

Australian Standard™

Fire hazard testing

**Part 6.30: Guidance and test methods
on the assessment of obscuration
hazard of vision caused by smoke
opacity from electrotechnical products
involved in fires—Small scale static
method—Determination of smoke
opacity—Description of the apparatus**



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 - Australian Information Industry Association
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 - Electrical Regulatory Authorities Council
 - Energy Networks Association
-

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Part 6.30: Guidance and test methods on the assessment of obscuration hazard of vision caused by smoke opacity from electrotechnical products involved in fires—Small scale static method—Determination of smoke opacity—Description of the apparatus

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PREFACE

This Standard was prepared by the Standards Australia Committee EL-053, Fire hazard testing—Electrotechnical equipment.

The objective of this series of standards is to provide the electrotechnology industry and standards writing committees with a series of standards which give guidance on assessing the fire hazard of electrotechnical products.

This Standard is identical with, and has been reproduced from IEC/TS 60695-6-30, Ed 1.0 (1996), *Fire hazard testing - Part 6: Guidance and test methods on the assessment of obscuration hazards of vision caused by smoke opacity from electrotechnical products involved in fires - Section 30: Small scale static method. Determination of smoke opacity - Description of the apparatus.*

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Any International Standard referenced should be replaced by an equivalent Australian Standard where one is available. The availability of equivalent Australian Standards can be determined either from the Standards Web Shop at www.standards.com.au or from the annual printed catalogue of Australian Standards.

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STANDARDS AUSTRALIA

Australian Standard**Fire hazard testing****Part 6.30: Guidance and test methods on the assessment of obscuration hazard of vision caused by smoke opacity from electrotechnical products involved in fires—Small scale static method—Determination of smoke opacity—Description of the apparatus**

1 Scope

This section of IEC 695-6 describes the apparatus, calibration procedures and basic experimental procedures for the determination of the specific optical density of smoke produced by materials exposed vertically to a radiant heat source with or without the application of a pilot flame. The test specimens are of a defined size. The determination of the optical density is carried out in a pressure controlled chamber previously calibrated with reference materials.

This method is applicable to solid, non-metallic flat test specimens only. It is not suitable for use with non-planar specimens, e.g. insulated wire and cable, because it is not possible to obtain a homogeneous distribution of heat flux with such products.

This standard does not provide a classification system for the behaviour of materials.

Materials which melt and flow away from the direct impingement of heat flux may not provide reproducible results and this method is not applicable.

Virtually all non-metallic materials, including those used in electrotechnical products, emit smoke when exposed to heat. Among the hazards associated with fire, smoke causes human and material damage and impairs fire fighting. Consequently, a reduction in the rate of generation of opaque smoke produced by materials/products during a fire reduces damage to equipment, facilitates evacuation of people and emergency services intervention.

WARNING: Appropriate safety measures are to be taken as toxic and harmful effluents may be produced by pyrolysis or combustion of test specimens.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this section of IEC 695-6. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this section of IEC 695-6 are encouraged to investigate the possibility of applying the most recent edition of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 584-1: 1977, *Thermocouples – Part 1: Reference tables*
Amendment 1 (1989)

IEC 584-2 : 1982, *Thermocouples – Part 2: Tolerances*

IEC 695-1-1: 1995, *Fire hazard testing – Part 1: Guidance for assessing fire hazard of electrotechnical products – Section 1: General guidance*

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IEC 695-4: 1993, *Fire hazard testing – Part 4: Terminology concerning fire tests*

ISO 1923: 1981, *Cellular plastics and rubbers - Determination of linear dimensions*

3 Definitions

For the purposes of this section of IEC 695-6, the following definitions taken from IEC 695-4 apply:

3.1

opacity (of smoke)

the ratio (I/T) of incident luminous flux (I) to transmitted luminous flux (T) through smoke, under specified test conditions.

3.2

optical density (of smoke) [$\lg(I/T)$]

the common logarithm of the opacity of smoke.

NOTE In this standard (D) is used to represent the optical density of smoke.

3.3

specific optical density, D_s

A measure of the smoke produced by a test specimen of a material or a product, taking into account the optical density and factors characteristic of the specified test method.

NOTE Specific optical density is a dimensionless number.

4 Principle

A test specimen, mounted vertically, is exposed to a controlled thermal radiation in a pressure controlled chamber, with or without the application of a pilot flame.

A photometric system is used to measure the opacity of the smoke generated.

5 Apparatus

This apparatus is able to measure a maximum specific optical density of 528 with the moveable filter in place, and 924 without this filter.

A description of the test apparatus is given in annex A (figures A.1 to A.8).

The details of construction are given in annex B.

The calibration procedure and suggestions for maintenance are given in annex C.

Two examples of the test apparatus are given in annex D.

5.1 Test chamber

5.1.1 The test chamber has a nominal volume of 0,51 m³ and the following internal dimensions:

- width: 914 mm $\pm$ 3 mm
- depth: 610 mm $\pm$ 3 mm
- height: 914 mm $\pm$ 3 mm

The interior surfaces shall be suitable for periodic cleaning and resistant to corrosion.

NOTE Example of panel construction: interior surface made of enamelled steel, core panels made of thermally insulating material, exterior surface made of galvanized steel.

5.1.2 When closed, the chamber shall be capable of maintaining positive pressure during test periods, in accordance with 6.3. A water manometer is suitable for measuring the chamber pressure.

A blow-out sheet of aluminium foil approximately 0,04 mm thick is used to cover an aperture in the floor of the chamber, to provide protection against a sudden increase in pressure. Before installing, carefully degrease, clean and wipe the floor of the chamber around the aperture.

Care shall be taken not to wrinkle the foil so that no leakage develops at any creases.

A stainless steel grid can be placed over the aluminium foil to protect it. A stainless steel receptacle can be placed under the specimen holder to collect flow from melting specimen which might damage the aluminium foil.

5.1.3 An exhaust system complying with safety environment regulations shall be connected to the smoke outlet.

5.1.4 A thermocouple shall be fixed to the centre of the inner surface of the wall opposite the door to measure the inside temperature (see clause B.8).

5.2 Furnace (radiant heat source) (see figure A.2 and clause B.1)

The furnace is a ceramic tube with an inside diameter of approximately 76,2 mm, containing an electric heating element (see figure A.2) and constructed and positioned as described in clause B.1.

The furnace and its support are positioned so that the distance between the heating element and the test specimen surface is $76,2 \text{ mm} \pm 1,0 \text{ mm}$.

The furnace operation shall be permanently monitored by means of an appropriate system. The output from the furnace shall be controlled such that the radiance level is maintained within the specified limits of $25 \text{ kW/m}^2 \pm 0,5 \text{ kW/m}^2$ averaged over a 38,1 mm diameter circle at the centre of the test specimen position (see annex C).

5.3 Test specimen holder and support

5.3.1 The test specimen holder (see figure A.4 and clause B.2) is placed on a support attached to the furnace support so that the centre of the test specimen can be moved by an appropriate device along the centreline of the furnace.

5.3.2 A blank specimen holder, consisting of a refractory plate $76,2 \text{ mm} \times 76,2 \text{ mm}$ shall be located in front of the furnace opening, whenever the furnace is energised, except during testing or calibration.

The refractory plate is held against the lips of the front of the test specimen holder by a spring and retaining rod.

NOTE A plate with a nominal density of between 800 kg/m^3 and 970 kg/m^3 and a minimum thickness of 10 mm has been found satisfactory.

5.4 Gas burner (see clause B.4)

During flaming exposure tests, a burner with a row of six tubes is fixed so that the tips of the horizontal tubes are centred $6,4 \text{ mm} \pm 1,5 \text{ mm}$ above the lower opening of the test specimen holder (N dimension in figure A.4) and $6,4 \text{ mm} \pm 0,8 \text{ mm}$ away from the test specimen area (M dimension in figure A.4).

The fuel used shall be a mixture of propane (purity 95 % or better) and air at flowrates of $50 \text{ cm}^3/\text{min} \pm 5 \text{ cm}^3/\text{min}$ and $500 \text{ cm}^3/\text{min} \pm 25 \text{ cm}^3/\text{min}$ respectively. The flow-rates are adjusted by needle valves and measured by two flow meters.

5.5 Photometric system (see figure A.5 and clause B.5)

The photometric system consists of a light source and photodetector oriented vertically to reduce measurement variations resulting from stratification of the smoke.

The photometric system shall ensure the recording of optical densities over 6 sensitivity ranges for the measurement of the transmittance factors comprised between 0,0001 % and 100 %.

The photometer shall have an accuracy of better than $\pm 3 \%$ of the maximum reading on any sensitivity range. The output of the photodetector is connected to a recording device.

5.5.1 The light source is an incandescent tungsten filament lamp (nominally 6,5V) mounted in a light-tight box separated from the test chamber by a window located in the floor, heated to about $50 \text{ }^\circ\text{C}$ in order to prevent condensation.

This box shall contain the necessary optics to provide a collimated light beam of $38,1 \text{ mm}$ diameter passing vertically through the chamber.

5.5.2 The photodetector is a photomultiplier tube with a dark current of less than 1 nA and an S-4 spectral sensitivity response in accordance with the ILC¹⁾, located at the top of the chamber opposite the light source in a light-tight box isolated from the test chamber by a window located in the ceiling. A converging lens shall be used to focus the beam on the detector. A removable neutral filter with a nominal optical density of 2, is used to extend the range of measurements of the optical density.

5.6 Measuring and recording devices

A data recorder shall be available to measure:

- the radiometer output voltage when calibrating the furnace (see 6.1);
- the photodetector output voltage during the tests (see 5.5.2).

6 Calibration and verification

Before any calibration or test, the temperature of the rear wall panel of the test chamber shall be stabilised at $33 \text{ }^\circ\text{C} \pm 4 \text{ K}$, the apparatus cleaned of any residues from previous tests, and flushed with air for at least 2 min.

6.1 Furnace calibration

The furnace shall be calibrated using the following procedure:

1) ILC: International Lighting Commission

Remove the burner, mount the radiometer in the furnace in the stand-by position and connect to the electrical and gas services. Place the blank test specimen holder in position in front of the furnace. Move the radiometer in front of the furnace by displacing the blank test specimen holder against the stop on the supporting framework, and check the accuracy of the radiometer alignment relative to the furnace opening using the 38,1 mm gauge, and make any necessary adjustments (see C.1.1).

NOTE This test is sensitive to small variations in the position of the radiometer and of test specimens relative to the radiant heat source. The furnace gauge can also be used for checking the position of specimen holders.

Return the radiometer and blank test specimen holder to their former positions, bring the apparatus to its normal operating condition with the chamber wall temperature remaining steady at $33\text{ }^{\circ}\text{C} \pm 4\text{ K}$, and move the radiometer to be in front of the furnace by displacing the blank test specimen holder against the stop.

With the chamber door closed, the inlet vent open and the exhaust vent closed, supply air to the radiometer cooler to maintain the radiometer body temperature at $93\text{ }^{\circ}\text{C} \pm 3\text{ K}$. Monitor the radiometer output to determine when equilibrium has been reached, and then adjust the furnace, as necessary, to give a steady voltage reading corresponding to the calibrated value equivalent to a steady-state irradiance of $25\text{ kW/m}^2 \pm 0,5\text{ kW/m}^2$. Allow about 10 min between adjustments to the furnace to ensure that the radiometer has reached equilibrium. If the door is opened for any reason during calibration, wait sufficient time after closing the door to allow thermal equilibrium to be reached before taking the final voltage reading.

At the end of the calibration procedure, return the blank specimen holder to the position in front of the furnace, turn off the radiometer cooling air supply and remove the radiometer from the test chamber.

6.2 Verification of the optical device (see C.1.3)

The accuracy and linearity of the photometer shall be confirmed by placing standard neutral density filters (described in C.1.3.2) in the light path. These filters shall cover the whole aperture of the optical system and the specific optical density values measured by the photometer shall be $\pm 5\%$ of the calibrated values.

NOTE In order to confirm the specified rated values of specific optical density given at 600 nm the light transmittance of these filters can be checked by spectrometric analysis in the range 400 nm-900 nm, because the light source has a wide spectral distribution. Hence, the specific optical density measured with this filter may not be accurate, but comparable from one laboratory to another, if the spectral distribution of the lamps is identical.

6.3 Verification of the chamber air-tightness

The chamber tightness shall be verified periodically by a leakage rate test using a U-shaped manometer (see figure A.8 and clause B.9). The pressure inside the chamber shall be raised to approximately 76 mm of water by introducing compressed air through a gas sampling port on the top of the chamber.

The time for the pressure to fall to 50 mm of water, determined using a stopwatch, shall not be less than 5 min.

7 Verification of the performance of the apparatus by the use of reference materials

Two reference materials shall be used to check the correct operation of the apparatus and the test procedure:

- alpha cellulose paper (reference SMR 1006) for the non-flaming test (see note),
- a sheet of plastic material (reference SMR 1007) for the flaming test (see note).

NOTE These reference materials can be obtained from the Office of Standards Reference Materials - National Institute of Standards and Technology (NIST), Gaithersburg, MD USA.

7.1 Test specimens

Prior to testing, all the test specimens of the reference materials shall be conditioned in accordance with instructions given by the certificate for each reference materials; with all faces in contact with air.

The test specimen shall be 76,2 mm × 76,2 mm.

The thickness of each test specimen shall be measured in accordance with ISO 1923, and a batch with at least six test specimens prepared in which the thickness range is less than 0,1 mm.

After conditioning, each specimen shall be prepared as follows:

Using a flat base, lay the sample face-upwards on the dull side of a piece of aluminium foil approximately 0,04 mm thick, and of sufficient size that will fold up over the edges and cover 6 to 10 mm around the face of the specimen.

Carefully fold the foil over the edges and onto the specimen face to achieve a close fit and minimum wrinkling (some preliminary diagonal cuts at the corners may help to reduce wrinkling). Avoid puncturing the foil.

Cut the top and side overlaps so as to expose the 65 mm × 65 mm test area, leaving the bottom flap to be turned down into the trough of the specimen holder as a chute for test debris after insertion. Avoid damaging the specimen face when cutting the foil. With some hard materials it may be possible to trim the foil against the aperture of the specimen holder, after insertion.

Insert the specimen into the specimen holder and back it with a 75 mm square piece of non-combustible insulating board of oven-dry density of $850 \pm 100 \text{ kg/m}^3$, with a nominal thickness of 12,5 mm, then insert the spring and retaining clip. For specimens greater than 16 mm thick an adjustable clip is used. Cut the foil around the specimen holder aperture, if required, and form the chute into the specimen holder trough.

7.2 Preparation of the apparatus

The windows of the photometric system shall be cleaned before each test.

NOTE Alcohol is a suitable product.

Switch on the light source and all the measuring devices and allow to stabilise.

If testing in the flaming mode, adjust the air and propane flowrates as specified in 5.4 and ignite the burner. If testing in the non-flaming mode, remove the burner and allow the burner to stabilise at its calibration setting (see 6.1).

Install a No. 2 density filter in the detector and connect the photometer to the recording system. Adjust the system to read zero when the detector is covered, and a full-scale reading on the least sensitive scale when the detector is exposed (100 % transmittance).

7.3 Procedure

The test specimen is exposed to the radiant heat flux emitted by the furnace. The average heat flux at the surface of the test specimen shall be $25 \text{ kW/m}^2 \pm 0,5 \text{ kW/m}^2$.

Test material referenced: SRM 1006 - no pilot burner application

Test material referenced: SRM 1007 - pilot flame applied