

Australian/New Zealand Standard™

Test methods for electric cables, cords and conductors

Method 5.1: Fire tests—Test for vertical flame spread of vertically-mounted bunched wires or cables



AS/NZS 1660.5.1:2005

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Australian/New Zealand Standard™

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Method 5.1: Fire tests—Test for vertical flame spread of vertically-mounted bunched wires or cables

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-003, Electric Wires and Cables to supersede AS/NZS 1660.5.1:1998, *Test methods for electric cables, cords and conductors*, Method 5.1: *Fire tests—Tests on bunched cables*. It is one of a set of fire tests for electric cables included in the AS/NZS 1660 series.

The objective of this Standard is to set out a method that will define the ability of bunched cables to restrain flame propagation in defined conditions.

This Standard adopts the content of IEC 60332-3, *Tests on electric cables under fire conditions*, Part 3: *Test for vertical flame spread of vertically-mounted bunched wires or cables* (all Parts). While this Standard is technically equivalent to the IEC Standards, it has been structured to include all six Parts of IEC 60332-3 in the one Australian/New Zealand Standard. This has been necessary due to the fact that AS/NZS 1660.5.1 is referenced as such in a number of other Standards. It was not possible to accommodate a further division within the Standards numbering system adopted by Standards Australia.

The technical content of AS/NZS 1660.5.1 and IEC 60332-3 is aligned as follows:

IEC 60332-3 Part	AS/NZS 1660.5.1 Section
10: Apparatus	2
21: Category AF/R	3
22: Category A	4
23: Category B	5
24: Category C	6
25: Category D	7

This Standard differs from the 1998 version in that it has adopted the technical contents of IEC 60332.3 (all Parts).

As this Standard adopts the content of an International Standard a full point should be substituted for a comma when referring to a decimal marker in Figure 4 and Figure 6.

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

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INTRODUCTION

AS/NZS 1660.5.6 specifies methods of test for flame spread characteristics for a single vertical insulated wire or cable. It cannot be assumed that, because a wire or cable meets these requirements, a vertical bunch of similar cables or wires will behave in a similar manner. This is because flame spread along a vertical bunch of cables depends on a number of features, such as—

- (a) the volume of combustible material exposed to the fire and to any flame which may be produced by the combustion of the cables;
- (b) the geometrical configuration of the cables and their relationship to an enclosure;
- (c) the temperature at which it is possible to ignite the gases emitted from the cables;
- (d) the quantity of combustible gas released from the cables for a given temperature rise;
- (e) the volume of air passing through the cable installation; and
- (f) the construction of the cable, for example armoured or unarmoured, multi- or single-core.

All of the foregoing assume that the cables are able to be ignited when involved in an external fire.

This Standard gives details of a test where a number of cables are bunched together to form various test sample installations. For easier use and differentiation of various test categories, the Sections of this Standard are designated as follows:

Section 2: Apparatus

Section 3: Category A F/R

Section 4: Category A

Section 5: Category B

Section 6: Category C

Section 7: Category D

Sections 3 to 7 define the various categories and the relevant procedures. The categories are distinguished by test duration, the volume of non-metallic material of the test sample and the method of mounting the sample for the test. In all categories, cables having at least one conductor of cross-sectional area greater than 35 mm² are tested in a spaced configuration, whereas cables of conductor cross-sectional area of 35 mm² or smaller are tested in a touching configuration.

The categories are not necessarily related to different safety levels in actual cable installations. The actual installed configuration of the cables may be a major determinant in the level of flame spread occurring in an actual fire.

The method of mounting described in Category A F/R (Section 3) is intended for special cable designs used in particular installations.

Categories A, B, C and D (Sections 4 to 7 respectively) are for general use where different non-metallic volumes are applicable.

Additional categories, especially to cover the use of small diameter communication cables in closely bunched configurations, will be further considered when more data are available.

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Australian/New Zealand Standard**Test methods for electric cables, cords and conductors**
Method 5.1: Fire tests—Test for vertical flame spread of vertically-
mounted bunched wires or cables

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies methods of test for the assessment of vertical flame spread of vertically-mounted bunched wires or cables, electrical or optical, under defined conditions.

NOTE: For the purpose of this Standard the term 'electric wire or cable' covers all insulated metallic conductor cables used for the conveyance of energy or signals.

The tests are intended for type approval testing. The flame spread is measured as the extent of damage of the cable sample. This procedure may be used to demonstrate the cable's ability to limit flame spread.

1.2 REFERENCES

The following documents are referred to in this Standard:

AS/NZS

60695 Fire hazard testing

60695.4 Part 4: Technology concerning fire tests

IEC

60811 Insulating and sheathing materials of electric cables – Common test methods

60811-1-3 Part 1-3: General application—Methods for determining the density—Water absorption tests—Shrinkage test

1.3 DEFINITIONS

For the purpose of this Standard the following definitions apply. The definitions are taken from AS/NZS 60695.4.

1.3.1 Ignition source

Source of energy that initiates combustion

1.3.2 Char

Carbonaceous residue resulting from pyrolysis or incomplete combustion

1.3.3 Flame spread

Propagation of a flame front

SECTION 2 APPARATUS

2.1 GENERAL

This Section details the apparatus and its arrangement and calibration.

2.2 TEST ENVIRONMENT

The test shall not be carried out if the external wind speed, measured by an anemometer fitted on the top of the test rig, is greater than 8 m/s and shall not be carried out if the temperature of the inside walls is below 5°C or above 40°C measured at a point approximately 1 500 mm above floor level, 50 mm from a side wall, and 1 000 mm from the door. The enclosure door shall be closed throughout the test.

2.3 TEST APPARATUS

The test apparatus consists of the following:

2.3.1 Test chamber

The test rig (see Figure 1) shall comprise a vertical test chamber having a width of $(1\,000 \pm 100)$ mm, a depth of $(2\,000 \pm 100)$ mm and a height of $(4\,000 \pm 100)$ mm; the floor of the chamber shall be raised above ground level. The test chamber shall be nominally airtight along its sides, air being admitted at the base of the test chamber through an aperture of (800 ± 20) mm $\times$ (400 ± 10) mm situated (150 ± 10) mm from the front wall of the test chamber (see Figure 1).

An outlet (300 ± 30) mm $\times$ $(1\,000 \pm 100)$ mm shall be made at the rear edge of the top of the test chamber. The back and sides of the test chamber shall be thermally insulated to give a coefficient of heat transfer of approximately $0.7 \text{ W.m}^{-2}\text{.K}^{-1}$. For example, a steel plate 1.5 mm to 2.0 mm thick covered with 65 mm of mineral wool with a suitable external cladding is satisfactory (see Figure 2). The distance between the ladder and the rear wall of the chamber is (150 ± 10) mm, and between the bottom rung of the ladder and the floor (400 ± 5) mm. The clearance between the lowest point of the test piece and the floor is approximately 100 mm (see Figure 3).

2.3.2 Air supply

A means of supplying a controlled air flow through the chamber shall be fitted.

NOTE: It is recommended that the air should be blown into the test chamber, via the air inlet, using a suitable fan.

Prior to burner ignition, the air flow shall be adjusted to a rate of $(5\,000 \pm 500)$ l/min at a constant controlled temperature of $(20 \pm 10)^\circ\text{C}$ and at atmospheric pressure and measured at the inlet side before the test commences. This air flow rate shall be maintained throughout the test until cable burning or glowing has ceased or for a maximum time of 1 h from completion of the test flame application period, after which period the flame or glowing shall be extinguished.

NOTE: In order to remove noxious gases, it is recommended to maintain the air flow for some minutes after the end of the test, before entering the test chamber.

2.3.3 Ladder types

There are two types of tubular steel ladder: a standard ladder of (500 ± 5) mm width and a wide ladder of (800 ± 10) mm width. Details of the types of ladder are given in Figures 4a and 4b.

2.3.4 Effluent cleaning attachment

Legal requirements may make it necessary for equipment for collecting and washing the effluent to be fitted to the test chamber. This equipment shall not cause a change in the air flow rate through the test chamber.

2.4 IGNITION SOURCE

2.4.1 Type

As required by the test procedure the ignition source shall be one or two ribbon-type propane gas burners complete with venturi mixer, and their own set of flowmeters. The propane gas shall be technical grade propane of nominal 95% purity. The flame-producing surface of the burner(s) shall consist of a flat metal plate through which 242 holes of 1.32 mm in diameter are drilled on 3.2 mm centres in three staggered rows of 81, 80 and 81 holes each to form an array having the nominal dimensions 257 mm × 4.5 mm. As the burner plate may be drilled without the use of a drilling jig, the spacing of the holes may vary slightly. Additionally, a row of small holes may be milled on each side of the burner plate to serve as pilot holes with the function of keeping the flame burning.

The burners are shown in Figures 5a and 5b, and the placement of the holes in Figure 6.

NOTE: To ensure reproducibility between results from different testing stations, a burner, which is readily available, is recommended for use. For details, see Appendix A.

Each burner shall be individually fitted with an accurate means of controlling the propane gas and air input flow rates, either by means of a rotameter-type flowmeter or mass flowmeter.

NOTE: Mass flowmeters are recommended for ease of use.

Figure 7 shows an example of a rotameter-type system.

SAFETY NOTE –

The following precautions are recommended to ensure safe operation of the ignition source:

- (a) The gas supply system should be equipped with flashback arresters.
- (b) A flame failure protection device should be used.
- (c) Safe sequencing of the propane and air supply should be employed during ignition and extinguishing.

The calibration of the propane gas and air rotameter-type flowmeters shall be checked after installation to ensure that the pipework and venturi mixer have not affected the calibration.

Corrections for the variations in temperature and pressure from that specified on the propane gas and air rotameter-type flowmeters shall be applied when necessary.

NOTE: See Appendix B for worked examples.

Propane gas and air rotameter-type flowmeters shall be calibrated according to the following reference conditions.

Reference temperature and pressure are 20°C and 1 bar (100 kPa).

For the purpose of this test, the air shall have a dew-point not higher than 0°C.

The flow rates at reference conditions (1 bar and 20°C) for the test shall be as follows:

- (a) Air (77.7 ± 4.8) l/min
- (b) Propane (13.5 ± 0.5) l/min

to provide a nominal $(73.7 \pm 1.68) \times 10^6$ J/h ((70 000 ± 1 600) Btu/h)* to each burner.

NOTE: The net heat of combustion is used to calculate the propane flow rate.

2.4.2 Positioning

For the test, the burner shall be arranged horizontally at a distance of (75 ± 5) mm from the front surface of the cable sample, (600 ± 5) mm above the floor of the test chamber and approximately symmetrical with the axis of the ladder. The point of application of the burner flame shall lie in the centre between two crossbars on the ladder and at least 500 mm above the lower end of the sample (see Figure 3 and Figure 5a).

Adjustment of air and gas flows prior to the test may be carried out away from the test position.

Where two burners are used in combination with the wide ladder, they shall be arranged so as to be approximately symmetrical with the axis of the ladder, as shown in Figure 5b. The burner system shall be positioned such that the centre line of the burner system is approximately coincident with the centre of the ladder.

* This is also equivalent to (20.5 ± 0.5) kW.

SECTION 3 CATEGORY A F/R TESTS

3.1 GENERAL

This Section covers Category A F/R and relates only to power cables of conductor cross-sectional area greater than 35 mm² installed on the test ladder in a spaced configuration on the front and rear to achieve a nominal total volume of non-metallic material of 7 l/m of test sample. The flame application time is 40 min. This method of mounting is intended for special cable designs used in particular installations when required in the cable specification. Category A F/R is not intended for general use.

The requirements for the selection of cables for testing are given in Appendix C.

NOTE: A recommended performance requirement is given in Appendix D.

3.2 TEST APPARATUS

3.2.1 General

The apparatus specified in Section 2 shall be used.

3.2.2 Ignition source

The ignition source shall be one ribbon-type propane gas burner as specified in Section 2.

3.3 TEST PROCEDURE

3.3.1 Test sample

The test sample shall comprise a number of test pieces of cable from the same production length, each having a minimum length of 3.5 m.

The total number of test pieces in the test sample shall be that number required to provide a nominal total volume of non-metallic material of 7 l/m of test sample.

The test sample shall be chosen within the limitations given in Appendix C.

The test pieces forming the test sample shall be conditioned at a temperature of $(20 \pm 10)^{\circ}\text{C}$ for at least 16 h before commencing the test. The test pieces shall be dry.

3.3.2 Determination of the number of test pieces

In order to calculate the appropriate number of test pieces, it is necessary to determine the volume per metre of non-metallic material of one test piece.

A length of cable which shall be not less than 0.3 m long is carefully cut to ensure that the surfaces are at right angles to the cable axis, thus enabling precise measurements of its length.

The density of each non-metallic component (including cellular material) shall be measured in an appropriate way, for example Clause 8 of IEC 60811-1-3, in order to obtain values expressed to the second decimal place.

Each non-metallic material C_1 shall be removed from the test piece and weighed. Any non-metallic material making up less than 5% of the total non-metallic mass of the test piece shall be assumed to have a density of 1.0 kg/dm³.

Where semi-conducting screens cannot be removed from the insulating material, the components may be considered as one for the purpose of measuring their mass and density.

The volume V_i (litres per metre of cable) of each non-metallic material C_i is calculated as follows:

$$V_i = \frac{M_i}{\rho_i \times l}$$

where

- M_i is the mass of the component C_i (kg);
- ρ_i is the density of the component C_i (kg/dm³);
- l is the length of the test piece of cable (m).

The total volume, V , of the non-metallic materials contained in 1 m of cable is equal to the sum of the individual volumes V_1 , V_2 , etc.

The closest integer (0.5 and above corresponding to 1) of the number of test pieces to be mounted is obtained by dividing the volume per metre, specified in Clause 3.3.1, by the total volume, V , of non-metallic material per metre of cable.

3.3.3 Mounting of the test sample

Each test piece shall be attached individually to each rung of the ladder by means of metal wire (steel or copper). For cables up to and including 50 mm diameter use wire between 0.5 mm and 1.0 mm in diameter. For cables above 50 mm diameter use wire between 1.0 mm and 1.5 mm in diameter.

The standard ladder shall be used, and the test sample shall be such that at least four test pieces are used. A minimum of two test pieces shall be mounted on the rear of the ladder.

Where more than four test pieces are required for the test sample, each successive additional piece shall be mounted alternately on the front and then the rear of the ladder.

The completed test sample shall be mounted such that—

- (a) the space between each test piece of one layer (front or rear) shall be 0.5 times the cable diameter, but not exceeding 20 mm;
- (b) the maximum width of a single layer shall be 300 mm;
- (c) the minimum distance between the sample edge and the inside of the ladder upright shall be 50 mm;
- (d) test pieces mounted on the rear of the ladder shall be centred relative to the space between pieces on the front of the ladder; and
- (e) the completed array of test pieces is approximately centred on the ladder.

Figure 8 illustrates the arrangement.

3.3.4 Flame application time

The test flame shall be applied for 40 min, after which it shall be extinguished. The air flow rate through the test chamber shall be maintained until cable burning or glowing has ceased, or until a maximum duration of 1 h, after which any remaining cable burning or glowing shall be extinguished.

3.4 EVALUATION OF TEST RESULTS

After all cable burning or glowing has ceased or been extinguished, the test sample shall be wiped clean.

All soot is to be ignored if, when wiped off, the original surface is undamaged. Softening or any deformation of the non-metallic material is also to be ignored. The flame spread shall be measured as the extent of the damage. It shall be measured in metres to two decimal places from the bottom edge of the burner to the onset of char. The onset of char is determined by pressing against the cable surface with a sharp object, for example a knife blade. Where the surface changes from a resilient to a brittle (crumbling) surface, this indicates the onset of char.

3.5 PERFORMANCE REQUIREMENTS

The performance requirements for a particular type or class of wire or cable should preferably be given in the individual cable Standard. In the absence of any given requirements, the recommended performance requirements given in Appendix D should be used.

3.6 RETEST PROCEDURE

In case of dispute, two further tests shall be undertaken as detailed in Clause 3.3. The test shall be deemed as satisfactory if both tests meet the stated requirement.

3.7 TEST REPORT

The test report shall include the following information:

- (a) Full description of the cable tested.
- (b) Manufacturer of the cable tested.
- (c) The Section of the Standard against which the test was carried out.
- (d) The number of test pieces.
- (e) The total volume of non-metallic material, per metre of test sample, of the test pieces.
- (f) The method of mounting, i.e. spaced.
- (g) The number of layers and number of test pieces in each layer.
- (h) Flame application time (i.e. 40 min).
- (i) The number of burners (i.e. one).
- (j) The extent of damage.
- (k) The time to extinction of all burning or glowing.

SECTION 4 CATEGORY A TESTS

4.1 GENERAL

This Section covers Category A and relates to cables installed on the test ladder to achieve a nominal total volume of non-metallic material of 7 l/m of test sample. The flame application time is 40 min. The method of mounting uses the front of the ladder, a Standard or wide ladder being used for cables having a conductor cross-section greater than 35 mm² according to the number of test pieces required, and a standard ladder for conductor cross-sections 35 mm² and smaller. The Category is intended for general use where high volumes of non-metallic material are required to be evaluated.

The requirements for the selection of cables for the testing are given in Appendix E.

NOTE: A recommended performance requirement is given in Appendix F.

4.2 TEST APPARATUS

4.2.1 General

The apparatus specified in Section 2 shall be used.

4.2.2 Ignition source

The ignition source shall be one or two ribbon-type propane gas burners as specified in Section 2.

A single burner shall be used with the standard ladder and two burners with the wide ladder.

4.3 TEST PROCEDURE

4.3.1 Test sample

The test sample shall comprise a number of test pieces of cable from the same production length, each having a minimum length of 3.5 m.

The total number of test pieces in the test sample shall be that number required to provide a nominal total volume of non-metallic material of 7 l/m of test sample.

The test sample shall be chosen within the limitations given in Appendix E.

The test pieces forming the test sample shall be conditioned at a temperature of $(20 \pm 10)^\circ\text{C}$ for at least 16 h before commencing the test. The test pieces shall be dry.

4.3.2 Determination of the number of test pieces

In order to calculate the appropriate number of test pieces, it is necessary to determine the volume per metre of non-metallic material of one test piece.

A length of cable which shall be not less than 0.3 m long is carefully cut to ensure that the surfaces are at right angles to the cable axis, thus enabling precise measurements of its length.

The density of each non-metallic component (including cellular material) shall be measured in an appropriate way, for example Clause 8 of IEC 60811-1-3, in order to obtain values expressed to the second decimal place.

Each non-metallic material C_i shall be removed from the test piece and weighed. Any non-metallic material making up less than 5 % of the total non-metallic mass of the test piece shall be assumed to have a density of 1.0 kg/dm³.

Where semi-conducting screens cannot be removed from the insulating material, the components may be considered as one for the purpose of measuring their mass and density.