

NFPA 272

Standard Method of Test for Heat and Visible Smoke Release Rates for Upholstered Furniture Components or Composites and Mattresses Using an Oxygen Consumption Calorimeter

2003 Edition



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An International Codes and Standards Organization

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2003 Edition

This edition of NFPA 272, *Standard Method of Test for Heat and Visible Smoke Release Rates for Upholstered Furniture Components or Composites and Mattresses Using an Oxygen Consumption Calorimeter*, was prepared by the Technical Committee on Fire Tests and acted on by NFPA at its November Association Technical Meeting held November 16–20, 2002, in Atlanta, GA. It was issued by the Standards Council on January 17, 2003, with an effective date of February 6, 2003, and supersedes all previous editions.

This edition of NFPA 272 was approved as an American National Standard on January 17, 2003.

Origin and Development of NFPA 272

In 1998 (F98) NFPA 264A was renumbered as NFPA 272 to coordinate a family of documents that will be relying on NFPA 271 as the base document for specifics on the test apparatus, calibration, and test procedure. The concept is to develop specific documents such as NFPA 272, which provides criteria for the specimen preparation for upholstered furniture components and mattresses.

The original 1990 edition of NFPA 264A was based on the methods of measuring rates of heat release using an oxygen consumption calorimeter developed at the National Bureau of Standards (now the National Institute of Standards and Technology) by V. Babrauskas et al. It addressed only upholstered furniture and mattresses. The 1994 edition of NFPA 264A was a reconfirmation of the original document, with minor editorial changes, because the methods of measuring rates of heat release were still being used within the industry in areas such as product development. In testing of other various materials, a new document, NFPA 264, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*, was developed. The NFPA 264 document was closely related to and derived from NFPA 264A.

The 1999 edition of NFPA 272 incorporated updated provisions for specimen preparation as used in current testing practices. Chapter 6 on calculations was updated and revised to include the measurement of smoke obscuration.

The 2003 edition of NFPA 272 incorporates all formatting changes required under the provisions of NFPA's *Manual of Style* and revised requirements for developing the report of results, as described in Chapter 8.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, Annex C lists the complete title and edition of the source documents for both mandatory and nonmandatory extracts. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex C.

Chapter 1 Administration

1.1 Scope.

1.1.1 This test method shall be used to determine the ignitability and release rates of heat and visible smoke from components or composite structures of upholstered furniture and mattresses using an oxygen consumption calorimeter.

1.1.2 In this test method, a horizontally oriented specimen shall undergo radiant thermal exposure using an external igniter.

1.1.3 Radiant exposure shall be maintained at a constant rate of 35 kW/m² to determine time to sustained flaming, rate of heat release per unit area (kW/m²), specific extinction area, and effective heat of combustion (MJ/kg).

1.1.4 The rate of heat release shall be determined by measurement of oxygen consumption as determined by the level of oxygen concentration and the flow rate in the combustion product stream.

1.1.5 The effective heat of combustion shall be determined from a concomitant measurement of specimen mass loss rate, in combination with the heat release rate.

1.1.6 The testing shall be done on bench-scale specimens combining the furniture or mattress cover fabrics and padding, but not including frame elements.

1.1.7 Safety.

1.1.7.1 This standard shall not purport to address all safety problems associated with use of the equipment.

1.1.7.2 It shall be the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

1.2 Purpose.

1.2.1 This test method is based on the observation that, generally, the net heat of combustion is directly related to the amount of oxygen required for combustion. Approximately 13.1 × 10³ kJ of heat are released per 1 kg of oxygen consumed.

1.2.2 Specimens in the test are burned in ambient air conditions while being subjected to a prescribed external heat flux of 35 kW/m².

1.2.3 The rate of heat release shall be determined by measurement of the oxygen consumption, as determined by the oxygen concentration and the flow rate in the combustion product stream.

1.2.4 The primary measurements are of oxygen concentration and exhaust gas flow rate, used (together with temperature and pressure measurements) to assess heat release rate.

1.2.4.1 Additional measurements include the mass loss rate of the specimen, the time to sustained flaming, the effective heat of combustion, the specific extinction area, and other measurements as required in the relevant material or performance standard.

1.2.4.2 Ignitability shall be determined as the measure of the time from initial exposure to time of sustained flaming.

1.3 Application.

1.3.1* This test method shall be used to determine fire properties, including the time to ignition and heat release rate (as indicated in 1.2.4.1) of materials and composites exposed to a prescribed heat flux.

1.3.2* Quantitative heat release measurements provide information that is potentially useful in the design of upholstery and mattress products and in product development.

1.4 Test Limitations. The test data has limited validity in the following situations:

- (1) When explosive spalling occurs
- (2) When the specimen swells sufficiently, prior to ignition, to cause it to touch the spark plug, or if it swells up to the plane of the heater base during combustion

1.5 Units and Formulas.

1.5.1 SI Units. Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI).

1.5.2 Unless otherwise stated, all dimensions included in the test and figures shall be mandatory and shall be followed within nominal tolerances of 1 mm.

1.5.3 Symbols. The following symbols shall be used in this standard:

- A_s = nominal specimen exposed surface area (0.01 m²)
 C = calibration constant for oxygen consumption analysis (m^{1/2} kg^{1/2} K^{1/2})
 $\Delta H_c/r_0$ = net heat of combustion (kJ/kg)
 $\Delta H_{c,eff}$ = effective heat of combustion (kJ/kg)

I	= actual beam intensity
I_0	= beam intensity with no smoke
k	= smoke extinction coefficient (m^{-1})
L	= extinction beam path length (m)
m	= specimen mass (kg)
m_f	= final specimen mass (kg)
m_i	= initial specimen mass (kg)
$\dot{m}$	= specimen mass loss rate (kg/sec)
ΔP	= orifice meter pressure differential (Pa)
q''	= total heat release (kJ/m^2)
$\dot{q}$	= heat release rate (kW)
$\dot{q}''$	= heat release rate per unit area (kW/m^2)
t_0	= stoichiometric oxygen/fuel mass ratio
t	= time (sec)
t_d	= oxygen analyzer delay time (sec)
Δt	= sampling time interval (sec)
T_e	= absolute temperature of gas at the orifice meter (K)
v	= volume exhaust flow rate measured at the location of the laser photometer (m^3/sec)
X_{O_2}	= oxygen analyzer reading, mole fraction of O_2
$X_{\text{O}_2}^0$	= initial value of oxygen analyzer reading
$X_{\text{O}_2}^1$	= oxygen analyzer reading, before delay time correction
σ_f	= average specific extinction area, for smoke (m^2/kg)

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publication. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 271, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*, 2001 edition.

2.3 Other Publications. (Reserved)

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1 Shall. Indicates a mandatory requirement.

3.2.2 Should. Indicates a recommendation or that which is advised but not required.

3.2.3 Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 Heat of Combustion.

3.3.1.1 Effective Heat of Combustion. The measured heat release divided by the mass loss for a specified time period. [271:3.3.1.1]

3.3.1.2 Net Heat of Combustion. The oxygen bomb calorimeter value for the heat of combustion, corrected for the gaseous state of water produced. [271:3.3.1.2]

3.3.2 Heat Release Rate. The heat evolved from the specimen, per unit of time. [271:3.3.2]

3.3.3 Heating Flux. The incident radiant heat flux imposed externally from the heater on the specimen at the initiation of the test. [271:3.3.3]

3.3.4 Ignitability. The propensity for ignition, as measured by the time to sustained flaming, in seconds, at a specified heating flux. [271:3.3.4]

3.3.5 Orientation. The plane in which the exposed face of the specimen is located during testing (e.g., horizontally facing the heater). [271:3.3.5]

3.3.6 Oxygen Consumption Principle. The expression of the relationship between the mass of oxygen consumed during combustion and the heat released. [271:3.3.6]

3.3.7 Smoke Obscuration. The reduction of light transmission by smoke, as measured by light attenuation. [271:3.3.7]

3.3.8 Sustained Flaming. The existence of flame on or over the surface of the specimen for periods of at least 4 seconds. [271:3.3.8]

3.3.9 Visible Smoke. The obscuration of transmitted light caused by combustion products released during the test. [271:3.3.9]

Chapter 4 Test Apparatus

4.1 General.

4.1.1 The test apparatus shall consist of the following components:

- (1) A conical-shaped radiant electric heater
- (2) Specimen holders
- (3) An exhaust-gas system with oxygen-monitoring and flow-measuring instrumentation
- (4) An electric ignition spark plug
- (5) A data collection and analysis system
- (6) A load cell for measuring specimen mass loss

4.1.2 The apparatus shall be configured as shown in Figure 4.1.2.

4.2 Specific. Test apparatus shall be constructed in accordance with Chapter 4, Test Apparatus, of NFPA 271, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*.

4.3 Calibration. The equipment shall be calibrated in accordance with Chapter 5, Calibration of Equipment, of NFPA 271, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*.