

AS 1049.2:2022



STANDARDS
Australia



Telecommunication cables — Insulation, sheath and jacket

Part 2: Test methods



AS 1049.2:2022

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- KNX National Group
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Additional Interests

- BICSI South Pacific (New Zealand)
- Telecommunications Users Association of New Zealand
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Telecommunication cables — Insulation, sheath and jacket

Part 2: Test methods

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Preface

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee CT-001, Communications Cabling, to supersede AS 1049.2—2008.

The objective of this document is to specify test methods to evaluate the properties of materials used to manufacture telecommunication cables. This document is intended for use by polymer manufacturers, communication cable manufacturers and end-users.

AS 1049 is divided in two parts, as follows:

AS 1049.1, *Telecommunication cables — Insulation, sheath and jacket, Part 1: Materials*

AS 1049.2, *Telecommunication cables — Insulation, sheath and jacket Part 2: Test methods* (this document)

Part 1 specifies the material requirements for the insulation, sheath and jacket of the finished products and some of the compounds used to manufacture telecommunication cables.

Part 2 provides a set of reference test methods for evaluating these material requirements.

The major changes in this edition are as follows:

- (a) Removal of [Appendix C](#) Test method 3: Softness number.
- (b) Correction of the ASTM G155 weatherometer apparatus types in [Appendix E](#).
- (c) Addition of thermogravimetric analysis as per IEC 60811-605 as an alternative test method for the determination of the carbon black concentration in [Appendix R](#).
- (d) Apparatus changed from as specified in AS/NZS 2122.2 to as specified in ISO 4589-2 for the combustion test in [Appendix DD](#).
- (e) Update of reference designation from AS/NZS 1660.5.4 to AS/NZS IEC 60754.2 for the acidity of gases evolved during combustion test in [Appendix EE](#).
- (f) General update to meet the requirements of Standards Australia drafting rules, including dividing test methods into consistent subclauses (where appropriate) and the addition of the test report subclause where previously missing.

The terms “normative” and “informative” are used in Standards to define the application of the appendices or annexes to which they apply. A “normative” appendix or annex is an integral part of a Standard, whereas an “informative” appendix or annex is only for information and guidance.

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Australian Standard®

Telecommunication cables — Insulation, sheath and jacket

Part 2: Test methods

Section 1 Scope and general

1.1 Scope

This document specifies test methods to evaluate the properties of materials used to manufacture telecommunication cables.

This document does not include the following:

- (a) Cables using non-metallic semi-conductive compound.

NOTE In the context of this document, semi-conductive compound is a polymer with the addition of a conductive additive such as carbon black which increases the conductivity of the polymer.

- (b) Aspects of telecommunication cables such as spacers or cores in coaxial cables.
- (c) Dimensions or electrical requirements of completed cables.
- (d) Cables used to conduct mains electrical power.

[Table 2.1](#) provides a summary of the material tests that are set out in the Appendices of this document.

1.2 Application

This document is intended for use by the following:

- (a) Polymer manufacturers, to form the basis of the raw material quality control procedures for the manufacture of polymer compounds.
- (b) Cable manufacturers, to form the basis of the cable material quality control procedures for the manufacture of a range of insulation, sheath and jacket of different materials.
- (c) Cable end users, to form the basis of the cable acceptance procedures for the completed cable.

1.3 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document.

NOTE Documents referenced for informative purposes are listed in the Bibliography.

AS 1049.1, *Telecommunication cables—Insulation, sheath and jacket, Part 1: Materials*

AS 2700, *Colour standards for general purposes*

AS 4004, *Lighting booths for visual assessment of colour and colour matching*

AS/NZS 1580.601.3, *Paints and related materials—Methods of test, Method 601.3: Colour—Methods of colour measurement*

AS/NZS 1660.2.1:1998, *Test methods for electric cables, cords and conductors, Method 2.1: Insulation, extruded semi-conductive screens and non-metallic sheaths—Methods for general application*

AS/NZS 1660.2.2, *Test methods for electric cables, cords and conductors, Method 2.2: Insulation, extruded semi-conductive screens and non-metallic sheaths—Methods specific to elastomeric, XLPE and XL PVC materials*

AS/NZS 1660.2.3:1998, *Test methods for electric cables, cords and conductors, Method 2.3: Insulation, extruded semi-conductive screens and non-metallic sheaths—Methods specific to PVC and halogen free thermoplastic materials*

AS/NZS 1660.2.4:1998, *Test methods for electric cables, cords and conductors, Method 2.4: Insulation, extruded semi-conductive screens and non-metallic sheaths—Methods specific to polyethylene and polypropylene materials*

AS/NZS 1660.3:1998, *Test methods for electric cables, cords and conductors, Method 3: Electrical tests*

AS/NZS IEC 60754.2, *Test on gases evolved during combustion of materials from cables, Part 2: Determination of acidity (by pH measurement) and conductivity*

IEC 60304, *Standard colours for insulation for low-frequency cables and wires*

IEC 60811-605, *Electric and optical fibre cables — Test methods for non-metallic materials, Part 605: Physical tests — Measurement of carbon black and/or mineral filler in polyethylene compounds*

ISO 1183-1, *Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pycnometer method and titration method*

ISO 4589-2, *Plastics — Determination of burning behaviour by oxygen index — Part 2: Ambient-temperature test*

ISO 18553, *Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds*

ASTM D1531, *Standard Test Methods for Relative Permittivity (Dielectric Constant) and Dissipation Factor by Fluid Displacement Procedures*

ASTM D3349, *Standard Test Method for Absorption Coefficient of Ethylene Polymer Material Pigmented with Carbon Black*

ASTM D4565, *Standard Test Methods for Physical and Environmental Performance Properties of Insulations and Jackets for Telecommunications Wire and Cable*

ASTM G152, *Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials*

ASTM G153, *Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials*

ASTM G155, *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*

EIA-359, *Standard colors for color identification and coding*

GR-421-CORE, *Generic Requirements for Metallic Telecommunications Cables*

1.4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

1.4.1

cable construction

1.4.1.1

air-core cable

cable construction where the interstices of the cable are not filled

1.4.1.2**filled cable****jelly-filled cable**

cable construction that has a cable core that is filled with a jelly-like substance which prevents water from seeping or flowing along the length of the cable in the event of a rupture through the protective sheath layer

1.4.1.3**integrally bonded PE sheath and PA jacket****bonded cable construction**

cable construction where the polyethylene (PE) sheath is integrally bonded to the polyamide (PA) jacket by chemical modification or by multiple processing technique, or by both

Note 1 to entry: This may be achieved using specially formulated PE or the addition of a bonding agent.

1.4.1.4**moisture-barriered cable**

cable construction that has an aluminium moisture barrier tape to prevent moisture permeation into the cable core

1.4.1.5**unbonded cable construction**

cable construction without integrally bonded PE sheath and PA jacket

1.4.2**colour system****1.4.2.1****chroma**

purity of colour or freedom from white or grey

Note 1 to entry: Refer to EIA-359 for a detailed explanation of chroma in the Munsell colour system.

1.4.2.2**hue**

variety of colour

Note 1 to entry: Refer to EIA-359 for a detailed explanation of hue in the Munsell colour system.

Note 2 to entry: Red, yellow, green, blue and purple are examples of hues in the Munsell colour system.

1.4.2.3**value**

lightness of colour

Note 1 to entry: Refer to EIA-359 for a detailed explanation of value in the Munsell colour system.

1.4.3**laboratory equipment****1.4.3.1****air oven**

chamber with controlled temperature, air flow and air exchange used to age a specimen of material by heating

1.4.3.2**apparatus**

instrument for the nominated tests

1.4.3.3**mandrel**

cylinder against which test specimen is shaped or wound

1.4.3.4

Nessler cylinder

clear laboratory glass tubes used for colour comparison

1.4.3.5

weatherometer

apparatus used to simulate weather ageing effects on a specimen of material by exposure to controlled light and moisture

1.4.4

layers of cable

Note 1 to entry: [Figure 1.1](#) shows examples of cable construction.

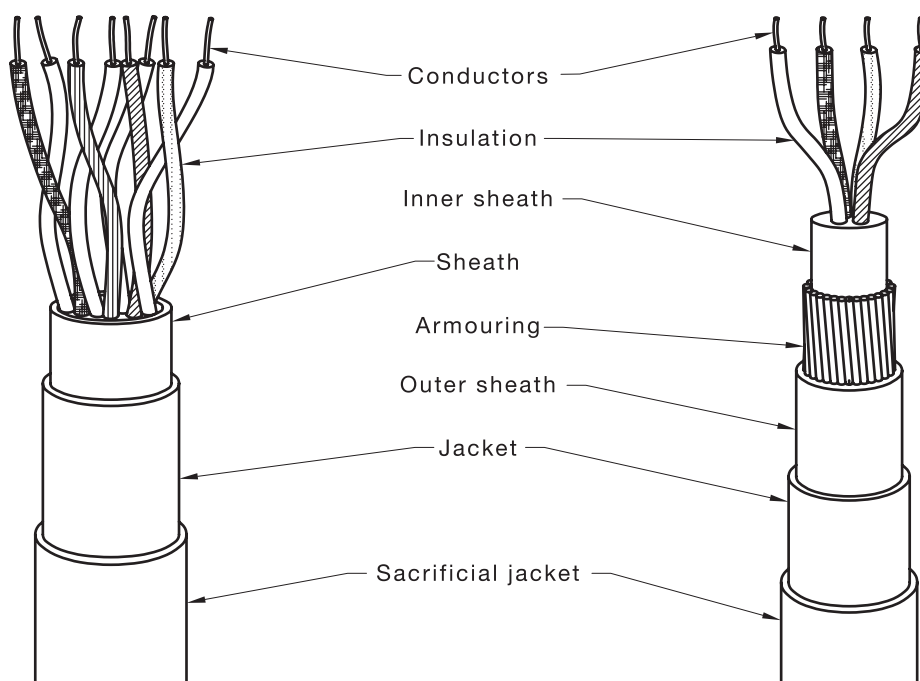


Figure 1.1 — Examples of cable construction

1.4.4.1

aluminium moisture barrier moisture barrier

aluminium tape bonded to the inner surface of the sheath to prevent moisture permeation into the cable core

Note 1 to entry: The aluminium tape may also serve as an electrical screen.

1.4.4.2

armouring

layer over the sheath of a cable to protect the installed cable against, for example, rodents or mechanical equipment

Note 1 to entry: The armouring may be bonded to the sheath and is typically manufactured from steel tape, wire or corrugated sheet. An example is rodent resistant armouring over a PE sheath with an outer sheath of PE and a PA jacket.

1.4.4.3**cellular insulation**

insulation with small air- or gas-filled cells uniformly dispersed

Note 1 to entry: Cellular insulation is manufactured by using a blowing agent compounded in the granules or by using air- or gas-blowing at the extrusion process.

1.4.4.4**core**

assembly of insulated conductors, coaxial elements and optical fibre elements, or any combination of these elements

1.4.4.5**filling compound**

jelly-like substance which prevents water from seeping or flowing along the length of cable

1.4.4.6**foam-skin insulation**

insulation with a cellular layer covered with a solid layer

1.4.4.7**insulated conductor**

conductor with insulation

1.4.4.8**insulation**

single or multiple layer of the same or different dielectric material(s) over the conductors

Note 1 to entry: An example of multiple layer insulation is foam-skin insulation.

1.4.4.9**jacket**

protective layer over the sheath of a cable

Note 1 to entry: Examples are a PE jacket over a metallic sheath and a PA jacket over a PE sheath.

1.4.4.10**sheath**

protective layer, for example, an inner sheath over the core of a cable or an outer sheath over the armouring

1.4.4.11**solid insulation**

insulation in which the dielectric material is continuous without air- or gas-filled cells

1.4.5**materials and material properties of cables****1.4.5.1****bonding agent**

chemical additive used to integrally bond polyethylene to polyamide

1.4.5.2**carbon black**

form of paracrystalline carbon added to polymer for UV stability

1.4.5.3**colour bleeding**

migration of a colourant from the plastic it is added to, into any materials in contact with this plastic

Note 1 to entry: Factors that affect colour bleeding are an increase in temperature, compatibility with the plastic and compatibility with the contact material.

1.4.5.4**compound**

polymer from the polymer manufacturer before it undergoes any cable manufacturing processes

1.4.5.5**conditioning**

subjection of a specimen for a specified duration to specific climatic conditions (usually a specified temperature and a specified relative humidity) or to an atmosphere of specified relative humidity or to complete immersion in water or other liquid

[SOURCE: IEC 60050-212]

1.4.5.6**crack**

circumferential break in the insulation, sheath and jacket

Note 1 to entry: Unless stated otherwise in the test method, cracks are to be observed using normal or corrected vision.

1.4.5.7**dielectric dissipation factor** **$\tan \delta$** **loss tangent**

absolute value of the ratio of the imaginary to the real part of the complex relative permittivity, $\tan \delta = \epsilon'' / \epsilon'$

[SOURCE: IEC 60050-212]

Note 1 to entry: The dielectric dissipation factor is equal to the tangent of the dielectric loss angle.

Note 2 to entry: In English the abbreviation DDF is sometimes used to characterize the dielectric loss in insulating materials.

1.4.5.8**indentation**

recess or notch on a surface

1.4.5.9**PE category**

classification of PE according its melt-flow rate

Note 1 to entry: Refer to AS 1049.1 for limits for each PE category.

1.4.5.10**PE type**

classification of PE according its density

Note 1 to entry: Refer to AS 1049.1 for limits for each PE type.

1.4.5.11**relative permittivity**

DEPRECATED: relative dielectric constant

DEPRECATED: dielectric constant

DEPRECATED: permittivity

scalar quantity or tensor quantity equal to the absolute permittivity divided by the electric constant

[SOURCE: IEC 60050-121]

1.4.5.12**temperature rating**

maximum continuous temperature of the cable

Note 1 to entry: Refer to AS 1049.1 for further details of the temperature ratings used in this document.

1.4.5.13**unaged**

test specimen that has not obtained any material degradation from exposures or stress from either thermal source, radiation sources (e.g. UV), chemical sources, environmental sources and electrical (current or voltage) sources

1.4.5.14**volatile loss**

weight loss from the test specimen under defined conditions of time and temperature

1.4.5.15**volume resistivity**

measure of material resistance to current flow through the volume

1.4.6**may**

indicates the existence of an option

1.4.7**shall**

indicates that a statement is mandatory

1.4.8**should**

indicates a recommendation

1.5 Abbreviations

The following abbreviations are used in this document:

°C	degrees Celsius
CIE	International Commission on Illumination
CIE $L^*a^*b^*$	CIELAB colour space
cm	centimetre
d	day
d.c.	direct current
ΔC	change of capacitance
ECTFE	copolymer of ethylene and chlorotrifluoroethylene
ESCR	environmental stress cracking resistance
ETFE	copolymer of ethylene and tetrafluoroethylene
FEP	copolymer of tetrafluoroethylene and hexafluoropropylene
g	gram
h	hour
HFFR	halogen free flame retardant
HT	high temperatures (indicating that the cable can operate at high temperatures for limited time)
K	degrees kelvin
kg	kilogram

kPa	kilopascal
kV	kilovolt
L	litre
lx	lux
m	metre
MFI	melt-flow index
mg	milligram
MHz	megahertz
min	minute
mL	millilitre
mm	millimetre
MPa	megapascal
N	newtons
NA	not applicable
nm	nanometre
OIT	oxidation induction time
PA	polyamide
PA 12	polyamide 12
PE	polyethylene
PFA	poly(perfluoro alkoxy alkane)
pH	potential of hydrogen
PP	polypropylene
PPO	poly(phenylene oxide)
PTFE	polytetrafluoroethylene
PVC	poly(vinyl chloride)
PVDF	poly(vinylidene fluoride)
rev	revolutions
RH	relative humidity
s	second (unit of time)
UV	ultraviolet
µm	micrometre
µS	micro-Siemen
V	volt
W	Watt
XL	cross-linked
XLEVA	cross-linked poly(ethylene-vinyl acetate)
XLPE	cross-linked polyethylene
XLPO	cross-linked polyolefin
XL PVC	cross-linked poly(vinyl chloride)

Section 2 Summary of material tests

[Table 2.1](#) provides an informative summary of the required tests as specified in AS 1049.1.

Table 2.1 — Summary of material tests

Test		Appendix	PE ins.	PA 12 ins.	PPO ins.	PVC ins.	PP ins.	PE sheath, jacket	PA jacket	Integrally bonded PE/PA	PVC sheath, jacket	HFFR ins., sheath, jacket	Fluoro- polymer ins., sheath, jacket	Crosslinked polymer ins., sheath, jacket
1	Density	A	comp.					comp.						
2	Melt-flow index	B	comp.					comp.						
4	Hot set test	D												✓
5	Tensile strength at break/yield	E		✓	✓	✓	✓		✓		✓	✓	✓	✓
	After ageing test			✓		✓	✓				✓	✓	✓	✓
6	Elongation at break		ins.	✓	✓	✓	✓	sj	✓	✓	✓	✓	✓	✓
	After ageing test		ins.	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
7	Flexibility after ageing	F											PVDF only	
8	Pressure test at high temperature	G										sj		
9	Shrinkback	H	ins.		✓	✓	✓				✓	✓	ins.	ins.
10	Stripping	I		✓	✓	✓								
11	Cold bend performance	J		✓		✓	✓				✓	ins.	✓	✓
12	Heat shock	K		✓								sj		
13	ESCR	L						✓						
14	Bond strength	M								✓				
	After ageing test									✓				
15	Bending performance	N							✓	✓				
16	Filling compound compatibility	O	ins.											
17	Corrosion	P				✓								
18	Volatile loss	Q			✓	✓					✓			
19	Carbon black concentration	R						✓	✓	✓				
20	Carbon black dispersion	S						✓	✓	✓				
21	Absorption coefficient	T						✓						
22	Visual colour difference	U	ins.	✓	✓	✓	✓				✓	✓	✓	✓

Table 2.1 (continued)

Test		Appendix	PE ins.	PA 12 ins.	PPO ins.	PVC ins.	PP ins.	PE sheath, jacket	PA jacket	Integrally bonded PE/PA	PVC sheath, jacket	HFFR ins., sheath, jacket	Fluoro- polymer ins., sheath, jacket	Crosslinked polymer ins., sheath, jacket
23	Instrumental colour difference	V						✓	✓	✓				
24	Colour bleeding	W	ins.	✓	✓	✓	✓					ins.	ins.	ins.
25	Colourfastness in water	X	ins.	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
26	Plasticizer compatibility	Y				✓					✓			
27	Volume resistivity	Z				✓								
28	Dielectric strength	AA				✓								
29	Spark test	BB	ins.	✓	✓	✓	✓					ins.	ins.	ins.
30	Dielectric dissipation factor	CC	comp.											
31	Relative permittivity		comp.											
32	Combustion	DD			✓	✓					✓	sj		
33	Acidity of gases	EE			✓							sj		
34	Thermal ageing	FF	ins.											
35	Wrapping	Refer to AS 1049.1	ins.											
36	Long-term stability	Refer to AS 1049.1	ins.											
37	OIT	Refer to AS 1049.1						sj						
Key comp. = compound ins. = insulation sj = sheath and jacket ✓ = insulation, sheath or jacket as indicated in column heading														

Appendix A (normative)

Test method 1: Density

A.1 Principle

This Appendix sets out the method for determining the density of a polymer compound.

Specimens of polymer compound are tested in accordance with ISO 1183-1 by one of the following three methods:

- (a) Method A — Immersion method is utilized for void-free solid plastics (except for powders). The test specimen is weighted in air and weighted while immersed in a liquid. The difference in mass and the density of the immersion liquid are used to calculate the specimen density.
- (b) Method B — Liquid pycnometer method is utilized for particles, powders, flakes, granules or small pieces. A pycnometer containing the test specimen and filled to capacity with the immersion liquid is weighted. The pycnometer without the test specimen and filled to capacity with the immersion liquid is also weighted. The difference in mass and the density of the immersion liquid are used to calculate the specimen density.
- (c) Method C — Titration method is utilized for void-free plastics. Pieces of test specimens are placed in a cylinder containing a specific amount of an immersion liquid with a density lower than the test specimens. Another immersion liquid with a density higher than the test specimens is gradually added to the cylinder until the heaviest test specimen pieces become suspended in the liquid mixture. The amount of the denser liquid added is noted and used to determine the density of the mixture and hence the density of the test specimens.

A correction for buoyancy in air is set out in ISO 1183-1 and a correction for carbon black is set out below.

A.2 Reagents

A.2.1 Method A — Immersion method

The reagent shall be immersion liquid, distilled or deionized water, or other suitable liquid as specified in ISO 1183-1 for the immersion method.

A.2.2 Method B — Liquid pycnometer method

The reagent shall be immersion liquid, distilled or deionized water, or other suitable liquid as specified in ISO 1183-1 for the liquid pycnometer method.

A.2.3 Method C — Titration method

The reagent shall be immersion liquids, one liquid with density lower than the test specimens and another liquid with density higher than the test specimens, as specified in ISO 1183-1 for the titration method.

A.3 Apparatus

A.3.1 Method A — Immersion method

The apparatus shall be as specified in ISO 1183-1, including the following:

- (a) *Analytic balance*, for mass measurement.
- (b) *Immersion vessel*.
- (c) *Stationary support*.
- (d) *Thermometer*.
- (e) *Wire* (if required), for suspending the specimen.
- (f) *Sinker*, to ensure specimen is submerged in the immersion liquid.
- (g) *Pycnometer*, for determining density of immersion liquid.
- (h) *Liquid bath*, thermostatically controlled.

A.3.2 Method B — Liquid pycnometer method

The apparatus shall be as specified in ISO 1183-1, including the following:

- (a) *Balance*.
- (b) *Liquid bath*, thermostatically controlled.
- (c) *Immersion liquid*.
- (d) *Stationary support*.
- (e) *Desiccator*.
- (f) *Pycnometer*.

A.3.3 Method C — Titration method

The apparatus shall be as specified in ISO 1183-1, including the following:

- (a) *Liquid bath*, thermostatically controlled.
- (b) *Glass cylinder*.
- (c) *Thermometer*.
- (d) *Volumetric flask*.
- (e) *Flat-tipped glass rod stirrer*.
- (f) *Burette*.

A.4 Test specimen

A.4.1 Selection

A.4.1.1 Method A — Immersion method

The test specimen shall be compound intended for insulation, sheath or jacket. The test specimen shall be void-free and not in powder form. The test specimen shall be selected as specified in ISO 1183-1 for the immersion method.

A.4.1.2 Method B — Liquid pycnometer method

The test specimen shall be compound intended for insulation, sheath or jacket. The test specimen shall be powders, granules or flakes as specified in ISO 1183-1 for the liquid pycnometer method.

A.4.1.3 Method C — Titration method

The test specimens shall be compound intended for insulation, sheath or jacket. The test specimens shall be void-free as specified in ISO 1183-1 for the titration method.

A.4.2 Preparation

A.4.2.1 Method A — Immersion method

The test specimen shall be prepared as specified in ISO 1183-1 for the immersion method.

When incising the test specimen from a larger specimen, the task shall be performed in a manner to ensure that the material characteristics are not altered. Since air bubbles may introduce inaccuracies in the density measurement, the surface of the test specimen shall be prepared to be smooth and free of burs and cavities.

A.4.2.2 Method B — Liquid pycnometer method

There is no preparation necessary for Method B.

A.4.2.3 Method C — Titration method

When incising the test specimens from a larger specimen, the task shall be performed in a manner to ensure that the material characteristics are not altered. Since air bubbles may introduce inaccuracies in the density measurement, the surface of the test specimen shall be prepared to be smooth and free of burs, cavities and the like.

A.5 Procedure

The test procedure shall be in accordance with ISO 1183-1 for Methods A, B and C.

A.6 Expression of results

A.6.1 Density calculation

A.6.1.1 Method A — Immersion method

The density shall be calculated in accordance with ISO 1183-1 for the immersion method.

For a more accurate result, the correction for buoyancy in air formulae as detailed in ISO 1183-1 may be applied to account for the buoyancy of the suspension wire in air.

A.6.1.2 Method B — Liquid pycnometer method

The density shall be calculated in accordance with ISO 1183-1 for the liquid pycnometer method.

A.6.1.3 Method C — Titration method

The density shall be determined in accordance with ISO 1183-1 for the titration method.

A.6.2 Correction for PE containing carbon black

If the PE test specimen contains carbon black, then a correction factor shall be applied to obtain the density of the base polymer, using [Equation A.1](#).

$$d = d_c - 0.45 C_B \quad \text{A.1}$$

where

d = corrected density value, in kg per m³

d_c = measured density value, in kg per m³

C_B = carbon black concentration, in g per kg, when determined in accordance with [Appendix R](#)

A.7 Test report

The density shall be reported in accordance with ISO 1183-1. The test report shall also include the following:

- (a) All details necessary for complete identification of the specimen tested, including:
 - (i) Compound identification description or code.
 - (ii) Specimen mass.
 - (iii) Preparation and pre-treatment (if any).
- (b) A reference to this Australian Standard (AS 1049.2) and to ISO 1183-1, each including the year of publication.
- (c) A reference to this test method and the ISO 1183-1 test method used.
- (d) The immersion liquid(s) used.
- (e) The test temperature and measurement procedure of test temperature.
- (f) The individual values and arithmetic mean of the density, including a reference to the ISO 1183-1 clause which explains how the results were calculated. All calculations shall be shown in full.
- (g) A statement as to whether any polyethylene carbon black correction factor was made.
- (h) A statement as to whether any buoyancy correction was made, and the correction made.
- (i) Any deviations from the test method or procedure.
- (j) Any unusual features observed.
- (k) The date of the test.

Appendix B (normative)

Test method 2: Melt-flow index

B.1 Principle

This Appendix sets out the method for determining the melt-flow index of PE compound.

The MFI is the quantity of material extruded in a given period of time at a given temperature through a specified die under the action of a load.

The melt-flow index test is performed in accordance with AS/NZS 1660.2.4:1998 Clause 2.1.

B.2 Apparatus

The apparatus for the extrusion plastimeter shall be as specified in AS/NZS 1660.2.4:1998 Clause 2.1.2, including the following:

- (a) *Cylinder*, fixed in vertical position.
- (b) *Piston*, for insertion into the cylinder.
- (c) *Load*, removable, to be placed on top of the piston.
- (d) *Heater*, capable of maintaining the required test temperature.
- (e) *Temperature measuring device*.
- (f) *Die*, placed at the bottom of the cylinder, for material to extrude through.

B.3 Test specimen

The test specimen shall be PE compound between 4 g and 5 g.

B.4 Procedure

The test procedure shall be in accordance with AS/NZS 1660.2.4:1998 Clause 2.1.3, with the following modifications:

- (a) PE containing a blowing agent shall be tested using either a 5.000 kg load at $140\text{ }^{\circ}\text{C} \pm 0.5\text{ }^{\circ}\text{C}$ or a 2.610 kg load at $160\text{ }^{\circ}\text{C} \pm 0.5\text{ }^{\circ}\text{C}$.
- (b) Cut-off time intervals shall be used in accordance with [Table B.1](#).

Table B.1 — Test specimen ageing conditions and crosshead speed

PE category	Temperature (°C)	Interval of time between cut-offs (s)
For 2.160 kg load		
Category 3	190	60
Category 4	190	120

Table B.1 (continued)

PE category	Temperature (°C)	Interval of time between cut-offs (s)
Category 5	190	180
Cellular PE	160	240
For 21.60 kg load		
Category 5	190	10
For 5.000 kg load		
Cellular PE	140	240, 120 or 60 ^a
^a The time interval is chosen so that the length of a single cut-off is between 10 mm and 20 mm.		

B.5 Expression of results

The MFI expressed in g per 600 s, shall be calculated in accordance with AS/NZS 1660.2.4:1998 Clause 2.1.4.

B.6 Test report

The MFI shall be reported in accordance with AS/NZS 1660.2.4:1998 Clause 2.1.5. The test report shall also include the following:

- (a) All details necessary for complete identification of the specimen tested, including:
 - (i) Compound identification description or code.
 - (ii) PE category.
 - (iii) Specimen mass.
 - (iv) Preparation and pre-treatment (if any).
- (b) A reference to this Australian Standard (AS 1049.2) and to AS/NZS 1660.2.4, each including the year of publication.
- (c) A reference to this test method and the AS/NZS 1660.2.4 test method (Measurement of the melt-flow index).
- (d) The mass of the test load used.
- (e) The test temperature and measurement procedure of test temperature.
- (f) The MFI in g per 600 s, including a reference to AS/NZS 1660.2.4:1998 Clause 2.1.4, which explains how the result was calculated. All calculations shall be shown in full.
- (g) Any deviations from the test method or procedure.
- (h) Any unusual features observed.
- (i) The date of the test.

Appendix C (normative)

This test method has been deleted

Appendix D (normative)

Test method 4: Hot set

D.1 Principle

This Appendix sets out the method for determining if a polymer test specimen taken from the insulation, sheath or jacket of a completed cable is adequately crosslinked.

The test specimen is heated under specified conditions. The elongation of the specimen is measured after a set time at an elevated temperature with a prescribed load attached to the specimen. The load is removed, and the retained extension measured after cooling.

The test is performed in accordance with AS/NZS 1660.2.2, test method for hot set test.

D.2 Apparatus

The apparatus shall be as specified in AS/NZS 1660.2.2 for the hot set test, as follows:

- (a) *Oven*, capable of maintaining the required test temperature and with a viewing window.
- (b) *Grips*, with upper grip to suspend the test specimen from the oven and lower grip with weights attached to be attached to the test specimen.
- (c) *Weights*.

D.3 Test specimen

D.3.1 Selection

The test specimen shall be taken from the insulation, sheath or jacket of a completed cable.

D.3.2 Preparation

D.3.2.1 Insulation

The insulation shall be cut into two test specimens, prepared and marked as specified in AS/NZS 1660.2.1:1998 Clause 2.2.1.3. The cross-sectional areas shall then be measured as specified in AS/NZS 1660.2.1:1998 Clause 2.2.1.4.

D.3.2.2 Sheath or jacket

The sheath or jacket shall be cut into two test specimens, prepared and marked as specified in AS/NZS 1660.2.1:1998 Clause 2.2.3.3. The cross-sectional areas shall then be measured as specified in AS/NZS 1660.2.1:1998 Clause 2.2.3.4.

D.4 Procedure

The test procedure shall be in accordance with AS/NZS 1660.2.2 for the hot set test.

D.5 Expression of results

For the two test specimens, the percentage of elongation under load at elevated temperature and residual elongation after cooling shall be calculated in accordance with AS/NZS 1660.2.2 for the hot set test. The results of both specimens shall be used to calculate the arithmetic mean results.

D.6 Test report

The results shall be reported in accordance with AS/NZS 1660.2.2. The test report shall also include the following:

- (a) All details necessary for complete identification of the specimen tested, including:
 - (i) Description of completed cable.
 - (ii) Compound identification description or code.
 - (iii) Specimen cross-sectional area.
 - (iv) Preparation and pre-treatment.
- (b) A reference to this Australian Standard (AS 1049.2) and to AS/NZS 1660.2.2, each including the year of publication.
- (c) A reference to this test method and the AS/NZS 1660.2.2 test method (Hot set test).
- (d) The mass of the test load used.
- (e) The test temperature and measurement procedure of test temperature.
- (f) The individual values and arithmetic mean of the percentage of elongation under load at elevated temperature and the residual elongation after cooling. A reference to the AS/NZS 1660.2.2 clause which explains how the results were calculated. All calculations shall be shown in full.
- (g) Any deviations from the test method or procedure.
- (h) Any unusual features observed.
- (i) The date of the test.

Appendix E (normative)

Test methods 5 and 6: Tensile strength at break/yield and elongation at break — Before and after ageing

E.1 Principle

This Appendix sets out the method for determining the initial tensile strength at break/yield and elongation at break, before and after ageing, for specimens prepared from insulation, sheath or jacket removed from cable.

Test specimens are cut into either dumb-bell or tubular shapes of predefined dimensions. A tensile load is applied to a specimen at a specified speed until the specimen reaches breaking or yielding point. The elongation of the specimen is then measured. If required, the same test is repeated with specimens which have been aged in an air oven or weatherometer.

The test method is based on AS/NZS 1660.2.1:1998 Clause 2.2. Since AS/NZS 1660.2.1 does not include the calculation of tensile strength at yield, weatherometer testing, or ageing and test conditions, these are described here in [Appendix E](#), along with material-specific conditions.

E.2 Apparatus

The apparatus shall be as follows:

- (a) *Air oven*, capable of maintaining the required test temperature for the duration of ageing time.
- (b) *Weatherometer*, conforming with the requirements of either of the following:
 - (i) ASTM G155, using apparatus air-cooled xenon arc lamps or water-cooled xenon arc lamps and under the following continuous test conditions:
 - (A) Irradiance level of 0.5 W/m²; 1 nm bandpass at 340 nm; daylight filters.
 - (B) Black panel temperature of 63 °C ± 5 °C.
 - (C) RH of 50 % ± 5 %.
 - (D) No water spray to be used.
 - (ii) ASTM G152 and ASTM G153, Test Method 3, using apparatus Type DH or HH and under the following test conditions:
 - (A) RH of 50 % ± 5 %.
 - (B) No water spray to be used.
 - (C) Air oven capable of operating at 70 °C ± 2 °C.
- (c) *Tensile testing machine*, with grips that exert a uniform pressure across the gripping surface.

E.3 Test specimens

E.3.1 Selection

For filled PE cables, irrespective of their date of manufacture, the cable specimen shall be pre-aged for 14 d at $70\text{ °C} \pm 2\text{ °C}$ in an air oven to ensure maximum uptake of the filling compound by the PE. All other cables shall be tested as received.

E.3.2 Preparation

E.3.2.1 Sheath or jacket

Any outer coverings shall be removed from the material being tested. The sheath or jacket shall be cut from the cable in the direction of the axis of the core.

All inner cable components shall be mechanically removed from the sheath or jacket, i.e. not chemically removed.

If the sheath or jacket contains any ridges, the test specimen shall be cut to obtain parallel surfaces.

The test specimen shall then be cut, prepared, marked and cross-sectional areas measured as specified in AS/NZS 1660.2.1:1998 Clause 2.2.3.3 and Clause 2.2.3.4.

E.3.2.2 Insulation

Five pieces of cable shall be cut, each approximately 150 mm in length.

The cable components shall be removed without damaging the insulation, sheath or jacket. The conductor may be removed by removing a small piece of insulation, sheath or jacket from each end of the specimen, elongating the conductor approximately 10 % and then removing the conductor.

The test specimen shall then be cut, prepared, marked and cross-sectional areas measured as specified in AS/NZS 1660.2.1:1998 Clause 2.2.1.3 and Clause 2.2.1.4.

E.3.3 Air oven ageing

Test specimens required to be aged in an air oven as specified in AS 1049.1 shall be aged at the temperature and time as specified in [Table E.1](#).

E.3.4 Weatherometer ageing

Test specimens required to be aged in a weatherometer as specified in AS 1049.1 shall be aged by exposure to ultraviolet radiation in the range 275 nm to 440 nm for the time specified in [Table E.1](#).

The weatherometer shall not be loaded beyond normal capacity. The weatherometer shall only contain test specimens of the same type of material.

E.3.5 Conditioning

The test specimens shall be conditioned at $23\text{ °C} \pm 2\text{ °C}$ for a minimum of 16 h. PA, PE and any composites of the two shall be concurrently conditioned at $50\text{ \%} \pm 5\text{ \% RH}$.

Table E.1 — Test specimen ageing conditions and crosshead speed

Material	Application	Ageing temperature (°C ± 2 °C)	Ageing time (h)	Crosshead speed (mm/min)
PE insulation	Cable jointed outdoors — Type I	NA	NA	500 ± 50
	Cable jointed outdoors — Types II, III	NA	NA	50 ± 5
	Other cable — Type I	100	48	500 ± 50
	Other cable — Types II, III	100	48	50 ± 5
PA 12 insulation	—	100	120	50 ± 5
PPO based insulation	—	100	120	50 ± 5
PVC insulation	60 °C rating	100	120	250 ± 50
	75 °C rating	100	240	250 ± 50
	90 °C rating	120	168	250 ± 50
	90 °C HT rating	135	168	250 ± 50
PP insulation	—	100	240	25 ± 5
PE sheath/jacket	All applications— Type I	NA	NA	500 ± 50
	Coloured, intended for UV exposure, Aged in weatherometer	NA	5 000	500 ± 50
	All applications — Types II, III	NA	NA	50 ± 5
	Coloured, intended for UV exposure, Aged in weatherometer	NA	5 000	50 ± 5
PA jacket	Unbonded cable construction — black and coloured			
	Aged in air oven	100	120	50 ± 5
	Aged in weatherometer	NA	1 200	50 ± 5
Integrally bonded PE sheath and PA sheath	Black and coloured PA jacketed composite	NA	NA	50 ± 5
PVC sheath/jacket	60 °C rating	100	120	250 ± 50
	75 °C rating	100	240	250 ± 50
	90 °C rating	120	168	250 ± 50
	90 °C HT rating	135	168	250 ± 50
	Cable exposed to UV radiation — coloured and black	100	240	250 ± 50
HFFR sheath/jacket	All applications	100	168	50 ± 5

Table E.1 (continued)

Material	Application	Ageing temperature (°C ± 2 °C)	Ageing time (h)	Crosshead speed (mm/min)
Fluoropolymer insulation and sheath/jacket	ECTFE and ETFE, 150 °C rating	180	168	50 ± 5
	FEP, 200 °C rating	230	168	500 ± 50
	PFA, 200 °C rating	260	96	500 ± 50
	PTFE, 250 °C rating	260	1 440	500 ± 50
	PVDF, 125 °C rating, either	160	168	50 ± 5
		135	720	50 ± 5
	PVDF, 150 °C rating	160	1 440	50 ± 5
XL insulation and sheath/jacket	XLPO, 105 °C rating	135	168	500 ± 50
	XLPE, XLPVC, XLEVA			
	75 °C rating	115	168	500 ± 50
	90 °C rating	120	168	500 ± 50

NA = Not applicable

E.4 Procedure

The test procedure shall be in accordance with AS/NZS 1660.2.1:1998 Clause 2.2.1.7. However, the crosshead speed in [Table E.1](#) shall be used. Any results from test specimens breaking in the grips shall be discarded. The testing shall be continued until a minimum of five test specimens that break outside the grip area are obtained.

[Figure E.1](#) illustrates the force at break/yield.

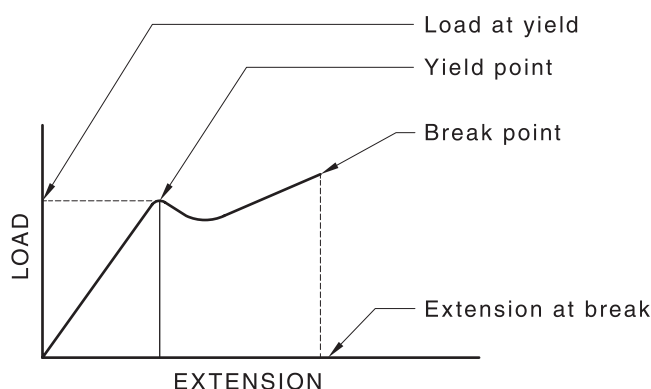


Figure E.1 — Example of a load-extension curve in tension showing load at yield and extension at break

E.5 Expression of results

The tensile strength at break and elongation at break, before and after ageing shall be calculated in accordance with AS/NZS 1660.2.1:1998 Clause 2.2.1.8.

In addition, tensile strength at yield shall be calculated using [Equation E.1](#).

$$\sigma_y = \frac{F_y}{A} \quad \text{E.1}$$

where

- σ_y = tensile strength at yield, in MPa
- F_y = force at yield, in N
- A = cross-sectional area of the test specimen, in mm²

E.6 Test report

The test report shall include the following:

- (a) All details necessary for complete identification of the specimen tested, including:
 - (i) Specimen source (insulation, sheath or jacket).
 - (ii) Description of completed cable.
 - (iii) Application of completed cable.
 - (iv) Material type (e.g. PE, PA, PPO, PVC or PP).
 - (v) Compound identification description or code.
 - (vi) Specimen cross-sectional area.
 - (vii) Preparation and pre-treatment.
- (b) A reference to this Australian Standard (AS 1049.2) and to AS/NZS 1660.2.1, each including the year of publication.
- (c) A reference to this test method and the AS/NZS 1660.2.1 test method (Test for determining the mechanical properties of insulating and sheathing materials).
- (d) The ageing temperature and ageing time.
- (e) The weatherometer used and the weatherometer test conditions (where applicable).
- (f) The distance between grips and crosshead speed.
- (g) The load and distance between marker lines at break and at yield.
- (h) The tensile strength at break, tensile strength at yield and the elongation at break. A reference to [Clause E.5](#) and to AS/NZS 1660.2.1:1998 Clause 2.2.1.8 which explains how the results were calculated. All calculations shall be shown in full.
- (i) Any deviations from the test method or procedure.
- (j) Any unusual features observed.
- (k) The date of the test.

Appendix F (normative)

Test method 7: Flexibility after ageing

F.1 Principle

This Appendix sets out the method for determining the flexibility after ageing of PVDF insulated conductor or completed cable.

A test specimen of the insulated conductor or completed cable is aged in an air oven and then bent around a mandrel and the behaviour observed.

F.2 Apparatus

The apparatus shall be as follows:

- (a) *Air oven of the closed type*, with forced air circulation and with no air changes or, alternatively, with 3 to 10 air changes per hour, capable of operating at the temperature specified in [Clause F.4](#) for the specific material being tested.
- (b) *Mandrels*, of suitable diameter as specified in [Clause F.4](#).

F.3 Test specimen

F.3.1 Selection

The test specimen shall be a sample of insulated conductor or completed cable.

F.3.2 Preparation

The test specimen shall be cut to a length at least six times the mandrel diameter as specified in [Clause F.4](#).

F.4 Procedure

F.4.1 Insulation

The test procedure for insulation shall be as follows:

- (a) An insulated conductor test specimen shall be suspended in an air oven for 168 h at $158\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ or, alternatively, for 30 d at $136\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$.
- (b) At the end of this ageing period, the specimen shall be removed from the air oven and allowed to cool to ambient temperature.
- (c) The specimen shall then be wound tightly for six close turns around a mandrel whose diameter shall be not greater than the nominal diameter for the insulated conductor under test. The insulation shall then be examined for cracks using a magnification of $5\times$.

F.4.2 Sheath

The test procedure for sheath shall be as follows:

- (a) A completed cable test specimen shall be suspended in an air oven for 168 h at $158\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ or, alternatively, for 30 d at $136\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$.
- (b) At the end of this ageing period, the specimen shall be removed from the air oven, allowed to cool to ambient temperature for not less than 16 h or more than 96 h.
- (c) The specimen shall then be wound onto a circular mandrel whose diameter is twice the nominal diameter of the specimen. Six contiguous turns shall be wound onto the mandrel, then unwound, and examined for cracks using normal or corrected vision without magnification.

F.5 Expression of results

Observance of any cracks on the test specimens.

F.6 Test report

The test report shall include the following:

- (a) All details necessary for complete identification of the specimen tested, including:
 - (i) Specimen source (insulated conductor or completed cable).
 - (ii) Description of insulated conductor or completed cable.
 - (iii) Compound identification description or code.
 - (iv) Preparation and pre-treatment.
- (b) A reference to this Australian Standard (AS 1049.2), including the year of publication.
- (c) A reference to this test method.
- (d) The ageing temperature and ageing time.
- (e) The mandrel diameters used.
- (f) Any cracks observed on the test specimen.
- (g) Any deviations from the test method or procedure.
- (h) Any unusual features observed.
- (i) The date of the test.

Appendix G (normative)

Test method 8: Pressure test at high temperature

G.1 Principle

This Appendix sets out the method for determining the resistance of sheathing materials to pressure at elevated temperature.

A specimen of completed cable, or a specimen of the sheath removed from the cable, is subjected to a compression force exerted by an indentation device at elevated temperature. The test specimen is then cooled under the compression load and the indentation measured.

This test method is based on AS/NZS 1660.2.3:1998 Clause 2.3, with the conditions set out below.

G.2 Apparatus

The apparatus shall be as specified in AS/NZS 1660.2.3:1998 Clause 2.3, including the following:

- (a) *Indentation device*, as specified in AS/NZS 1660.2.3:1998 Figure 2.3, including a rectangular blade and a load to apply compression force upon the test specimen.
- (b) *Air oven*, capable of maintaining the required test temperature for the duration of the test.
- (c) *Cold water*, for chilling the test specimen after the heating cycle.

G.3 Test specimen

G.3.1 Selection

Three test specimens each 50 mm to 100 mm of the sheath removed from the completed cable, shall be selected as specified in AS/NZS 1660.2.3:1998 Clause 2.3.2.1. Alternatively, three test specimens of the completed cable shall be selected if the inner surface of the sheath contains ridges which cannot be removed as specified in AS/NZS 1660.2.3:1998 Clause 2.3.2.2.

G.3.2 Preparation

The test specimen shall be prepared as specified in AS/NZS 1660.2.3:1998 Clause 2.3.2.2.

G.4 Procedure

The test procedure shall be in accordance with AS/NZS 1660.2.3:1998 Clause 2.3.2, under the following conditions:

- (a) The compressing force shall be as specified in AS/NZS 1660.2.3:1998 Clause 2.3.2.4.
- (b) Coefficient $k = 0.6$.
- (c) Test temperature = $75\text{ °C} \pm 2\text{ °C}$.
- (d) Time = 4 h for test pieces with an outer diameter $\leq 15\text{ mm}$, or 6 h for test pieces with an outer diameter $> 15\text{ mm}$.