sup> 19/2.14 ANNEALED CIRCULAR STRANDED COMPACTED COPPER CONDUCTOR (CLASS 2-AS1125), 0.6-1kv V-90 INSULATED GREEN/YELLOW               | Distribution earthing system- connecting electrodes. Direct buried.  |
| 4    | 1087850-95mm <sup>2</sup> Cu Ins Green/Yellow                   | CABLE SINGLE CORE 95MM <sup>2</sup> 19/2.45 ANNEALED CIRCULAR STRANDED COMPACTED COPPER CONDUCTOR (CLASS 2-AS1125), 0.6-1kv V-90 INSULATED GREEN/ YELLOW CABLE.       | Zone substation – upright earths. Direct buried/partly above ground. |
| 5    | SZ12465-95mm <sup>2</sup> bare Cu                               | CABLE SINGLE CORE BARE 95MM <sup>2</sup> 19/2.45 ANNEALED CIRCULAR STRANDED COPPER CONDUCTOR (CLASS 2-AS1125 )                                                        | TR and Zone substation earth grid Direct buried.                     |
| 6    | 1552090-120mm <sup>2</sup> Cu Ins Green Yellow                  | CABLE SINGLE CORE 120MM <sup>2</sup> 37/2.03 ANNEALED CIRCULAR STRANDED COMPACTED COPPER CONDUCTOR (CLASS 2-AS1125), 0.6-1kv V-90 INSULATED GREEN/ YELLOW CABLE.      | TR substation – upright earths. Direct buried/partly above ground.   |
| 7    | New Stock Code- 240mm <sup>2</sup> Cu SDI Black                 | CABLE SDI 240 MM <sup>2</sup> 61/2.25 ANNEALED CIRCULAR STRANDED COMPACTED COPPER CONDUCTOR (CLASS 2-AS1125), 0.6-1kv X-90 INSULATED 5V-90 OVER SHEATHED BLACK CABLE. | ECC Install in conduits when buried/partly above ground.             |
| 8    | New Stock Code- 120mm <sup>2</sup> Cu SDI Green Yellow Flexible | CABLE SDI 120MM <sup>2</sup> COPPER (CLASS 6-AS1125) MULTI-STRAND X-HF-110 OR X-110 (XLPE) INSULATED AND HFS-110-TP OVER SHEATHED GREEN/ YELLOW FLEXIBLE              | TR substation moving parts. Above ground use.                        |
| 9    | 001564137-95mm <sup>2</sup> Cu SDI Green Yellow Flexible        | CABLE SDI 95MM <sup>2</sup> COPPER (CLASS 6-AS1125) MULTI-STRAND X-HF-110 OR X-110 (XLPE) INSULATED AND HFS-110-TP OVER SHEATHED GREEN/ YELLOW FLEXIBLE               | Zone substation moving parts. Above ground use.                      |
| 10   | SZ13666-70mm <sup>2</sup> Cu SDI Green Yellow Flexible          | CABLE SDI 70MM <sup>2</sup> COPPER (CLASS 6-AS1125) MULTI-STRAND X-HF-110 OR X-110 (XLPE) INSULATED AND HFS-110-TP OVER SHEATHED GREEN/ YELLOW FLEXIBLE               | Distribution moving parts (ABS handle). Above ground use.            |

## **5.1 Requirements**

All earthing cables shall be designed, manufactured and tested in accordance with the requirements of AS/NZS 1995:2003, AS/NZS 3008.1.1:1998, AS/NZS 3808:2000, AS/NZS 5000.1:2005, AS/NZS 1125:2001, AS/NZS 1574:1996, this specification, and all other relevant standards referenced within this specification.

For all designs completed after the release of this Specification cables manufactured and tested to previous or later versions of the Standards shall not be accepted without approval from Manager Primary Systems. Previously approved cables that are required by a design certified less than 12 months prior to the release of this standard can be utilised for construction as required by Company Policy 9.2.5 Network Asset Design.

Cables manufactured to other recognised international standards may be accepted, provided the standards are at least equivalent to the relevant Australian/IEC standards.

Where the relevant Australian/IEC standards and this Specification differ, the requirements of this Specification shall prevail. However, significant inconsistencies should be referred to Manager Primary Systems for resolution.

All cables within the scope of this document are to be reviewed and approved by the Earthing and Power Quality Manager in line with Endeavour Energy product approval process prior to being ordered.

The cables will be installed either direct buried in suitable backfill material, installed in PVC conduits or polyethylene pipes, PVC conduit system or above ground as stated in Table 1.

## **5.2 Requirements exceeding the Australian Standards**

The following requirements are above those contained in AS/NZS 5000.1:2005:-

- Cable markings: additional markings on the external surface of the cable are:  
batch number, cross-sectional area of the conductor, material of the conductor, outer sheathing material, month and year of manufacture in the form 'mm/yyyy' and the conductor code, refer to clause 5.4.6 of this Specification.
- Drum markings: additional markings on the drum are:  
manufacturer's drum serial number, purchase order number with the name of the purchaser, length of cable and the start and finish numbers of the metre marking for the length, gross mass of the drum and the cable, net mass of the cable on the drum, year of manufacture of the cable, and an arrow with the words "CABLE PULLING DIRECTION", refer to clause 5.8.2 of this Specification.

## **5.3 Summary of technical requirements**

The designed one second short circuit temperature of the insulated conductor shall be 250 deg. C. (Refer to Table 53 AS/NZS 3008.1.1) using of the adiabatic method (that is, when heat loss from the current-carrying component during the short circuit is neglected).

**Table 2: Summary of technical requirements**

|                                    |                                                           |
|------------------------------------|-----------------------------------------------------------|
| Conductor class as per AS1125:2001 | Class 2                                                   |
| Rated voltages                     | 0.6/1kV                                                   |
| Rated frequency                    | 50 Hertz                                                  |
| Insulation material                | V-90 or X-90 or X-HF-110 or X-110 as specified in Table 1 |
| Over sheath material               | 5V-90 or HFS-110-TP as specified in Table 1               |

## 5.4 Technical requirements

### 5.4.1 Conductor

The conductors shall be stranded, either aluminium or high conductivity plain annealed copper as specified for each item listed in Table 1 of this Specification. All conductors shall comply with the requirements of AS/NZS 1125:2001.

The aluminium conductors shall be made from alloy 1350 as specified in AS 2848.1:1998.

The chemical composition and temper designation of the annealed copper conductors shall be C11000-O as specified in AS/NZS 1574:1996.

A certificate of chemical composition from the ingot supplier in the case of aluminium conductors, or from the copper rod supplier in the case of copper conductors shall be submitted with the offer.

The minimum number of strands for conductors shall be as stated in Table 1 except for flexible cables. For flexible cables the number of strands of the conductor shall be based on the diameter of strands. The maximum diameter of the strands is 0.31mm (Ref Table 2.5 of AS/NZS 1125) for the flexible cables.

### 5.4.2 Insulation

The insulation of the cable shall be V-90, X-90, X-HF-110 or X-110 as specified in Table 1 and shall comply with the requirements of AS/NZS 3808:2000.

The insulation of single insulated cables are subjected to direct sunlight and shall be a PVC V-90 material complying with the requirements of Clause 6.1.1 of AS/NZS 5001.1-2005 and containing a minimum of 1 % carbon black by weight for UV protection.

Thickness of the insulation means the thickness of V-90, X-90, X-HF-110 or X-110 and does not include any other materials, such as separator tapes. The average and minimum insulation thickness of the completed cables shall be determined by the method specified in AS/NZS 1660.2.1:1998.

The insulation shall be applied over, but shall not adhere to, the conductor.

The average thickness of insulation shall be not less than the nominal thickness and the minimum thickness at any point shall not fall below the nominal thickness by more than 10% of the nominal thickness plus 0.1 mm and shall not fall below the minimum insulation thickness as outlined in 6.3 of AS/NZS 5000.1:2005 and shown in Table 3.

**Table 3: Nominal and minimum insulation thickness**

| Conductor size<br>Single core<br>mm <sup>2</sup> | insulation | Nominal<br>thickness of<br>insulation<br>mm | Minimum<br>thickness of<br>insulation<br>mm |
|--------------------------------------------------|------------|---------------------------------------------|---------------------------------------------|
| 70                                               | V-90       | 1.4                                         | 1.16                                        |
| 95                                               | V-90       | 1.6                                         | 1.34                                        |
| 95                                               | X-90       | 1.1                                         | 0.89                                        |
| 120                                              | V-90       | 1.6                                         | 1.34                                        |
| 240                                              | X-90       | 1.7                                         | 1.43                                        |
| 70                                               | X-HF-110   | 1.1                                         | 0.89                                        |
| 95                                               | X-HF-110   | 1.1                                         | 0.89                                        |
| 120                                              | X-HF-110   | 1.2                                         | 0.98                                        |

For green/yellow insulation one colour shall cover not less than 30% and not more than 70% of the surface area, with the other colour covering the remainder of the surface. Refer to 3.8.1 of AS/NZS 3000.

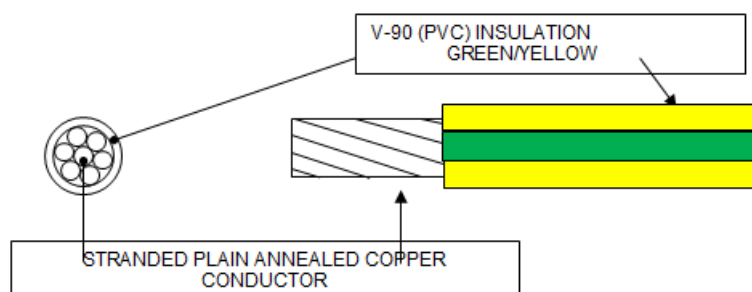
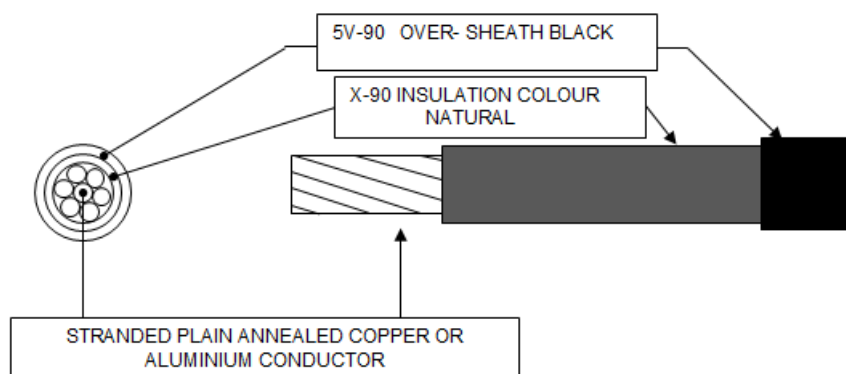
#### 5.4.3 Core identification

Colour identification shall be within the mass of the insulation. Colour identification only at the surface of the insulation is not acceptable.

The colour of the core insulation for double insulated cables shall be natural.

Colour of the over sheath and insulation for single insulated cables are as specified in Table 1. Refer also to Figure 1, 2 and 3.

#### 5.4.4 Illustration of cable construction


**Figure 1-Green\Yellow single insulated earth cable**

**Figure 2- Insulated black over-sheath SDI earth cable**

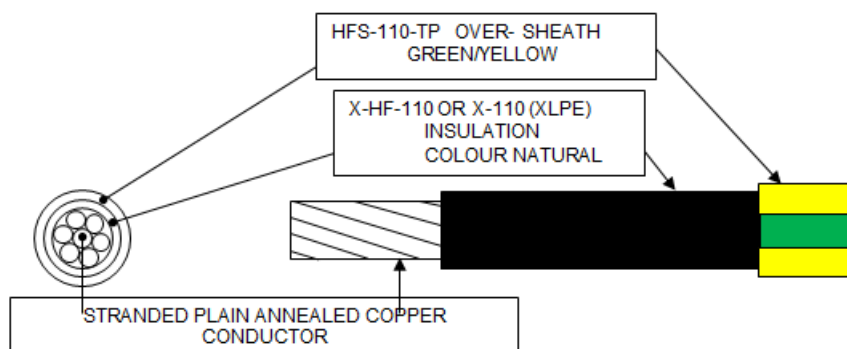


**Figure 3- Insulated Green\Yellow over-sheathed flexible SDI earth cable**

#### 5.4.5 Over sheath

The over sheath shall be PVC 5V-90 or HFS-110-TP as specified in Table 1 and comply with the requirement of AS/NZS 3808:2000, and shall be UV stabilised by the addition of a minimum of 1% carbon black. Colour of the over sheath shall be as specified in Table 1. The over sheath shall comply with AS/NZS 5000.1:2005. For flexible cable over sheath thickness must be based on moving cables as outlined in section 13.4.1 (b) of AS/NZS 5000.1:2005. The nominal and minimum thickness of over-sheath shall be as given in Table 4. The over sheath shall not adhere to the underlying cable component except for the binder tape.

**Table 4: Nominal and minimum over sheath thickness**

| Conductor size<br>mm <sup>2</sup> | Over sheath | Nominal<br>thickness of<br>over-sheath<br>mm | Minimum<br>thickness of<br>over-sheath<br>mm |
|-----------------------------------|-------------|----------------------------------------------|----------------------------------------------|
| 95                                | 5V-90       | 1.5                                          | 1.14                                         |
| 240                               | 5V-90       | 1.7                                          | 1.37                                         |
| 70                                | HFS-110-TP  | 2.5                                          | 1.98                                         |
| 95                                | HFS-110-TP  | 2.7                                          | 2.15                                         |
| 120                               | HFS-110-TP  | 2.9                                          | 2.32                                         |

#### 5.4.6 Cable identification

The following information shall be provided on the outer surface of the insulated earthing cables in accordance with clause 16 of AS/NZS 5000.1:2005, by means of embossing on cables with conductor cross section 240 mm<sup>2</sup>, and embossing or printing on the other cables;

- registered name or registered trade mark that enables the manufacturer of the cable to be identified;
- information, such as batch number, that will help trace the batch in the manufacturing process;
- the words **ELECTRIC EARTHING CABLE**;
- operating voltage expressed in the form U<sub>0</sub>/U<sub>i</sub>;
- cross-sectional area of the conductor;
- material of the conductor;
- material of the insulation;
- outer sheathing material;

- month and year of manufacture in the form 'mm/yyyy'; and
- conductor code (prefix 'CC' followed by a maximum five digit number, which will be supplied to the cable manufacturer upon award of the contract).

**Example:** Cable.Co. XY0123 ELECTRIC EARTHING CABLE 0.6/1kV 240 CU XLPE PVC 01/2015 CC01234.

When the above information is supplied, the supplier/manufacturer shall be able to trace the batch to which the particular piece of cable carrying the information belongs.

The maximum gap between the end of one block of markings and the beginning of the next shall not exceed 550mm.

The legibility of the markings shall be assessed with normal or corrected vision at an illuminance of 400-600 lux at a distance of 300mm.

#### *5.4.7 Metre marking of cable*

Metre markings shall be indelibly printed on the external surface of the insulated cables at one metre intervals, with the end of the cable to be removed first from the cable drum is marked with the highest metre increment. The metre marking shall indicate the cable length remaining on the drum. The metre marking shall be limited to six digits. The printing shall be in a contrasting colour to the colour of the cable outer surface.

### **5.5 Sealing of cable ends**

All conductors of insulated cable shall be fully discharged from any residual voltages/charges prior to sealing of the ends using end caps.

Both ends of each length of insulated earthing cable shall be hermetically sealed using adhesive lined heat shrinkable caps to prevent the ingress of moisture, as shown in Figure 4. Dual end caps to comply with Equipment Technical Specification ETS 0056 - Heat shrinkable end caps for distribution cables, shall be installed. Layers of mastic tape not less than 50mm wide shall be applied over the cable at a distance not less than 30 mm from end of the cable, prior to installing the inner end cap. The inner cap shall provide adequate sealing against the ingress of moisture while the outer end cap shall provide mechanical protection for the inner cap.

Sealed cable ends must be capable of withstanding the compression and tension forces imposed by a stocking grip under the corresponding maximum allowable pulling tension of the cable.

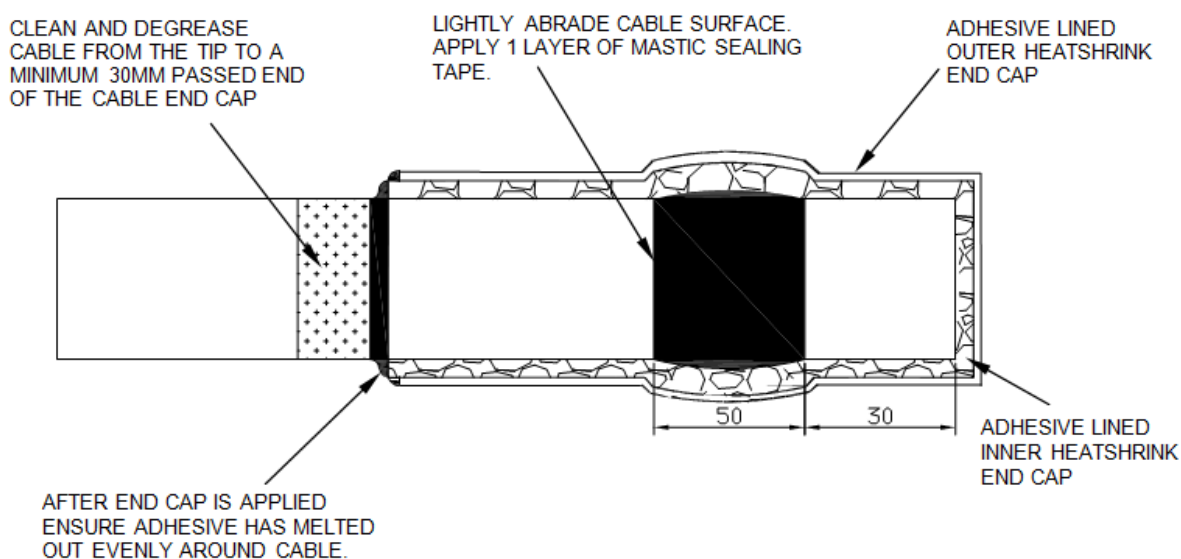


**Figure 4 - Typical cable end sealing detail**

#### 5.5.1 Clamping of bare cable ends

Conductors of bare earthing cables shall be clamped at both ends utilising hose clamps.

### 5.6 Cable testing requirements

The supplier shall provide:

- Qualification Test Reports (QTRs) to cover the range of cables being offered, to show compliance with the test requirements of Table 6 of AS/NZS 5000.1:2005; and
- Sample and routine test reports for each cable being offered in accordance with Table 6 of AS/NZS 5000.1:2005;

All type tests shall be carried out by a testing authority/laboratory holding accreditation:

- by NATA Australia; or,
- by an accreditation authority recognised by NATA Australia.

Tests from other testing authorities may be accepted at the discretion of the Earthing and Power Quality Manager.

All type test reports shall be accompanied by copies of the accreditation certificate(s) issued to the testing laboratory. The accreditation certificate(s) shall be valid for the relevant test(s) and for the duration of the test(s).

Type tests shall be less than five years old. Type tests beyond this limit may be submitted provided sufficient information to demonstrate that the manufacturing process, raw materials, design and quality control processes have not significantly changed since the original test date is also submitted with the offer.

All sample and routine tests may be conducted at the manufacturing facility's test laboratory on the condition that sufficient evidence is provided to demonstrate the testing facility's capability to perform the specified tests. As a minimum, the following information shall be provided:-

- qualifications/experience of the testing employees;
- test procedures for all sample/routine tests;
- testing facility quality control procedures; and
- test instrument calibration certificates/procedures.

All documentation submitted (including reports, tests, testing procedures/policies, calibration certificates and the like) written in any language other than English shall not be accepted unless the reports are translated into English by a sworn translator.

After reviewing above documentation, and if Endeavour Energy is satisfied with the testing facility the Earthing and Power Quality Manager will inform in writing the acceptance of sample and routine tests being conducted at the manufacturing facility's test laboratory.

## **5.7 Testing information format and product approval.**

Technical information and test results must be supplied in the format provided by the Earthing and Power Quality Manager. Technical information and test results together with a copy of each of the test reports and accreditation certificates and product samples shall be submitted for review/approval. Once the product is approved a product approval number is issued for each product.

### *5.7.1 Qualification test report*

The requirements of the qualification test reports (QTRs) are:

- a QTR is defined as a report of results obtained from all type, routine and sample tests;
- a QTR on a cable type with a small and large conductor size in the range shall qualify all sizes of cables from two sizes smaller than the smallest cable tested to two sizes larger than the largest size tested, provided the cables have the same insulation and over sheath designation and manufactured to AS/NZS 5000.1:2005;
- a QTR on a single cable size shall qualify all sizes of cables from two sizes smaller than the cable size tested to two sizes larger than the cable size tested, provided the cables have the same insulation and over sheath designation and manufactured to AS/NZS 5000.1:2005;
- a separate QTR will be required for cables where the insulation or the over sheath designation of the cable varies;
- a QTR covering a multicore cable will qualify a single core cable of that size; and,
- a QTR shall be valid only for the products manufactured in the factory and the same manufacturing line in which the tested product is manufactured.

A separate QTR will be required if any changes are made to the cable insulation/sheath material, cable design or to the manufacturing process.

Separate QTRs will also be required for each manufacturing plant intended to be used for manufacturing cable to this specification. For example, if a supplier sources cable from more than one supplier or a manufacturer operates more than one manufacturing facility, QTRs will be required for each of the manufacturing facilities or sources of supply.

### *5.7.2 Type tests*

All type tests shall be carried out as set out in Table 6 of AS/NZS 5000.1:2005 and 2.5 of AS/NZS 1574:1996. Table 5 below is prepared based on information given in Table 6 of AS/NZS 5000.1:2005 and AS/NZS 1574:1996. All type tests shall be carried out according to the method specified in AS/NZS 1660 relevant to the test.

Type tests shall be repeated should any of the following events occur:

- Changes to the processes of manufacturing.
- Change to design of the cable.
- Change in the materials used, except conductor material that is, copper or aluminium).
- Change in the manufacturing technology.
- Change in source of the raw material.
- Any other circumstances, at the discretion of the relevant organisation.

Table 5: Type Test Requirements

|            | Test required                                                                        | Test reference                      | Pass criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------|--------------------------------------------------------------------------------------|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Insulation | Mechanical test before aging                                                         | Table 6<br>Test 3<br>AS/NZS 5000.1  | i) tensile strength $\geq 12.5$ MPa for X-90 and V-90<br>5 MPa for X-HF-110<br>(Ref Table 5, 7 and 9 of AS/ANZ 3808:2000)<br>ii) elongation at rupture (as a percentage of the un-stretched length) $\geq 200\%$ for X-90,<br>150% for V-90 and<br>125% for X-HF-110<br>(Ref Table 5, 7 and 9 of AS/ANZ 3808:2000)                                                                                                                                                                                                                                                                     |
|            | Mechanical test after aging, as a percentage of values found in unaged specimens.    |                                     | After aging in an air oven for 168 hrs @135 $\pm$ 3 °C for X-90:-<br>i) tensile strength $\geq 75\%$ .<br>ii) elongation at rupture $\geq 75\%$ .<br>(Ref Table 9 of AS/ANZ 3808:2000)<br><br>After aging in an air oven for 504 hrs @115 $\pm$ 2 °C for V-90:-<br>i) tensile strength $\geq 75\%$ .<br>ii) elongation at rupture $\geq 65\%$ .<br>(Ref Table 5 of AS/ANZ 3808:2000)<br><br>After aging in an air oven for 168 hrs @150 $\pm$ 3 °C for X-HF-110:-<br>i) tensile strength $\geq 70\%$ .<br>ii) elongation at rupture $\geq 70\%$ .<br>(Ref Table 7 of AS/ANZ 3808:2000) |
|            | Insulation resistance constant ( $k_i$ )                                             |                                     | For X-90:<br>i) At 20 °C $\geq 3000$ G $\Omega$ .m<br>ii) At 90 °C $\geq 3.0$ G $\Omega$ .m<br>(Ref Table 9 of AS/ANZ 3808:2000)<br><br>For V-90:<br>i) At 20 °C $\geq 40$ G $\Omega$ .m<br>ii) At 90 °C $\geq 0.002$ G $\Omega$ .m<br>(Ref Table 5 of AS/ANZ 3808:2000)<br><br>For X-HF-110:<br>i) At 20 °C $\geq 40$ G $\Omega$ .m<br>ii) At 90 °C $\geq 0.002$ G $\Omega$ .m<br>(Ref Table 7 of AS/ANZ 3808:2000)                                                                                                                                                                   |
|            | Compatibility test after aging, as a percentage of values found in unaged specimens. | Table 6<br>Test 14<br>AS/NZS 5000.1 | After aging in an air oven for 240 hrs @100 $\pm$ 2 °C:-<br>i) tensile strength $\geq 75\%$ .<br>ii) elongation at rupture $\geq 65\%$ .                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|            | Acid and corrosive gas emission:                                                     | Table 7 of<br>AS/ANZ<br>3808:2000   | For X-Hf-110:<br>i) PH $\geq 3.5$<br>ii) Conductivity( $\mu$ S $\text{cm}^{-1}$ ) $\leq 100$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

|                     | Test required                                                                     | Test reference                     | Pass criteria                                                                                                                                                                                                                                                                                                                                                                             |
|---------------------|-----------------------------------------------------------------------------------|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Oversheath/Covering | Mechanical test before aging                                                      | Table 6<br>Test 4<br>AS/NZS 5000.1 | For 5V-90:<br>i) tensile strength $\geq 12.5$ MPa<br>ii) elongation at rupture (as a percentage of the un-stretched length) $\geq 150\%$ .<br>(Ref Table 6 of AS/ANZ 3808:2000)<br><br>For HFS-110-TP:<br>i) tensile strength $\geq 6$ MPa<br>ii) elongation at rupture (as a percentage of the un-stretched length) $\geq 125\%$ .<br>(Ref Table 8 of AS/ANZ 3808:2000)                  |
|                     | Mechanical test after aging, as a percentage of values found in unaged specimens. |                                    | After aging in an air oven for 504 hrs @ $115 \pm 2$ °C for 5V-90:-<br>i) tensile strength $\geq 75\%$ .<br>ii) elongation at rupture $\geq 65\%$ .<br>(Ref Table 6 of AS/ANZ 3808:2000)<br>After aging in an air oven for 480 hrs @ $110 \pm 2$ °C for HFS-110-TP:-<br>i) tensile strength $\geq 6\%$ .<br>ii) elongation at rupture $\geq 100\%$ .<br>(Ref Table 8 of AS/ANZ 3808:2000) |
|                     |                                                                                   |                                    |                                                                                                                                                                                                                                                                                                                                                                                           |
|                     | Loss of mass                                                                      |                                    | After 120 hrs @ $115 \pm 2$ °C for 5V-90:-<br>$\leq 2.5$ mg/cm <sup>2</sup><br>(Ref Table 6 of AS/ANZ 3808:2000)                                                                                                                                                                                                                                                                          |
|                     | Pressure test at high temperature                                                 |                                    | For 5V-90:<br>Test temperature @ $90 \pm 2$ °C:-<br>Indentation (as a percentage of mean thickness of the test piece) $\leq 50\%$<br>(Ref Table 6 of AS/ANZ 3808:2000)<br>For HFS-110-TP:<br>Test temperature @ $90 \pm 2$ °C:-<br>Indentation (as a percentage of mean thickness of the test piece) $\leq 50\%$<br>(Ref Table 8 of AS/ANZ 3808:2000)                                     |
|                     | Exudation of plasticizers                                                         |                                    | For 5V-90:<br>When subjected to pressure not less than 3.5MPa at a temperature of $23 \pm 2$ °C:-<br>There shall be no greasiness or droplets of liquid.                                                                                                                                                                                                                                  |

|                   | Test required                                                                        | Test reference                         | Pass criteria                                                                                                                                                                                                                                                                                                       |
|-------------------|--------------------------------------------------------------------------------------|----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                   | Compatibility test after aging, as a percentage of values found in unaged specimens. | Table 6<br>Test 14<br>AS/NZS 5000.1    | After aging in an air oven for 240 hrs @100±2 °C for 5V-90, and 120±2 °C for HFS-110-TP :-<br>i) tensile strength ≥75%.<br>ii) elongation at rupture ≥65%.                                                                                                                                                          |
|                   | Oil immersion:                                                                       | Table 8 of<br>AS/ANZ<br>3808:2000      | For HF110-R:<br>After immersion in oil at 120±30C for 18hrs:<br>i) Tensile strength ≥60%<br>ii) Elongation at rupture ≥60%                                                                                                                                                                                          |
|                   | Acid and corrosive gas emission:                                                     | Table 8 of<br>AS/ANZ<br>3808:2000      | For HFS-110-TP PH≥3.5<br>i) Conductivity(μScm-1)≤100                                                                                                                                                                                                                                                                |
| Cable             | High voltage a.c. test for 4 hrs                                                     | Table 6<br>Test 10<br>AS/NZS 5000.1    | High Voltage of 1.8kV a.c between conductor/s and the water in which the cable is immersed shall be applied for four hours:-<br>No breakdown shall occur.                                                                                                                                                           |
|                   | Vertical flame propagation                                                           | Table 6<br>Test 15<br>AS/NZS 5000.1    | The distance between the lower edge of the top support and the onset of charring shall be greater than 50mm.<br>The charring shall not extend downwards to a point greater than 540mm from the lower edge of the top support.<br>During the test, any falling particles shall not ignite the filter paper underlay. |
|                   | Legibility of marking on the outer surface                                           | Table 6<br>Test 16<br>AS/NZS 5000.1    | The marking shall be legible with normal or corrected vision at an luminance of 400-600 lux.                                                                                                                                                                                                                        |
| Bare Copper Cable | Diameter tolerances                                                                  | Clause 2.5.1 of<br>AS/NZS<br>1574:1996 | The deviation of the mean diameter from specified shall not exceed ±0.05mm.                                                                                                                                                                                                                                         |
|                   | Ovality                                                                              | Clause 2.5.2 of<br>AS/NZS<br>1574:1996 | Ovality shall not exceed ±0.05mm.                                                                                                                                                                                                                                                                                   |

|  | Test required          | Test reference                   | Pass criteria                                                 |
|--|------------------------|----------------------------------|---------------------------------------------------------------|
|  | Electrical resistivity | Clause 2.6.1 of AS/NZS 1574:1996 | Electrical resistivity @ 20 deg C shall not exceed 17.241nΩ.m |

### 5.7.3 Sample tests

All sample tests stated in Table shall be carried out. Table 6 below has been prepared based on information given in Table 6 of AS/NZS 5000.1:2005. All sample tests shall be carried out according to the method specified in AS/NZS 1660 relevant to the test.

**Table 6: Sample Test Requirements**

|           | Test required                                                                                                                                                                                                                                                                                                                                                                                                      | Test reference                     | Pass criteria                                                                                                       |                                     |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|---------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| Conductor | Elongation of wires (strands) of the conductor – copper conductors only<br>(For compacted conductors this test shall be completed prior to stranding)<br><br><b>Note:</b> Provided that the minimum average elongation of all wires tested is maintained, any individual wire or group of wires removed from a multiple wire conductor may have an elongation of not less than 50% of the appropriate value shown. | Table 6<br>Test 1<br>AS/NZS 5000.1 | The average elongation appropriate to the wire diameter shall be not less than the corresponding value given below. |                                     |
|           |                                                                                                                                                                                                                                                                                                                                                                                                                    |                                    | Wire diameter mm                                                                                                    | Minimum average elongation %        |
|           |                                                                                                                                                                                                                                                                                                                                                                                                                    |                                    | ≤0.14                                                                                                               | 5                                   |
|           |                                                                                                                                                                                                                                                                                                                                                                                                                    |                                    | >0.14 ≤0.21                                                                                                         | 9                                   |
|           |                                                                                                                                                                                                                                                                                                                                                                                                                    |                                    | >0.21 ≤0.51                                                                                                         | 14                                  |
|           |                                                                                                                                                                                                                                                                                                                                                                                                                    |                                    | >0.51 ≤1.36                                                                                                         | 18                                  |
|           |                                                                                                                                                                                                                                                                                                                                                                                                                    |                                    | >1.36                                                                                                               | 22                                  |
|           | Tensile strength of solid core or wires (strands) of the conductor (MPa) – aluminium conductors only<br><b>Note :</b> Minimum number of individual wires to be tested for the tensile strength shall be the square root of the total number of wires in the conductor (to the nearest whole number), subject to a maximum of 20 wires.                                                                             |                                    | Stranded conductors:- ≥120 MPa and ≤205 MPa                                                                         |                                     |
|           | Conductor d.c. resistance                                                                                                                                                                                                                                                                                                                                                                                          | Table 6<br>Test 2<br>AS/NZS 5000.1 | Conductor size (mm <sup>2</sup> )                                                                                   | Maximum dc resistance @20 °C (Ω/km) |
|           |                                                                                                                                                                                                                                                                                                                                                                                                                    |                                    | Copper conductor                                                                                                    |                                     |

|                     | Test required                                | Test reference                     | Pass criteria                                                                                                                                                                                                             |        |
|---------------------|----------------------------------------------|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
|                     |                                              |                                    | 70                                                                                                                                                                                                                        | 0.268  |
|                     |                                              |                                    | 95                                                                                                                                                                                                                        | 0.193  |
|                     |                                              |                                    | 120                                                                                                                                                                                                                       | 0.153  |
|                     |                                              |                                    | 240                                                                                                                                                                                                                       | 0.0754 |
|                     |                                              |                                    | Aluminium conductor                                                                                                                                                                                                       |        |
|                     |                                              |                                    | 95                                                                                                                                                                                                                        | 0.320  |
| Insulation          | Hot set test                                 | Table 6<br>Test 3<br>AS/NZS 5000.1 | For X-90 and X-HF-110:<br>At a temperature of 200±3 °C for 15 mins. Under a load of 200kPa:-<br>i) elongation under load ≤175%<br>ii) residual elongation after cooling ≤15%.<br>(Ref Table 5, 7 & 9 of AS/ANZ 3808:2000) |        |
|                     | Measurement of insulation thickness          | Table 6<br>Test 5<br>AS/NZS 5000.1 | The average and the minimum thickness shall comply with clause 5.4.2 and the relevant values given in Table of this specification.                                                                                        |        |
| Oversheath/Covering | Heat shock                                   | Table 6<br>Test 4<br>AS/NZS 5000.1 | For 5V-90 and HFS-110-TP:<br>There shall be no cracks.                                                                                                                                                                    |        |
|                     | Measurement of oversheath/covering thickness | Table 6<br>Test 6<br>AS/NZS 5000.1 | The average and the minimum thickness shall comply with clause 5.4.5 and the appropriate values given in Table 4 of this specification.                                                                                   |        |

#### 5.7.4 Routine Tests

All routine tests shall be carried out as set out in Table 6 of AS/NZS 5000.1:2005. Table 7 below has been prepared based on information given in Table 6 of AS/NZS 5000.1:2005. All routine tests shall be carried out in according to the method specified in AS/NZS 1660 relevant to the test.

Table 7: Routine Test Requirements

|            | Test required | Test reference                      | Pass criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------------|---------------|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Insulation | Spark test    | Table 6<br>Test 11<br>AS/NZS 5000.1 | The value of the voltage that is applied between the contact electrode and the conductor shall be as follows:-<br>i) if the minimum insulation thickness is $>1$ and $\leq 1.5$ mm, an a.c. voltage of 10 kV r.m.s. at 50 Hz or a d.c. voltage of 15 kV.<br>ii) if the minimum insulation thickness is $>1.5$ and $\leq 2.0$ mm, an a.c. voltage of 15 kV r.m.s. at 50 Hz or a d.c. voltage of 23 kV.<br>No breakdown shall occur.<br>Refer AS/NZS 1660.3;1998. |

## 5.8 Cable drum requirements

### 5.8.1 General Requirement

The cable shall be supplied on timber drums manufactured in accordance with AS/NZS 2857:1996 or metal drums in accordance with AS/NZS 3983:1991 and shall be suitable for outdoor storage. The spindle holes shall be fitted with steel spindle plates. Drums with spindle tubes will not be accepted.

Only one continuous length of cable shall be wound on each drum.

Wooden drums shall be treated or lined on both the barrel and the inner face of the flange with a robust and impervious material to prevent damage to the cable due to leaching of wood acids.

### 5.8.2 Marking

The cable drums shall be permanently marked in accordance with Clause 16.4 of AS/NZS 5000.1:2005. The following information shall be on the drums:

- The complying Australian Standard for the cable.
- A registered name or registered trade mark that enables the manufacturer of the cable to be identified.
- Manufacturer's drum serial number
- Purchase order number with the name of the purchaser (Endeavour Energy).
- Voltage rating e.g. 0.6/1 kV.
- Number of cores and cross sectional area of conductors.
- Conductor material.
- Designation of insulation and sheath.
- Length of cable and the start and finish numbers of the metre marking for the length.
- Gross mass of the drum and the cable.
- The net mass of the cable on the drum.

- An arrow with the words “CABLE PULLING DIRECTION” shall be marked on the outer face of both flanges.
- Year of manufacture of the cable.

#### **5.8.3 Protective lagging**

Wooden battens or an equivalent substantial mechanical protective material shall protect the cable.

### **5.9 Product approval for earthing cables purchased outside the tender process**

All earthing cables for which approval is sought shall comply with this Specification. All applicants (suppliers/manufacturers) seeking approval shall provide documentation as outlined in 5.9.1 and product samples (refer to 5.10) to follow the Endeavour Energy's product approval process. Once the product is approved a product approval number is issued for each product.

#### **5.9.1 Documentation required**

The applicant (supplier/manufacturer) who requests the approval of a cable shall provide the following documentation to the Earthing and Power Quality Manager with the application:

- technical information for the product in the format provided by Endeavour Energy's Earthing and Power Quality Manager;
- copies of accreditation certificate/s issued to the testing laboratory to cover all type tests;
- copies of test report for all type, sample and routine tests listed in Table 5 for all items in the application; and,
- written confirmation from the cable manufacturer that the product complies with this specification.

### **5.10 Sample of cables**

Suppliers must submit sample/s for inspection when requested, at no cost to the purchaser. A 1.5 metre sample of each cable type being offered would suffice.

The complete cable identification complying with clause 5.4.6 of this Specification shall be clearly visible on sample/s. Sample/s shall be capped as per the requirements of clause 5.5 of this specification.

### **5.11 Safety Data Sheet (SDS)**

A Safety Data Sheet (SDS) for each material used in the manufacturing of the cable shall be provided with the offer.

### **5.12 Environment consideration**

Suppliers are required to demonstrate if each component of the product can be recycled and/or disposed of at the end of products life (for example, recycling of aluminium conductor). Any materials that cannot be recycled shall be listed and recommended disposal / handling processes provided.

### **5.13 Service history**

Suppliers shall state:

- The period of service of the items being offered within the Australian environmental conditions.
- Australian Customers/Electricity Supply Authorities who have a service history of the items being offered.
- Contact names and telephone numbers of relevant employees of those customers/electricity supply authorities who can verify the service performance claimed.

#### 5.14 Quality assurance

The supplier and/or manufacturer shall provide with the offer a certificate of Quality Management System in accordance with AS/NZS ISO 9001 or similar and/or an Environmental Management System in accordance with AS/NZS ISO 14001 or similar.

### 6.0 AUTHORITIES AND RESPONSIBILITIES

**Chief Engineer** has the authority and the responsibility for:

- approving technical specifications, including any variations;
- making all decisions concerning compliance with this Specification;
- approving nominations of Endeavour Energy representatives;
- delegating any of these authorities and responsibilities to the Manager Primary Systems.

**Manager Primary Systems** has the authority and responsibility for:

- review this Specification and making recommendations to the Chief Engineer;
- making recommendations concerning compliance with this Specification; and,
- making nominations of Endeavour Energy representatives.

**Earthing and Power Quality Manager** has the authority and responsibility for:

- assessing the manufacturing facilities and their capability to perform the specified tests;
- reviewing all test reports submitted and making recommendations to the Manager Primary Systems; and
- Approving the product and allocating a product approval numbers.

**Commercial Manager** has the authority and responsibility for certifying that all earthing cables purchased through the tender process complies with the requirements of this Specification.

**Contractor Operations Manager** has the authority and responsibility that all earthing cables installed by Level 1 and Level 2 Accredited Service Providers comply with the requirements of this Specification.

**Manager Project Developments** has the authority and responsibility for all earthing cables installed by Endeavour Energy employees and Accredited Service Providers/contractors comply with the requirements of this specification.

**Manufacturers/suppliers** have the authority and responsibility for:

- awareness of their responsibilities under this instruction;
- confirming that the ASPs under their control have provided suitable training for their employees;
- maintaining that an effective quality auditing system in place; and
- implementing this instruction and keeping Endeavour Energy or other responsible equivalent officers informed of any factors that may prevent them from accepting responsibility for its full implementation.

### 7.0 DOCUMENT CONTROL

**Documentation content coordinator:** Earthing and Power Quality Manager

**Documentation process coordinator:** Standards Process Coordinator