INTERNATIONAL STANDARD

ISO 12949

First edition
2011-11-01

Standard test method for measuring the heat release rate of low flammability mattresses and mattress sets

Méthode d'essai normalisée pour mesurer le débit calorifique de matelas et d'éléments de matelas à inflammabilité réduite

Reference number
ISO 12949:2011(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12949 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

Introduction

A typical bed consists of several components, including a mattress, a foundation, and a collection of bedclothes (e.g. mattress pad, sheets, pillows, blankets, quilts and/or comforters). Mattress and bedding fires are a major contributor to residential fire deaths [1]. A significant portion of these deaths and injuries results from fires in which the bedclothes are the first items ignited, and those flames ignite the mattress or foundation. In the United States, approximately two-thirds of all deaths from flaming bed fires occur after the room has reached the point of flashover [2]. This accounts for nearly all the fatalities that occur outside the room of fire origin and about half of the fatalities that occur within the room of origin.

A burning mattress is generally the primary energy contributor to a fatal bedroom fire. Once the mattress is ignited, the fire develops rapidly. Room flashover occurs at heat release rates near or above 1 000 kW (1 MW) for small-to-medium size bedrooms [3]. 1 m wide mattresses, without bedclothes, have been shown to reach peak heat release rates of 2 MW and flash over a room in less than 300 s [3]. In addition, a typical set of bedclothes on a 1 m wide bed can lead to a fire whose peak rate of heat release is approximately 100 kW to 200 kW [4], with values up to 400 kW possible for the heaviest sets [5]. A bed clothes fire can become appreciably more threatening on larger beds [6].

It follows that a significant reduction in bed fire fatalities can be achieved by reducing the combined peak heat release rate of a bed, the bedclothes, and other furnishings ignited by the bedclothes to a level well below 1 MW. Current regulation in the United States limits the peak rate of heat release of a mattress and foundation to 200 kW and the total heat release to 15 MJ during the first 10 min of the test [7], [8]. Combined with the typical heat release rate of the bedclothes, which generally occurs well before the peak heat release from the mattress, the overall heat release rate from the burning bed is substantially below the value that leads to room flashover. Furthermore, as the intensity of the bed fire is decreased this much, there is an accompanying reduction in the spatial extent of the radiant heat from flames. This reduces the likelihood that other bedroom furnishings will be ignited by the bed fire and greatly increases the time available for occupants to recognize and escape the fire.

This International Standard addresses a fire hazard scenario different from one in which a cigarette ignites the bed and threatens people who might be asleep on the bed with their heads near the location of the dropped cigarette. The resulting deaths most often result from inhalation of the toxic fumes from the smouldering fire and are distinct from the deaths that are to be averted by limiting the flaming intensity of the bed fire. In several countries, mattresses are tested for cigarette ignition resistance [9], which reduces the likelihood of smouldering fires, but infrequently addresses the fire hazard addressed by this International Standard.

Standard test method for measuring the heat release rate of low flammability mattresses and mattress sets

WARNING — So that suitable precautions can be taken to safeguard health, the attention of all concerned with fire tests is drawn to the possibility that toxic or harmful gases are evolved during combustion of test specimens.

The test procedures involve high temperatures. Hazards can therefore exist for burns and ignition of extraneous objects or clothing. The operators should use protective clothing, helmets, face-shields, and breathing equipment for avoiding exposure to toxic gases.

Laboratory safety procedures should be set up to ensure the safe termination of tests. It is imperative that adequate means of extinguishing such a fire are provided.

1 Scope

This International Standard provides a full-scale test method for determining the heat release rate and total heat release from a mattress or a mattress and foundation. The test specimen is ignited by exposure to a pair of gas burners that simulate burning bedclothes [5]. The measurement capability is designed for mattress sets of low flammability, i.e. having a peak rate of heat release below 300 kW.

This International Standard applies to mattresses and mattress and foundation sets. This International Standard does not apply to mattress pads, pillows, blankets, or other items used on top of a mattress.

This International Standard is a performance standard and does not prescribe the use of any specific components, fire retardant chemicals, or materials, and does not prescribe any design features that might lead to improved or degraded performance of a mattress set.

Annex A describes an analysis that indicates the potential reduction in life loss achievable by limiting the magnitude of the bed fire.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9705, *Fire tests — Full-scale room test for surface products*

ISO 13943, *Fire safety — Vocabulary*

ISO 24473, *Fire tests — Open calorimetry — Measurement of the rate of production of heat and combustion products for fires of up to 40 MW*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943 and the following apply.

3.1
foundation
ticking-covered structure used to support a mattress or other sleep surface

3.2
mattress
resilient material, used alone or in combination with other materials, enclosed in a ticking, and intended or promoted for sleeping upon

3.3
mattress set
mattress and foundation labelled for sale as a single unit or a mattress labelled for sale without any foundation

3.4
tape edge
edge made by using binding tape to encase and finish raw edges of a mattress or foundation

3.5
ticking
outermost layer of fabric or related material of a mattress or foundation

NOTE This does not include any layers of fabric or related materials that are quilted together with the outermost layer of fabric or related material.

4 Summary of test method

This test method measures the flammability performance of a mattress or mattress set by exposing the specimen to a specified flaming ignition source and allowing it to burn freely in a controlled test area. The test area shall be one of two configurations, either an open calorimeter, as in ISO 24473, or a test room meeting specified dimensions and connected to a collection hood. The flaming ignition source is specified as a pair of propane burners, simulating burning bedclothes, that impose differing heat fluxes for differing times on the top and side of the test specimen. Measurements of the time-dependent heat release rate from the test specimen are made during and after exposure to the specified burners in order to quantify the enthalpy generated by the fire. The rate of heat release is measured by oxygen consumption calorimetry derived from measurements in the exhaust duct. The test continues for 30 min or until there is a significant threat to the safety of test personnel and/or the test equipment and test facility.

5 Significance and use

This International Standard defines an apparatus and a process for measuring the rate of heat release and the total heat generated by a bed whose peak heat release rate is near or under 300 kW. This value, even combined with the heat release rate from bedclothes for a 1 m wide bed, is significantly lower than the heat release rate that results in flashover of a typical bedroom.

6 Apparatus and equipment

6.1 Test area

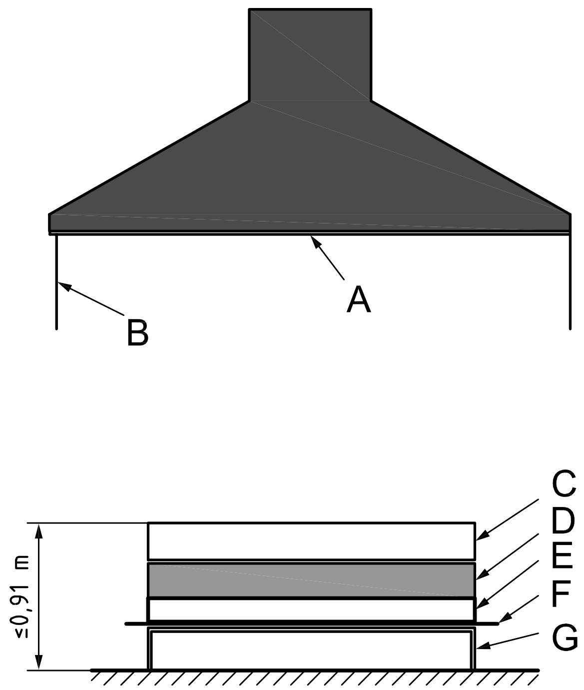
The test shall be conducted in an open calorimeter or in a test room.

6.1.1 Environmental conditions

The test area shall be maintained at a temperature greater than 10 °C and less than 30 °C and a relative humidity less than 75 %.

6.1.2 Open calorimeter

6.1.2.1 In this configuration (Figure 1), the specimen to be tested is placed under the centre of an open calorimeter whose characteristics are described in ISO 24473. The calorimeter shall be capable of measuring a heat release rate of 300 kW or lower, with a total uncertainty of no more than 20 kW.



Key

A calorimeter hood
B optional hood skirt
C mattress
D foundation
E bed frame
F catch surface
G elevated support (optional)

Figure 1 — Test assembly, shown under an open calorimeter

6.1.2.2 The area surrounding the test specimen shall be sufficiently large that there are no heat re-radiation effects from any nearby materials or objects.

6.1.2.3 The calorimeter hood shall capture the entire smoke plume and is instrumented for the measurement of the heat release rate using oxygen consumption calorimetry. The air supply to the hood shall be sufficient that the fire is not in any way limited or affected by the available air supply.

6.1.2.3.1 As needed, skirts shall be placed on the hood periphery to help assure capture of the entire smoke plume. Such skirts shall not be of such an excessive length as to cause the incoming flow to disturb the burning process. The skirts shall not heat to the point that they contribute significant re-radiation to the test specimen.

6.1.2.3.2 The fire plume shall not enter the hood exhaust duct.

NOTE Flickers of flame that last for a few seconds and occupy only a minor fraction of the hood exhaust duct inlet cross-section are acceptable because they do not signify appreciable suppression of flames.

6.1.2.4 The air flow to the test specimen shall be symmetrical from all sides. A small flame placed in the centre of the test specimen area shall not bend consistently in one direction.

6.1.2.5 The test specimen shall be placed on a test frame, which is to be centred under the hood.

6.1.3 Test room

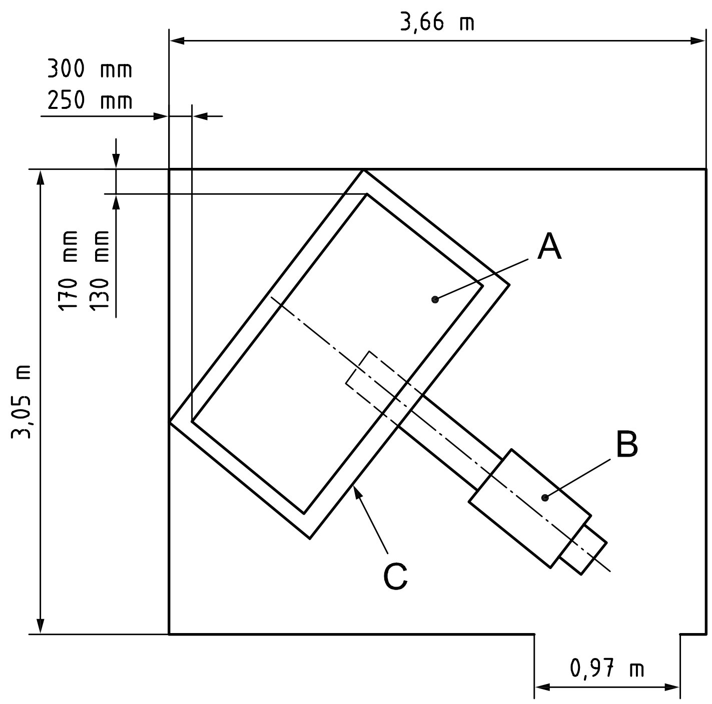
6.1.3.1 The test room (Figure 2) shall have dimensions of at least 3 m wide × 3 m deep × 2,4 m high.

NOTE 1 This is larger than the ISO 9705 test room.

NOTE 2 The larger room and the angled position of the bed in the room are necessary to minimize radiative feedback from the room walls to the bed, especially if there is burning along the side panels. Radiative feedback can increase the burning rate of the test specimen in a non-repeatable manner and can also lead to results different from those obtained in an open calorimeter.

NOTE 3 A room of these dimensions is sufficiently large to accommodate a mattress that is up to 1 000 mm wide and up to 2 000 mm long, along with the space needed for the movement of the burner assembly. To test larger mattresses, the minimum room dimensions are increased by the increases in the length and width of the larger test mattress over those of the twin mattress.

6.1.3.2 The room shall have no large openings permitting air infiltration other than a doorway opening (970 ± 5) mm wide and (2 030 ± 5) mm high, which shall be located as shown in Figure 2. There may be small openings necessary to make the prescribed measurements. There shall be no obstructions to the set-up in the air supply.



Key

A mattress and foundation on bed frame

B burner footprint

C catch surface

NOTE All dimensions are ±5 mm.

Figure 2 — Apparatus and specimen arrangement in test room

6.1.3.3 For video or photographic recording of the tests, there shall be at least one window to allow full view of the specimen, sealed with heat resistant glass, in one of the room walls. The window(s) shall be appropriately placed to obtain the required full-length view of the specimen (see 8.6).

6.1.3.4 An exhaust hood shall be positioned outside of and directly above the doorway so as to collect all of the combustion gases. The hood exhaust system shall be instrumented for oxygen consumption calorimetry measurements, as described in ISO 9705.

6.1.3.5 The test room shall be constructed of wood or metal studs and shall be lined with non-combustible material at least 12,7 mm thick.

NOTE Gypsum wallboard and calcium silicate board have been found to be suitable liner materials.

6.1.3.6 The test specimen shall be placed on a test frame in the test room as shown in Figure 2. One corner of the test specimen shall be 130 mm to 170 mm from the wall, and the other corner shall be 250 mm to 300 mm from the wall. The test room shall contain no furnishings or combustible materials except for the test specimen.

NOTE The angled placement is intended to minimize the interaction of flames on the side surfaces of the test specimen with the room walls.

6.1.4 Test area air flow

The horizontal air flow at a distance of 0,5 m on all sides of the test specimen at the mattress top height shall be no more than 0,5 m/s. If there is any visual evidence that the burner flames are disturbed by drafts during their exposure durations, the burner regions shall be enclosed on two or more sides by at least a triple layer of screen wire. The screens shall be at least 250 mm high. The screen(s) for the top burner shall sit on the mattress top and shall be wide enough to extend beyond the area of the burner impingement. All screens shall be far enough away (typically 300 mm or more) from the burner tubes so as not to interfere or interact with flame spread during the burner exposure. The screen for the side burner will require a separate support from below. All screens shall be removed at the end of the 70 s exposure interval.

NOTE The objective is to keep the burner flames impinging on a fixed area of the specimen surface rather than wandering back and forth over a larger area.

6.1.5 Heat release rate calibration

The oxygen consumption calorimetry system shall be calibrated at a minimum of two calibration points, 75 kW and 200 kW, using the procedures in ISO 24473 for open calorimetry or ISO 9705 if a test room is utilized.

6.2 Test frame

6.2.1 The test specimen shall be supported around its perimeter by a test frame with a flat surface and no edges extending up from the surface. The frame shall be made from a welded, nominally 40 mm steel angle. The top surface of the frame shall be flat, with no edges extending up from the surface, i.e. the angle is configured downward. The outer dimensions of the test frame shall be within 5 mm of the outer dimensions of the test specimen. The frame shall be completely open under the test specimen except for two crosspieces, each 25 mm wide, and located at the one-third length points. If the sagging of the specimen between the crosspieces exceeds 19 mm below the frame, a minimal number of additional crosspieces shall then be added to prevent such sagging of the specimen.

6.2.2 The test frame shall be 115 mm high, except if adjustments are necessary to accommodate the required side burner position. The height of the frame shall also be adjusted, as necessary, so that the burner is no less than 25 mm above the supporting surface of the frame.

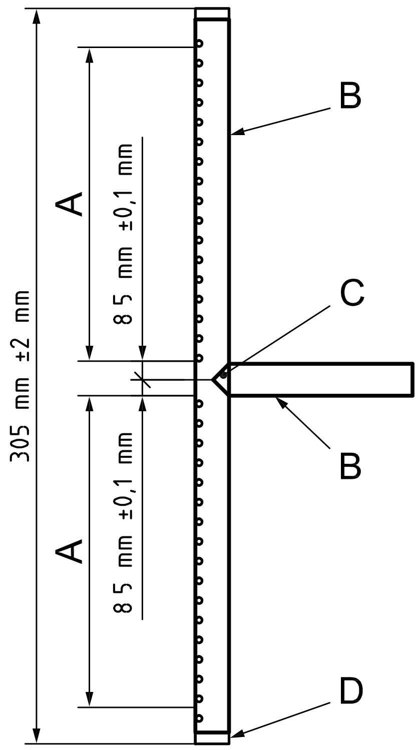
6.2.3 The test frame feet shall rest on a surface of either calcium silicate board or fibre cement board, 13 mm thick, and 200 mm wider and longer than the outer dimensions of the test specimen. The top surface of this board shall be cleaned between tests to avoid build-up of combustible residues. Lining this surface with aluminium foil to facilitate cleaning is not recommended because this might increase fire intensity via reflected radiation.

NOTE The board serves as a catch surface for any flaming melt/drip material falling from the bed assembly and can thus be the location of a pool fire that consumes such materials.

6.3 Ignition source

6.3.1 General

The ignition source shall consist of two T-shaped burners, shown in Figures 3 and 4. One burner impinges flames on the top surface of the mattress; the second burner impinges flames on the side of the mattress and on the side of the foundation. Each of the burners shall be constructed from stainless steel tubing (12,7 mm diameter with 0,89 mm ± 0,05 mm wall thickness). Each burner shall incorporate a standoff foot to set its distance from the test specimen surface (Figure 5). Both burners shall be mounted with a mechanical pivot point. The side burner is locked in place to prevent movement about this pivot in normal usage. The top burner is free to rotate about its pivot during a burner exposure and is lightly weighted so as to exert a downward force on the mattress top through its stand-off foot so that the burner follows a receding top surface on the test specimen. The combination of burner stand-off distance and propane gas flow to the burners determines the heat flux they impose on the surface of the test specimen. The top burner is set to generate a nominally 18 kW flame for 70 s; the side burner is set to generate a nominally 9 kW flame for 50 s.



Key

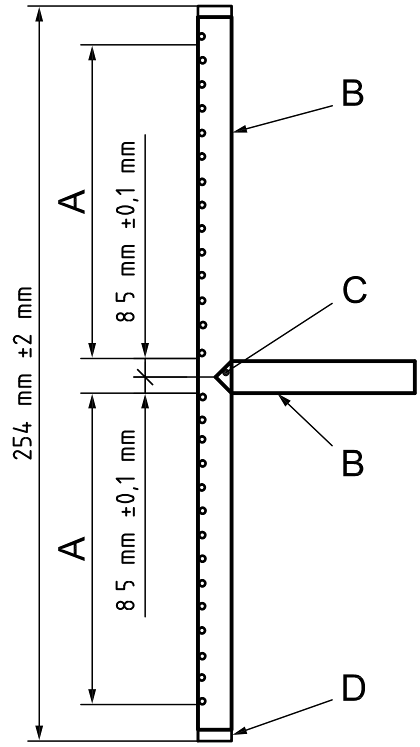
A 17 holes spaced over 135 mm length, pointing 5° out of the plane of the diagram

B stainless steel tubing

C gas-tight weld at 90° angle

D top and bottom end caps with gas-tight welded seal

Figure 3 — Details of horizontal burner head



Key

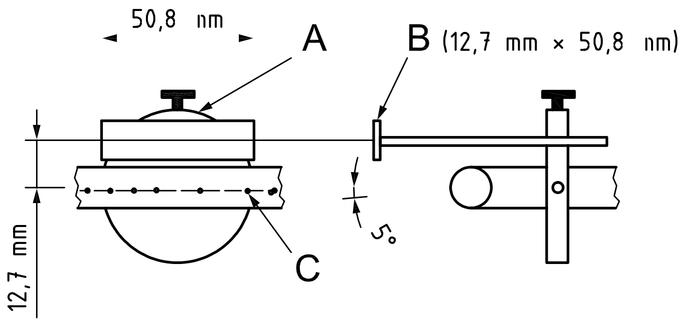
A 14 holes spaced over 110 mm length, pointing 5° out of the plane of the diagram

B stainless steel tubing

C gas-tight weld at 90° angle

D top and bottom end caps with gas-tight welded seal

Figure 4 — Details of vertical burner head



a) Front view b) End view

Key

A collar holding stand-off

B stand-off foot

C burner holes pointing 5° out of the plane of the burner, away from the stand-off

NOTE All dimensions are ±0,5 mm.

Figure 5 — Details of burner stand-off

6.3.2 Top surface burner

The T head of the top surface burner (horizontal burner, Figure 3) shall be (305 ± 2) mm long, with gas-tight plugs in each end. Each end of the T shall contain 17 holes equally spaced over a 135 mm length, i.e. (8,5 ± 0,1) mm apart. The holes on each side shall begin 8,5 mm from the centreline of the burner head. The holes shall be 1,45 mm to 1,53 mm in diameter. The holes shall point 5° out of the plane of the diagram as shown in Figure 3.

NOTE 1 The diameter of the holes corresponds to Grade 10 machining practice with a well formed No. 53 drill bit.

NOTE 2 Pointing the holes out of the plane broadens the width of the heat flux profile imposed on the surface of the test specimen.

6.3.3 Side surface burner

The T head of the side surface burner (vertical burner) shall be constructed similarly to the top surface burner, as shown in Figure 4, except that its overall length shall be (254 ± 2) mm. Each end of the burner head shall contain 14 holes spaced evenly over a 110 mm length, i.e. (8,5 ± 0,1) mm apart. The holes shall be 1,45 mm to 1,53 mm in diameter. The holes shall point 5° out of the plane of the diagram as shown in Figure 4.

6.3.4 Pilot lights

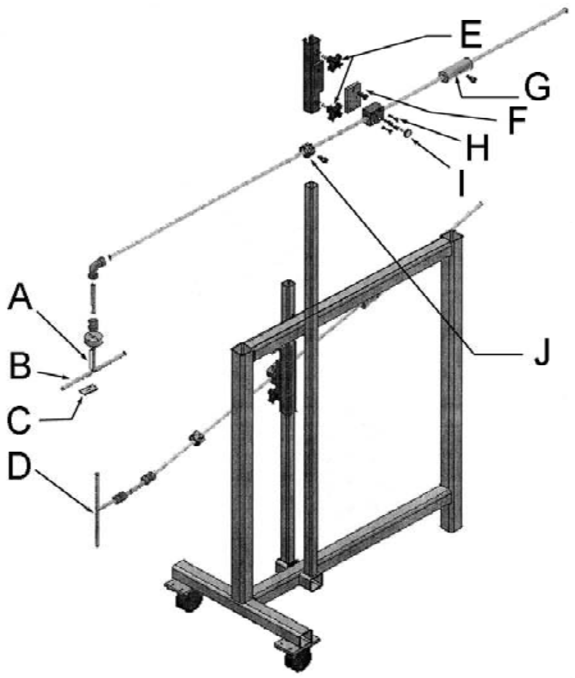
Each burner head shall have a pilot light consisting of a 3 mm outside diameter copper tube with an independently controlled supply of propane gas. The tube terminates within 10 mm of the centre of the burner head. Care should be taken to set the pilot flame size small enough so as not to heat the test specimen before the timed burner exposure is begun.

6.3.5 Burner arms

Each burner shall be connected to a metal arm made of stainless steel tubing of 12,7 mm outside diameter. The top burner arm is to be approximately 1,8 m long; the side burner arm is to be approximately 1,3 m long.

6.3.6 Burner frame

The arms of the two burners shall be supported on a burner frame (Figure 6). The burner frame shall rest on three feet, with the two forward points on wheels. Each arm shall be connected to the frame with a pivot to enable adjustment of the burner height and burner arm length from the pivot point. On the top burner arm is a counterweight to adjust the downward force on the stand-off foot (see 6.3.7). The location of the counterweight can be adjusted using a knob or thumbscrew.



Key

A pilot light
B top burner
C stand-off foot
D side burner
E thumb screws
F pivot point screw
G sliding weight
H pivot point pin
I set screw
J sliding weight

Figure 6 — Burner assembly, showing arms and pivots in relation to portable frame, allowing burner height adjustment

6.3.7 Burner stand-off

The burner stand-off on each burner shall consist of a collar fixed by a set screw onto the inlet tube of the burner head (Figure 5). The collar shall hold a 3 mm diameter stainless steel rod having a 12,7 mm by 51 mm by (2 mm to 2,5 mm) thick stainless steel pad welded on its end with its face (and long axis) parallel to the T head of the burner. The foot pad shall be displaced about 10 mm to 12 mm from the longitudinal centreline of the burner head so that it does not rest on the test specimen in an area of peak heat flux. A short section of copper tubing shall be placed in each inlet gas line just before each burner so that it can be bent to make the burners nominally parallel to the test specimen surfaces (see 8.5). These sections of copper tubing shall be 9,5 mm outer diameter and about 80 mm long. The copper tube on the top surface burner shall be protected from excessive heat and surface oxidation by wrapping it with a suitable layer of high temperature insulation to protect the equipment. Both copper tubes are to be bent by hand in the burner alignment process. They shall be replaced if they become work-hardened or crimped in any way. As shown in Figure 6, the gas inlet lines shall be 12,7 mm outside diameter stainless steel tubing. The length to the pivot for the top burner shall be approximately 1 m.

6.4 Fuel supply and control

6.4.1 Fuel

The fuel for the T burners shall be propane gas of minimum 99 % purity.

NOTE The grade described by some suppliers as CP, or “chemically pure”, is not reliable because the actual purity can vary by supplier.

6.4.2 Gas control console

6.4.2.1 Location

The gas control console for metering the propane to the T burners is to be located outside of the test room (if used) throughout the test procedure.

6.4.2.2 Transfer lines

The metal gas inlet lines of the T burners shall be attached to the gas control console by flexible, reinforced plastic tubing. The plastic tubing shall be anchored both on the lower rear of the burner frame and on the gas control console.

NOTE 1 Fibre-reinforced PVC tubing, 6 mm inside diameter and 9,5 mm outside diameter, has been found suitable for this purpose.

NOTE 2 A length of approximately 1,5 m between the burner frame anchor point and the end of each burner inlet allows free movement of the top burner about its pivot point.

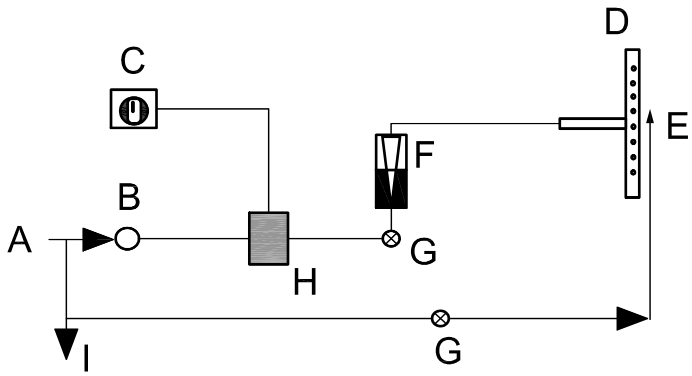
6.4.3 Flow control system

Each burner shall have a flow control system of the type shown in Figure 7. The pressure of propane gas is reduced from its source pressure to approximately 170 kPa. Separate gas flows proceed to each burner through a manual on/off valve, a solenoid on/off valve, a flow controller, and a flowmeter. An interval timer, accurate to $\pm 0,2$ s, actuates the solenoid valve to control the duration of the burner flames.

NOTE 1 The timing system provides for a nominally square-wave flame, i.e. constant flow with rapid onset and termination.

NOTE 2 The pilot lights assure that the burners will ignite when the solenoid valves open.

NOTE 3 If the side burner, or more commonly one half of the side burner, fails to ignite quickly, adjust the position of the pilot light, bearing in mind that propane is heavier than air. The best burner behaviour test assessment is carried out against an inert surface, to spread the gas as it would during an actual test.



Key

A regulated propane flow from storage container

B on/off valve

C time delay relay

D burner

E pilot light

F flowmeter

G flow control

H solenoid valve

I to duplicate controls for second burner

Figure 7 — Elements of propane flow control for the two burners

6.5 Ignition burner gas flow

6.5.1 Requirements

The gas flow to the top burner is (12,9 ± 0,1) L/min measured at a pressure of (101 ± 5) kPa and a temperature of (22 ± 3) °C. This is equivalent to a gas mass flow of (23,5 ± 1,5) g/min. The gas flow to the side burner is (6,6 ± 0,05) L/min measured at a pressure of (101 ± 5) kPa and a temperature of (22 ± 3) °C. This is equivalent to a gas mass flow of (12,0 ± 0,8) g/min. The total heat release rate of the burners is (27 ± 2) kW.

6.5.2 Calibration of flowmeters

6.5.2.1 The most practical and accurate method of measuring and calibrating the flowmeter for propane is with the use of a diaphragm test meter (DTM), also called a dry test meter.

6.5.2.2 The DTM is installed between the top burner control valve and the flowmeter.

6.5.2.3 Ensure that the assembled propane delivery system is free of gas leaks.

6.5.2.4 Open the main valve on the propane tank and set the regulator to an outlet pressure of (140 ± 3,5) kPa.

6.5.2.5 Set the timers in the control box for 999 s (or the maximum range possible).

6.5.2.6 Record the barometric pressure.

6.5.2.6.1 It is necessary to take into account that the flow resistance of the burner holes causes a pressure increase in the flowmeter. Thus, if a calibration at 101 kPa is provided by the manufacturer, the flowmeter reading, at the internal pressure existing in the meter, required to get the required flows shall be corrected, typically by the square root of the absolute pressure ratio. This calls for measuring the actual pressure in the flowmeter when set near the correct flow values. A correction of roughly 1 kPa to 3 kPa can be expected.

6.5.2.6.2 The burner holes shall be visually checked for any blockage after every test. Blockage of the burner holes will change the pressure in the flowmeters; and this will, in turn, affect the propane flow.

6.5.2.7 Ignite the top burner.

6.5.2.8 Allow the propane to flow for 2 min to 3 min until the DTM is stabilized.

6.5.2.9 Record the pressure and temperature in the DTM. Use a stopwatch to record at least 1 min worth of complete rotations while counting the number of rotations.

NOTE With a diaphragm test meter well-sized to this application, this would be more than five rotations. A 1 L per rotation will require 10 to 15 rotations for the flow measurements and the requirement for a minimum of 1 min recording time.

6.5.2.10 Calculate the propane gas flow using the total flow, the recorded time, and the number of rotations.

6.5.2.11 Convert the flow to standard temperature and pressure.

6.5.2.12 Repeat this measurement for two additional meter settings to enable calibrating the flowmeter throughout the range of interest.

6.5.2.13 Plot the three flows versus their meter readings and fit a best line or curve (possibly quadratic) through these points to find the meter setting for a flow of 12,9 L/min at standard temperature and pressure.

6.5.2.14 Repeat this procedure for the side burner to find the flowmeter setting that gives a flow of 6,6 L/min at the standard conditions.

6.5.2.15 After completion of the calibration, re-set the timers to 70 s and 50 s.

7 Test specimens

A complete mattress or mattress/foundation set shall be tested, with no bedclothes or pillows. The size of the test specimen shall be consistent with the requirements of the test area (see 6.1).

8 Test preparation

8.1 Specimen conditioning

8.1.1 Specimens shall be removed from packaging prior to conditioning.

8.1.2 Specimens shall be conditioned in air at a temperature of (23 ± 2) °C and at a relative humidity of (50 ± 5) % for at least 48 continuous hours prior to test. During the conditioning period, specimens shall be supported in a manner to permit free movement of air around them and should not be supported or compressed on the side where the ignition flame will impinge.

8.1.3 If a sample is out of the conditioning area longer than 20 min before ignition, the specimen shall be returned to the conditioning space. The returned specimen shall be reconditioned for three times as long as it was out of the conditioning room. For example, if a specimen is out of the conditioning area for 40 min, it shall be returned to the conditioning area and reconditioned for at least 120 min.

8.2 Instrument calibration

8.2.1 The oxygen consumption instrumentation shall be calibrated at least at the beginning of each test day. The calibration shall be checked at the end of each day.

8.2.2 The burner flows shall be calibrated at the start of each test week, or sooner if the appearance of the burner flames has changed. A determination that the burner flows are not as prescribed may lead to the rejection of all test data since the last calibration. This may lead to a decision to calibrate the flows more often.

8.3 Specimen orientation

8.3.1 Testing shall begin within 20 min of removing the test specimen from the conditioning area (see 8.1.3).

8.3.2 Centre the test specimen on the test frame, which is centred on the catch surface. If a foundation is included in the testing and is of the same width, the mattress shall be centred on the foundation. If the mattress is narrower than the foundation, the mattress shall be shifted so that the side to be exposed to the flame is in the same plane as the side of the foundation.

8.3.3 All mattress designs shall be tested with each side facing up, unless the manufacturer has designated only one side as a sleeping surface. A product having an intended sleeping surface on only one side shall be tested with the sleeping side up, so that the sleeping surface is exposed to the propane burner.

NOTE In most mattress designs, both surfaces are designed as a surface on which people can lie when sleeping. In some of these designs, the surfaces may not be identical. For example, one side may provide a softer sleeping surface and the other a firmer sleeping surface. In some mattress designs, one side of the mattress is not intended by the manufacturer to be the surface on which people lie when sleeping. Depending on local labelling requirements, this surface may be marked as a non-sleeping surface.

8.3.4 If the testing is to be conducted in an open calorimeter, the specimen assembly shall be centred under the hood. If the testing is to be conducted in a test room, the specimen assembly is to be placed as shown in Figure 2 and described in 6.1.3.

8.4 Burner set-up

8.4.1 While the burners are not adjacent to the test specimen, both burners shall be ignited at the same time and the propane flows to the burners shall be set at the appropriate level on their flowmeters to provide the flows listed in 6.5.1. The burners are allowed to extinguish via the timer control of the solenoid valves. The burners shall be allowed to cool until a drop of water no longer sizzles upon contact with the burners.

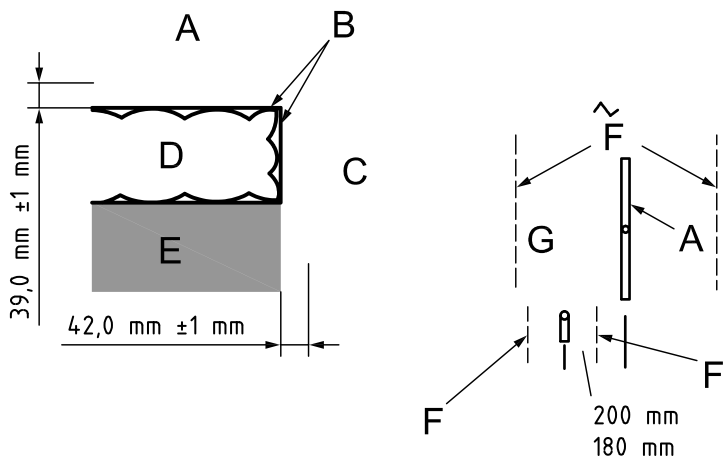
NOTE If the burners are too hot when they are placed in position for a test, they can distort the ticking, leading to a misleading test result. This is more likely to be a problem when testing mattresses with thermoplastic ticking materials.

8.4.2 The timers for the burner exposures are to be set to 70 s for the top burner and 50 s for the side burner. Check the accuracy of the gas flow timers against a stop watch at these standard time settings.

8.4.3 The burner pilot flows are to be set to a position that will not cause them to impinge on the test specimen surfaces.

8.4.4 The gas burner heads shall be placed within 300 mm of the midpoint along the length of the mattress. If there are unique construction features (e.g. handles, zippers) within the burner placement zone, the burner shall impinge on these features.

8.4.5 The burners shall be placed in relation to the mattress and foundation surfaces in the manner shown in Figure 8, i.e. at the nominal spacings shown and with the burner tubes nominally parallel to the mattress surfaces on which they impinge. Because the heat flux levels seen by the test specimen surfaces depend on the burner spacing from the specimen, as well as gas flow, care shall be taken with the set-up process.



a) Side view **b) Top view**

Key

A top burner
B flat platen
C side burner
D mattress
E foundation
F screen
G mattress top

Figure 8 — Burner placement on test specimen

8.4.6 Because the top surface of the mattress is not necessarily planar, the top burner shall be aligned tangential to the mattress surface at the burner mid-length.

NOTE This burner orientation will not necessarily be parallel to the overall average mattress surface, nor will it necessarily be horizontal.

8.4.7 For a quilted mattress top, the stand-off foot pad shall alight on a high, flat area between dimples or quilting thread runs. The same is to be true for the side burner, if that surface is quilted. If a specimen design presents a conflict in placement such that both burners cannot be placed between local depressions in the surface, the top burner shall be placed at the highest flat surface.

8.5 Burner alignment procedure

8.5.1 Preliminary steps

8.5.1.1 Check that the pivot point for the mattress top burner feed tube and the two metal plates around it are clean and well-lubricated, so as to allow smooth, free movement.

8.5.1.2 Set the two burners such that the 5° out-of-plane angling of the flame jets makes the jets on the two burners point slightly toward each other.

8.5.1.3 Check the burner stand-off feet for straightness and perpendicularity between foot pad and support rod and ensure that they are clean of residue from a previous test.

8.5.1.4 Have at hand the following items to assist in burner set-up:

— a 3 mm thick piece of flat stock (any material) to assist in checking that the burners are parallel to the mattress surfaces;

— a 24 gauge stainless steel sheet metal platen, shown in Figure 9, for setting the sides of the mattress and foundation in the same plane.

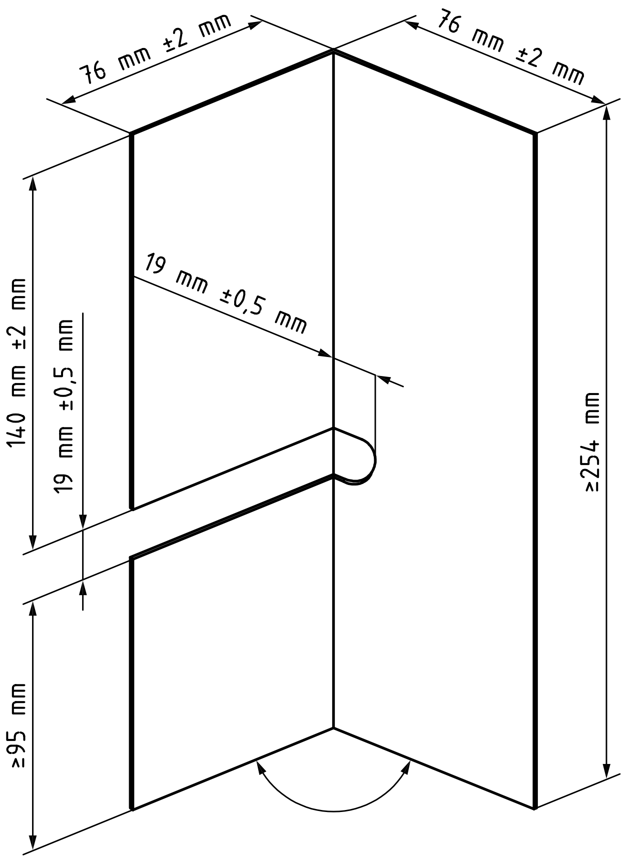


Figure 9 — Platen for setting mattress and foundation sides in the same plane

8.5.2 Alignment procedure

8.5.2.1 For mattresses having a planar or concave side surface, place the burner assembly adjacent to the test specimen. Place the sheet metal platen on the mattress with the shorter side on top. The location shall be within 300 mm of the longitudinal centre of the mattress. Press the platen laterally inward from the edge of the mattress so that its side makes contact with either the top and bottom edge or the vertical side of the mattress. Use a 200 mm strip of duct tape (platen to mattress top) to hold the platen firmly inward in this position.

8.5.2.2 For mattresses having a convex side surface, use the platen only to set the top burner parallel. Set the in/out distance of the top burner to the specification in 8.5.2.6. Set the side burner so that it is approximately (visually) parallel to the flat side surface of the foundation below the mattress/foundation crevice once its foot is in contact with the materials in the crevice area. The burner will not be vertical in this case. If the foundation side is also non-flat, set the side burner vertical (±3 mm, as above) using a bubble level as a reference. The side surface convexities will then bring the bowed out sections of the specimen closer to the burner tube than the stand-off foot. For mattresses with nominally flat, vertical side surfaces, see 8.5.2.8 for adjustment of the parallel position of the side burner.

8.5.2.3 With both burner arms pinned in a horizontal position, fully retract the stand-off feet of both burners and, if necessary, the pilot tubes as well. Neither is to protrude past the front face of the burner tubes at this point. Move the burner assembly forward (perpendicular to the mattress) until the vertical burner lightly contacts the sheet metal platen.

NOTE The pilot tubes can normally be left with their ends just behind the plane of the front of the burner tube. In this way, they will not interfere with positioning of the tube, but their flames will readily ignite the burner tubes.

8.5.2.4 Adjust the height of the vertical burner on its vertical support column so as to centre the tube on the crevice between the mattress and the foundation. For a pillow top mattress, ignore the crevice between the pillow top and the main body of the mattress. Adjust the height of the horizontal burner until it sits lightly on top of the sheet metal platen. Its burner arm shall be horizontal.

8.5.2.5 For tests of a mattress alone, set the centre of the side burner at the lower edge of the mattress or set the top (upper tip) of the side burner 25 mm below the top edge of the mattress, whichever is lower. The bottom of the side burner shall be at least 25 mm above the test floor. The height of the test frame shall be raised relative to the test floor to accomplish this.

NOTE This prevents inappropriate (excessive) exposure of the top surface of the mattress to the side burner. For products less than 15 mm thick, the side burner centre will not be able to be aligned at the mattress-foundation or mattress-test frame interface. In order to maintain the side burner at 25 mm below the top surface of the mattress, the burner centre will be below the typical interface point.

8.5.2.6 Move the horizontal burner in/out (loosen the thumb screw near the pivot point) until the outer end of the burner tube is 13 mm to 19 mm from the corner bend in the platen and then tighten the thumb screw.

NOTE This adjustment is facilitated by putting a pair of lines on the top of the platen 13 mm and 19 mm from the bend and parallel to it.

8.5.2.7 Make the horizontal burner parallel to the top of the platen, within ± 3 mm over the burner tube length, by bending the copper tube section appropriately. Use the 3 mm flat stock to check this.

NOTE After the platen is removed (see 8.5.2.11), the burner tube may not be horizontal; this is normal.

8.5.2.8 For mattress/foundation combinations having nominally flat, vertical sides, adjust the vertical burner to be parallel to the sides and vertical within ± 3 mm. If the mattress surfaces result in the platen not being flat and vertical, make the side burner parallel to the mattress/foundation sides by the best visual estimate after the platen has been removed.

8.5.2.9 Move the burner assembly perpendicularly back away from the mattress about 300 mm. Set the two stand-off feet to their respective distances using the jig designed for this purpose. Install the jig fully onto the burner tube (on the same side of the tube as the stand-off foot), with its side edges parallel to the burner feed arm, at about the position where one end of the foot will be. Loosen the set screw and slide the foot out to the point where it is flush with the bottom end of the jig. Tighten the set screw. Make sure the long axis of the foot is parallel to the burner tube. It is essential to use the correct side of the spacer jig with each burner. Double check this. The jig shall be clearly marked.

8.5.2.10 Set the downward force of the horizontal burner. Remove the retainer pin near the pivot. While holding the burner feed arm horizontal using a spring scale hooked onto the thumbscrew holding the stand-off foot, move the small and/or large weights on the feed tube appropriately so that the spring scale reads 170 g to 225 g.

NOTE An acceptable spring scale has a calibrated spring mounted within a holder and hooks on each end.

8.5.2.11 Remove the sheet metal platen and the tape holding it.

8.5.2.12 Hold the horizontal burner up while sliding the burner assembly forward until the side burner stand-off foot just touches the mattress and/or the foundation, then release the horizontal burner. The outer end of the burner tube shall extend a minimum of 6 mm to a maximum of 12 mm beyond the uppermost corner/edge of the mattress so that the burner flames hit the edge. If the location of the outer edge of the burner tube is not within this range, move the full burner assembly — not the horizontal burner alone — perpendicular to the mattress side until it is. Finally, using the set screw near the vertical burner pivot, move the vertical burner tube until its stand-off foot just touches the side of the mattress and/or the foundation.

NOTE For a pillow top mattress, the uppermost edge is that of the pillow top.

8.5.2.13 The foot of the vertical burner shall depress the surface it first contacts by no more than 1 mm to 2 mm. This is best seen up close, not from the rear of the burner assembly. However, if a protruding edge, such as a tape edge, is the first item contacted, compress it until the foot is in the plane of the mattress/foundation vertical sides. The burner shall be spaced a fixed distance from the vertical mattress/foundation sides, not from an incidental protrusion. Similarly, if there is a wide crevice in this area which would allow the foot to move inward and thereby place the burners too close to the vertical mattress/foundation sides, the spacer jig (rather than the stand-off foot) shall be placed above or below this crevice to set the proper burner spacing. Compress the mattress/foundation surface 1 mm to 2 mm when using the jig for this purpose.

8.5.2.14 Tighten all thumbscrews.

8.5.2.15 Once this set-up is achieved, do not disturb the burner assembly. Do not disturb the flexible lines that bring propane to it because they may pull on the burner assembly.

8.6 Video recording

8.6.1 Place a video or still frame camera so as to have, when the lens is zoomed out, just slightly more than a full-length view of the side of the test specimen being ignited, including a view of the flame impingement area while the burner assembly is present. The view shall also include the catch pan, so that it is clear whether any melt pool fire in this pan participates significantly in the growth of fire on the test specimen.

8.6.2 The camera shall include a measure of elapsed time to the nearest 1 s for video and 1 min for still frame within its recorded field of view. This clock should be built into the camera if possible.

8.6.3 For testing in a room, the camera shall be placed at a height just sufficient to give a view of the top of the specimen while remaining under any smoke layer that may develop in the room. The specimen shall be brightly lit so that the images do not lose detail due to overexposure from the flames. This requires a pair or more of 1 kW photo flood lights illuminating the viewed side of the specimen. The lights may need to shine into the room from the outside via sealed windows.

8.6.4 Provision shall be made to obtain continuous video recording and/or a minimum of eight photographs of the testing of each mattress or mattress set.

8.6.5 The eight photographs shall include, as a minimum, one taken before the start of the test, one taken within 45 s of the start of the test, and six taken at 5 min intervals, starting at 5 min after burner flame initiation and ending at the conclusion of the 30 min test interval.

8.6.6 The test specimen identification number, the date and time of the test, and the name and location of the testing facility shall be clearly displayed in all visual records.

9 Test procedure

9.1 Safety precautions

9.1.1 Respirators shall be worn by test personnel if the ventilation system does not maintain safely low levels of smoke and combustion gases.

9.1.2 Charge the hose line to be used for fire suppression with water.

9.1.3 If testing in a room enclosure, the person manning the fire hose should be wearing full turn-out gear and self-contained breathing apparatus.

9.1.4 Test personnel shall be alert to the possibility of re-ignition of the test specimen.

9.1.5 After completion of testing, the used specimens shall not be piled on top of each other.

9.2 Burner preparation

9.2.1 Ensure that the burner gas flows are properly set as in 6.5, the timers are properly set as in 8.2.2 and the burner assembly is properly aligned on the test specimen as in 8.5.2.

9.2.2 Place screens around both burners, if needed (see 6.1.4).

9.2.3 Open the pilot ball valves one at a time, ignite the pilots with a hand-held flame, and adjust the flame sizes, if necessary. Avoid a jet flame that could prematurely ignite the test specimen.

NOTE After a long interval between tests (e.g. overnight), the low pilot flow will require more time to displace air in the line and achieve the steady state flame size.

9.3 Initiation of recording systems

9.3.1 Turn on the calorimetry system.

9.3.2 Set the zero point of the oxygen analyser with a gas containing no more than 0,002 % oxygen by volume. Adjust the span of the analyser with a gas mixture containing 19,000 % oxygen by volume to 21,000 % oxygen by volume. The required precision of the gas measurements shall be as required in ISO 24473 and ISO 9705.

9.3.3 Start the data logging systems two minutes before burner ignition. Start the video lights and the video cameras, if used. If not using video, take a picture of the setup.

9.4 Test initiation

9.4.1 Start the test exposure by simultaneously turning on power to both burner timers, igniting the burners, and starting a 30 min timer of the test duration.

9.4.2 Immediately check, and adjust as necessary, the propane flows to the two burners. Experience has shown that the flow will not remain the same from test to test in spite of fixed valve positions. Thus, adjustment is essential.

9.4.3 If not using video, take at least one photo within the first 45 s of starting the burners.

9.4.4 If screens are being used (see 6.1.4 and 9.2.2) and if they interfere with the mattress flame spread during the period while the burners are turned on, the screens shall be removed promptly and in a manner that is safe for the person removing the screens.

9.5 Test conduct

9.5.1 When the burners go out (after 70 s for the longer exposure), remove all remaining screens and carefully lift the top burner tube and then back the ignition assembly away from the specimen surface, producing as little disturbance as possible to the specimen.

NOTE "Longer exposure" refers to the 70 s duration for the top burner.

9.5.2 Remove the burner assembly from the specimen area to facilitate the video camera view of the full side of the specimen. For room-based testing, remove the burner assembly from the room to protect it.

9.5.3 Note the time and nature of any unusual behaviour.

NOTE This is most easily done by narration into an audio recorder and then transcription in the test record or narration into a camcorder.

9.5.4 A test shall be terminated at any time if the safety of the test staff, the facility, or the equipment is threatened.

9.5.5 In addition, if all signs of combustion have ceased, as indicated by no visible smoke production, no smouldering or afterglow, and no flames for five consecutive minutes, a test may be terminated after 5 min of testing, but before the end of the 30 min test interval if, for five consecutive minutes, all signs of combustion have ceased, as indicated by no visible smoke production, no smouldering or afterglow, and no open flames.

NOTE A thermal imaging device of quality suitable for use by firefighters has been found useful to determine the complete cessation of combustion.

9.5.6 Following a decision to conclude the test, suppress the burning specimen.

9.5.7 If water is used for fire suppression and if it falls on the catch surface below that bed frame, that surface shall be dried or be replaced with a dry surface before the next test.

9.5.8 Turn off the power to both timers.

9.5.9 Continue recording the data for heat release rate calculations and taking video and/or photographs until the fire has been fully out for several minutes to allow the system zero to be recorded.

10 Test report

The report shall include the following information for each test conducted:

— name and complete physical address of the test facility;

— whether the test was conducted under an open calorimeter or within a test room;

— the room dimensions, if the test was conducted in a test room;

— the temperature, relative humidity, and atmospheric pressure at the test area;

— the elapsed time that the test specimen spent out of conditioning area before starting the test;

— appropriate identification of the test specimen, including whether the specimen was a mattress or a mattress/foundation set;

- the raw data used in the determination of heat release, as described in ISO 9705 or ISO 24473;
- a graphic depiction of the rate of heat release and total heat release over the duration of the test;
- the peak rate of heat release;
- the total heat release in the first 10 min following the ignition of the burner flames;
- the name and signature of the person conducting the test;
- the date of the test;
- all visual records (see 8.6) and noted observations (see 9.5.3).

Annex A
(informative)

Reducing fire hazards associated with mattress flammability

Several years of research on mattress fires conducted by the National Institute of Standards and Technology (NIST) for the mattress industry and the U.S. Consumer Product Safety Commission (CPSC) provided the basis for the 16 CFR Part 1633 and thus this International Standard. The comprehensive, scientifically based research projects were designed to address the open-flame ignition of mattresses and bedclothes under controlled conditions closely resembling those of actual fire scenarios. The programme focused on understanding the characteristics of fires involving mattress and bedclothing assemblies and on developing an appropriate and technologically practicable methodology to measure (or characterize) and effectively address the hazard. The programme also provided the basis for the regulatory requirements for mattresses and mattress sets. These requirements are that a mattress shall not exceed a peak heat release rate of 200 kW during the first 30 min of test, as described in the main body of this International Standard. The total heat released shall not exceed 15 kJ over the first 10 min of testing.

A burning mattress is generally the primary energy contributor in a typical bedroom fire. A bed in a typical bedroom consists of several components including the mattress, foundation, and a collection of bedclothes (mattress pad, sheets, pillows, blankets, quilts and comforters). Typically, burning bedclothes create a large open-flame ignition source for the mattress. Once the mattress is ignited, the fire develops rapidly, potentially leading to room flashover. As flashover is approached, the room conditions become untenable, preventing escape from the fire.

Early in the fire, the hazard is contained to the room. The fire forces relatively small amounts of dilute smoke from the room. As the room fire grows, the layer of accumulating hot gases and smoke thickens downward from the ceiling. Eventually, the layer can descend from the ceiling to reach the floor level. Fire modelling and available fire test data show that the interface descends to about 1,5 m above the floor for relatively small fires (with heat release rates of approximately 300 kW). For fires exceeding 600 kW, the interface descends to less than 1 m. Heat release rates exceeding 500 kW are generally considered to pose a serious threat, as a dangerous pre-flashover situation is approaching, and the threat of igniting nearby items is high. The threat of incapacitation to occupants in the room of origin is also likely.

At flashover, the entire combustible contents of a room are ignited simultaneously by radiant heat from the hot gases and smoke accumulating in the upper portions of the room. As the layer of hot gases accumulates and smoke at the ceiling thickens, the heat release rate of the burning bed and the temperature in the room increase. Room temperatures typically exceed 600 °C to 800 °C at flashover. The high heat release rates, high room temperatures, and oxygen depletion lead to the rapid production of carbon monoxide. The high temperature increases the pressure in the room, driving uncombusted pyrolysis gases out of open doorways and/or broken windows. Depending on the conditions in this exhaust, these gases may ignite when they mix with the air outside the room. This outward flow of heat, smoke, and toxic gases pose a serious survival threat to those outside the room.

Flashover occurs when the heat release rate reaches a critical value. The critical heat release value depends on several factors, predominately room size and ventilation. The ability of a person to escape a fire depends on fire growth and intensity, smoke density, and threat from heat and toxic gases. The rapid and intense burning of mattresses in typical fire scenarios provides insufficient time for escape from the fire source, room of origin, and other rooms under certain conditions. It is necessary for fire detection and escape from the fire to take place before the fire grows to the critical heat release rate for the specific room.

NIST estimates of critical heat release rates were based on relationships between heat release and estimated hazard. A critical heat release rate for an ordinary sized room is estimated to be about 1 000 kW (1,0 MW). This estimate is based on a collective contribution from any items possibly involved. Staying below this value could be accomplished by reducing the heat release from the bed and by reducing the likelihood of involving other objects in the same room [3].

About two-thirds of all mattress fatalities in the US are attributed to mattress fires that lead to flashover. This accounts for nearly all the fatalities that occur outside the room of fire origin and about half of the fatalities that occur within the room of origin [3]. Tests on traditional twin size mattress constructions (16 CFR Part 1632 compliant) without bedclothes measured peak heat release rates that exceeded 2 000 kW in less than 300 s (5 min). Peak heat release rates of king size mattresses approached a factor of two times greater than tests of twin size mattresses [3].

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