

Australian/New Zealand Standard™

**Test methods for electric cables, cords
and conductors**

Method 5.5: Fire tests—Circuit integrity



AS/NZS 1660.5.5:2005

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Australian/New Zealand Standard™

Test methods for electric cables, cords and conductors

Method 5.5: Fire tests—Circuit integrity

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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 1660.5.5:1998, *Test methods for electric cables, cords and conductors*, Method 5.5: *Fire tests—Circuit integrity under fire conditions*. 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 test methods that will define the ability of cables to maintain circuit integrity under defined fire conditions.

This Standard adopts the content of IEC 60331, *Tests on electric cables under fire conditions—Circuit integrity* (all Parts). While this Standard is technically equivalent to the IEC Standards, it has been structured to include all six Parts of IEC 60331 in the one Australian/New Zealand Standard. This has been necessary due to the fact that AS/NZS 1660.5.5 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 1660.5.5 and IEC 60331 is aligned as follows:

IEC 60331 Part	AS/NZS 1660.5.5 Section
11: Apparatus—Fire alone at a flame temperature of at least 750°C	2
12: Apparatus—Fire with shock at a temperature of at least 830°C	3
21: Procedures and requirements—Cables of rated voltage up to and including 0.6/1.0 kV	4
23: Procedures and requirements—Electric data cables	5
25: Procedures and requirements—Optical fibre cables	6
31: Procedures and requirements for fire with shock—Cables of rated voltage up to and including 0.6/1.0 kV	7

This Standard differs from the 1998 edition as follows:

- (a) The technical content of IEC 60331 (all Parts) has been adopted.
- (b) A test is now included for low-voltage power and control cables required to maintain circuit integrity when subjected to fire and shock.
- (c) The range of cables covered by the test for fire alone is now extended to data and optical fibre cables.

As this Standard adopts the contents of an International Standard a full point should be substituted for a comma when referring to the decimal point in Figures 2, 7, 8 and D1.

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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Australian/New Zealand Standard
Test methods for electric cables, cords and conductors

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies the test apparatus, the test procedure and the performance requirements to be used for testing cables of rated voltages up to 0.6/1.0 kV, data cables and optical cables which are required to maintain circuit integrity when subject to fire alone. The test condition is based upon a flame with a controlled heat output corresponding to a temperature of a least 750°C.

It also covers testing of cables of rated voltages up to 0.6/1.0 kV when subject to fire and mechanical shock where the test condition is based upon a flame with a controlled heat output corresponding to a temperature of a nominal 850°C. This method is intended for use when testing cables of greater than 20 mm overall diameter.

1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

- 60269 Low voltage fuses
 60269.3.1 Part 3.1: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and applications)-Sections I to IV: Examples of types of standardized fuses

IEC

- 60584 Thermocouples
 60584-1 Part 1: Reference tables
 60793 Optical fibres
 60793-1-4 Part 1: Generic specification-Section 4: Measuring method for transmission and optical characteristics
 61034 Measurement of smoke density of cables burning under defined conditions
 61034-1 Part 1: Test apparatus

1.3 DEFINITIONS

For the purpose of this Standard, the following definition applies:

1.3.1 Circuit integrity

Ability to continue to operate in the designated manner whilst subjected to a specified flame source for a specified period.

SECTION 2 APPARATUS — FIRE ALONE AT A FLAME TEMPERATURE OF AT LEAST 750 °C

2.1 GENERAL

This Section specifies the test apparatus to be used for testing cables required to maintain circuit integrity when subject to fire alone where the test condition is based upon a flame with a controlled heat output corresponding to a temperature of at least 750°C.

The method of verification of the burner and control system used for the test is provided in Appendix A.

2.2 TEST CONDITIONS

2.2.1 Test environment

The test shall be carried out in a suitable chamber with facilities for disposing of any noxious gases resulting from burning. Sufficient ventilation shall be available to sustain the flame for the duration of the test.

NOTE: An example of a suitable chamber is given in IEC 61034-1.

The chamber shall be maintained in an external environment where the temperature is between 5°C and 40°C.

The same ventilation and shielding conditions shall be used in the chamber during both the verification and cable test procedures.

NOTES:

- 1 Shields, such as those described in IEC 61034-1, may need to be placed in an appropriate position to protect the burner from draughts that may influence the flame geometry.
- 2 The test given in this Standard may involve the use of dangerous voltages and temperatures. Suitable precautions should be taken against the risk of shock, burning, fire and explosion that may be involved, and against any noxious fumes that may be produced.

2.3 TEST APPARATUS

2.3.1 Sample supporting system

The cable sample, as described in the relevant procedure in Section 4 onwards shall be held horizontally by means of suitable supports at each end of the sheathed or protected portion. The sample shall be securely clamped at one end to prevent movement and supported at the other end to allow for thermal expansion in the longitudinal direction. The middle portion of the cable shall be supported by two metal rings placed approximately 300 mm apart; these, as well as any other metal parts of the supporting apparatus, shall be earthed. The rings shall have an inside diameter of approximately 150 mm and shall be made from a circular steel rod of (10 ± 2) mm in diameter. The cable supporting arrangement is shown in Figure 1.

For unarmoured cables of less than 10 mm in diameter, three additional metal supporting rings, each placed approximately 150 mm from the two previously specified rings, shall be used to support the cable.

2.3.2 Source of heat

2.3.2.1 Burner system

The source of heat shall be a ribbon type propane gas burner with a nominal burner face length of 500 mm with Venturi mixer. A centre-feed burner is recommended. The nominal burner face width shall be 15 mm. The face of the burner shall have three staggered rows of drilled holes, nominally 1.32 mm in diameter and drilled on 3.2 mm centres, as shown in Figure 2. Additionally, a row of small holes milled on each side of the burner plate, to serve as pilot holes for keeping the flame burning, is permitted.

NOTE: Guidance on the choice of recommended burner system is given in Appendix B.

2.3.2.2 Flowmeters

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

Figure 3 shows an example of a rotameter-type system. In order to allow for variations in temperature or pressure from those specified for the rotameter-type flowmeters, corrections shall be applied when necessary.

NOTES:

- 1 Guidance on the application of correction factors is given in Appendix C.
- 2 Mass flowmeters are recommended for ease of use and accuracy of control.

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

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

- (a) Air: (80 ± 5) l/min per 500 mm burner face length.
- (b) Propane: (5 ± 0.25) l/min per 500 mm burner face length.

2.3.2.3 Verification

The burner and control system shall be subject to verification following the procedure given in Appendix A.

2.3.3 Positioning of source of heat

The burner face shall be positioned in the test chamber so that it is at least 200 mm above the floor of the chamber and at least 300 mm from any chamber wall.

The burner shall be aligned with the test sample, as shown in Figure 4, so that—

- (a) its horizontal central plane is at a distance of (70 ± 10) mm below the lowest point of the test sample; and
- (b) its vertical front face is approximately 45 mm from the central vertical plane of the test sample.

The exact burner location to be used during cable testing shall be determined using the verification procedure given in Appendix A.

SECTION 3 APPARATUS — FIRE WITH SHOCK AT A TEMPERATURE OF AT LEAST 830 °C

3.1 GENERAL

This Section specifies the test apparatus to be used for testing cables required to maintain circuit integrity when subject to fire and mechanical shock where the test condition is based upon a flame with a controlled heat output corresponding to a temperature of a nominal 850°C. It is intended for use when testing cables of greater than 20 mm overall diameter.

The method of verification of the burner and control system used for the test is provided in Appendix D.

3.2 TEST CONDITIONS

3.2.1 Test environment

The test shall be carried out in a suitable chamber, of minimum volume 20 m³, with facilities for disposing of any noxious gases resulting from burning. Sufficient ventilation shall be available to sustain the flame for the duration of the test, but forced ventilation shall not be used.

NOTE: An example of a suitable chamber is given in IEC 61034-1.

The chamber and test apparatus shall be between 10°C and 40°C at the start of each test.

The same ventilation and shielding conditions shall be used in the chamber during both the verification and cable test procedures.

NOTES:

- 1 Shields, such as those described in IEC 61034-1, may need to be placed in an appropriate position to protect the burner from draughts that may influence the flame geometry.
- 2 The test given in this Standard may involve the use of dangerous voltages and temperatures. Suitable precautions should be taken against the risk of shock, burning, fire and explosion that may be involved, and against any noxious fumes that may be produced.

3.3 TEST APPARATUS

3.3.1 Test equipment

The test equipment consists of the following:

- (a) A test ladder, on to which the cable is mounted, comprising a steel framework fastened to a rigid support as described in Clause 3.3.2.
- (b) A source of heat comprising a horizontally mounted ribbon burner as described in Clause 3.3.3.
- (c) A shock-producing device as described in Clause 3.3.4.
- (d) A test wall equipped with thermocouples for verification of the source of heat as described in Appendix D.

A general arrangement of the test equipment is shown in Figures 5, 6 and 7.

3.3.2 Test ladder and mounting

The test ladder consists of a steel framework as shown in Figure 5. The two central vertical elements of the ladder are adjustable in order to accommodate different sizes of cable under test. The test ladder is approximately 1 200 mm long and 600 mm high, and the total mass of the test ladder shall be (18 ± 1) kg. Ballast, if required, shall be placed on the steel supports.

NOTE: Angle iron approximately 45 mm wide and 6 mm thick, with suitable slots cut to allow for movement of vertical elements and fixing of the bolts and clips, has been found to be a suitable material for construction of the ladder.

Each horizontal element shall have a mounting hole not more than 200 mm from each end, the exact position and diameter being determined by the particular supporting bush and supporting framework used. The test ladder shall be fastened to a rigid support by four bonded rubber bushes of hardness 50 to 60 Shore A fitted between the horizontal steel elements of the ladder and the support framework, as shown in Figures 5 and 6 so as to allow movement under impact.

NOTE: A typical rubber bush, which has been found to be suitable, is shown in Figure 8.

3.3.3 Source of heat

3.3.3.1 Burner system

The source of heat shall be a ribbon type propane gas burner with a nominal burner face length of 500 mm with a Venturi mixer. A centre-feed burner is recommended. The nominal burner face width shall be 10 mm. The face of the burner shall have three staggered rows of drilled holes, nominally 1.32 mm in diameter and drilled at centres 3.2 mm from one another, as shown in Figure 2. Additionally, a row of small holes milled on each side of the burner plate, to serve as pilot holes for keeping the flame burning, is permitted.

NOTE: Guidance on the choice of recommended burner system is given in Appendix B.

3.3.3.2 Flowmeters

Mass flowmeters shall be used as the means of controlling accurately the input flow rates of fuel and air to the burner.

NOTE: Rotameter type flowmeters may be used as an alternative, but are not recommended. Guidance on their use, and the application of appropriate correction factors is given in Appendix C. Figure 3 shows an example of a rotameter type system.

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

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

- (a) Air: (160 ± 8) l/min.
- (b) Propane: (10 ± 0.4) l/min.

3.3.3.3 Verification

The burner and control system shall be subject to verification following the procedure given in Appendix D.

3.3.4 Shock producing device

The shock producing device consists of a mild steel round bar (25 ± 0.1) mm in diameter and (600 ± 5) mm long. The bar is freely pivoted about an axis parallel to the test ladder, which is in the same horizontal plane as, and (200 ± 5) mm away from, the upper edge of the test ladder. The axis divides the bar into two unequal lengths, (400 ± 5) mm and approximately 200 mm, respectively, the longer length impacting the ladder. The bar drops under its own weight from an angle of 60° to the horizontal to strike the test ladder at its midpoint as shown in Figures 5 and 7.

3.3.5 Positioning of source of heat

The burner face shall be positioned in the test chamber so that it is at least 200 mm above the floor of the chamber, or any solid mounting block, and at least 500 mm from any chamber wall.

By reference to the centre point of the cable to be tested, the burner shall be positioned centrally at a horizontal distance of $(H \pm 2)$ mm from the burner face to the centre of the cable and at a vertical distance of $(V \pm 2)$ mm from the burner centre line to the centre of the cable, as shown in Figure 7.

The exact burner location to be used during cable testing shall be determined using the verification procedure given in Appendix D, where the values of H and V to be used shall be determined.

NOTE: The burner should be rigidly fixed to the framework during testing so as to prevent movement relative to the test sample.

SECTION 4 PROCEDURES AND REQUIREMENTS — CABLES OF RATED VOLTAGE UP TO AND INCLUDING 0.6/1.0 kV

4.1 GENERAL

This Section specifies the test procedure and gives the performance requirement, including a recommended flame application time, for cables of rated voltage up to and including 0.6/1.0 kV required to maintain circuit integrity when subjected to fire under specified conditions.

It describes the means of sample preparation, continuity checking arrangements, electrical testing procedure, method of burning the cables and gives requirements for evaluating test results.

It is intended to cover low voltage power cables, and control cables with a rated voltage.

4.2 SAMPLE PREPARATION

A sample of the completed cable approximately 1 200 mm long shall have approximately 100 mm of sheath or outer coverings removed at each end.

At each end of the cable, each conductor shall be suitably prepared for electrical connections, and the exposed conductors shall be spread apart to avoid contact with each other.

4.3 CONTINUITY CHECKING ARRANGEMENTS

During the test a current for continuity checking is passed through all conductors of the cable and this shall be provided by a three-phase star connected or single-phase transformer(s) of sufficient capacity to maintain the test voltage up to the maximum leakage current allowable.

This current is achieved by connecting, at the other end of the sample, a suitable load and an indicating device (e.g. lamp) to each conductor, or group of conductors.

NOTE: A current of 0.25 A at the test voltage, through each conductor or group of conductors, has been found to be suitable.

4.4 TEST PROCEDURE

4.4.1 Apparatus

The test procedure defined in this Clause shall be carried out using the apparatus detailed in Section 2.

4.4.2 Fuses

Fuses used in the test procedure shall be type DII complying with AS 60269.3.1. Alternatively, a circuit-breaker with equivalent characteristics may be used.

Where a circuit-breaker is used, its equivalent characteristics shall be demonstrated by reference to the characteristic curve shown in Appendix E.

The fuse shall be the reference method in the case of dispute.

4.4.3 Sample and burner positioning

Mount the sample in the clamp and supports. Adjust the burner to the correct position relative to the sample, as defined by the values of x and y arising from the verification procedure (see Section 2).

4.4.4 Electrical connections

At the transformer end of the sample, earth the neutral conductor and any protective conductors. Any metal screens, drain wire or metallic layer shall be interconnected and earthed. Connect the transformer(s) to the conductors, excluding any conductor which is specifically identified as intended for use as a neutral or a protective conductor, as shown in the circuit diagram in Figure 9. Where a metallic sheath, armour or screen acts as a neutral or protective conductor, it shall be connected, as shown in the circuit diagram in Figure 9, as for a neutral or protective conductor.

For single-, twin- or three-phase cables, connect each phase conductor to a separate phase of the transformer(s) output with a 2 A fuse or circuit-breaker with equivalent characteristics in each phase.

For multicore cables that have four or more conductors (excluding any neutral or protective conductors), the conductors shall be divided into three roughly equal groups, ensuring that adjacent conductors are, as far as possible, in different groups.

For multipair cables, the conductors shall be divided into two equal groups, ensuring that the a-core of each pair is connected to one phase and the b-core of each pair is connected to another phase (L1 and L2 of Figure 9). Quads shall be treated as two pairs.

For multitriples cables, the conductors shall be divided into three equal groups, ensuring that the a-core of each triple is connected to one phase, the b-core of each triple to another phase and the c-core of each triple to the third phase of the transformer. (L1, L2 and L3 of Figure 9.)

Connect the conductors of each group in series and connect each group to a separate phase of the transformer output with a 2 A fuse or circuit-breaker with equivalent characteristics in each phase.

NOTE: For cable constructions not specifically identified above, the test voltage should be applied, as far as is practicable, to ensure that adjacent conductors are connected to different phases.

At the end of the sample remote from the transformer—

- (a) connect each phase conductor, or group of conductors, to one terminal of the load and indicating device (as described in Clause 4.3), the other terminal being earthed; and
- (b) connect the neutral conductor and any protective conductor to one terminal of the load and indicating device (as described in Clause 4.3), the other terminal being connected to L1 (or L2 or L3) at the transformer end (see Figure 9).

4.4.5 Commencement of test

Ignite the burner and adjust the propane and air flow rates to those obtained during the verification procedure (see Section 2).

Switch on the electricity supply and adjust the voltage to the rated voltage of the cable (subject to a minimum voltage of 100 V a.c.), i.e. the test voltage between conductors shall equal the rated voltage between conductors, and the test voltage from conductor to earth shall equal the rated voltage from conductor to earth. In the case of single-core cables the voltage shall be applied between the conductor and the earthed supporting apparatus and earthed metallic covering, if present.

4.4.6 Test duration

The test shall continue for the flame application time given in Clause 4.5.1, after which the flame shall be extinguished but the cable sample shall remain energized for a further 15 min. The total test duration shall be the flame application time together with the 15 min cooling period.

4.5 PERFORMANCE REQUIREMENT

4.5.1 Flame application time

The flame application time shall be as specified in the relevant cable Standard. In the absence of such a cable specification, a 90 min flame application is recommended.

NOTE: A 90 min flame application time has been found to be acceptable on the basis of products tested to date.

4.6 ACCEPTANCE CRITERIA

With reference to the test procedure given in Clause 4.4 the cable possesses the characteristics for providing circuit integrity so long as during the course of the test—

- (a) the voltage is maintained, i.e. no fuse fails or circuit-breaker is interrupted; and
- (b) a conductor does not rupture, i.e. the lamp is not extinguished.

4.7 RETEST PROCEDURE

In the event of a failure, as judged by the requirements of the relevant standard, two further samples shall be tested. If both comply the test shall be deemed successful.

4.8 TEST REPORT

The test report shall include the following information:

- (a) Full description of cable tested.
- (b) Manufacturer of cable tested.
- (c) Test voltage.
- (d) Any deviations in methodology from the requirements of this Standard.
- (e) The actual performance requirement applied (by reference to Clause 4.5 or to the relevant cable Standard).
- (f) The flame application time.

NOTE: The flame application time is that time normally stated in the cable specification as the circuit integrity rating of the cable. If the cable is to be marked to demonstrate conformity with this standard, it is recommended that the flame application time be marked as well, i.e. 'AS/NZS 1660.5.5 Section 4 (90)' for a 90 min flame application time.