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Fixed fire protection systems – Industrial and commercial watermist systems

Part 7: Fire performance tests and requirements for watermist systems for the protection of low hazard occupancies

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 24, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 8489 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 May 2016. It was prepared by Subcommittee FSH/18/5, *Watermist systems*, under the authority of Technical Committee FSH/18, *Fixed fire fighting systems*. A list of organizations represented on these committees can be obtained on request to their secretary.

Supersession

This part of BS 8489 supersedes DD 8489-7:2011, which is withdrawn.

Relationship with other publications

BS 8489 is published in a series of parts:

- Part 1: *Code of practice for design and installation*;
- Part 4: *Tests and requirements for watermist systems for local applications involving flammable liquid fires*;
- Part 5: *Tests and requirements for watermist systems for the protection of combustion turbines and machinery spaces with volumes up to and including 80 m^3;*
- Part 6: *Tests and requirements for watermist systems for the protection of industrial oil cookers*;
- Part 7: *Tests and requirements for watermist systems for the protection of low hazard occupancies*.

BS 8489-7 is intended to be read in conjunction with BS 8489-1.

Information about this document

This document converts DD 8489-7 into a full British Standard and incorporates minor technical updates.

Third-party testing/certification. Users of this British Standard are advised to consider the desirability of third-party testing/certification of conformity with this British Standard.

Use of this document

This British Standard is intended for use by manufacturers, designers and installers of watermist systems, and for authorities having jurisdiction.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its methods are expressed as a set of instructions, a description, or in sentences in which the principal auxiliary verb is "shall". Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. "organization" rather than "organisation").

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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1 Scope

This part of BS 8489 describes tests and specifies requirements for industrial and commercial watermist systems for the protection of low hazard occupancies as defined in BS 8489-1.

This part of BS 8489 is applicable to ceiling heights up to 5 m.

2 Normative references

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

BS 476-7:1997, *Fire tests on building materials and structures – Part 7: Method of test to determine the classification of the surface spread of flame of products*

BS 8489-1, *Fixed fire protection systems – Industrial and commercial watermist systems – Part 1: Code of practice for design and installation*

BS EN 12259-1, *Fixed firefighting systems – Components for sprinkler and water spray systems – Part 1: Sprinklers*

BS EN ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories*

ISO 5660-1, *Reaction-to-fire tests – Heat release, smoke production and mass loss rate – Part 1: Heat release rate (cone calorimeter method)*

3 Terms and definitions

For the purposes of this part of BS 8489, the terms and definitions given in BS 8489-1 and the following apply.

3.1 category I system
system that covers rooms up to and including 37 m^2 containing low hazard fire loads

3.2 category II system
system that covers rooms above 37 m^2 containing low hazard fire loads

3.3 category III system
system that covers rooms containing low hazard fire loads

3.4 low hazard occupancy
non-storage, non-manufacturing occupancy where the quantity and/or combustibility of the content is low and fires with relatively low rates of heat release are expected, with maximum fuel loads and obstructions as indicated in **4.7** to **4.10**

4 Apparatus

NOTE Unless otherwise stated, the following tolerances apply:

- *length: ±2%;*
- *volume: ±5%;*
- *pressure: ±3%;*
- *temperature: ±5%.*

4.1 *Test hall* of appropriate size to accommodate the largest test area (**4.5**), with natural or minimal ventilation that will not interfere with the fire testing within the enclosure or test rig.

4.2 Watermist system comprising nozzles, piping, control valves and water supplies. The individual nozzles shall be automatic and shall include either a fusible or a glass bulb assembly which meets BS EN 12259-1 quick response criteria. The nominal operating temperature of the nozzle shall not exceed 107 °C. The system shall be configured in accordance with the manufacturer's design manual and the test conditions specified in Clause **5**.

4.3 *Test room A (small compartment)*, as specified in Annex A.

4.4 *Test room B (large compartment)*, as specified in Annex A.

4.5 *Test area C (open space)*, as specified in Annex A.

4.6 *Test area D (simulated work station)*, as specified in Annex A.

4.7 *Fuel package 1 (bunk beds)*, as specified in Annex B.

4.8 *Fuel package 2 (corner crib and simulated furniture)*, as specified in Annex B.

4.9 *Fuel package 3 (sofas)*, as specified in Annex B.

4.10 *Fuel package 4 (simulated work station)*, as specified in Annex B.

4.11 *Igniter*, consisting of porous material (e.g. pieces of insulating fibreboard), 75 mm in length, and either oblong with a depth and height of 60 mm or cylindrical with a diameter of 75 mm.

4.12 *Heptane*.

4.13 *White spirit*.

4.14 *Thermocouples*, suitable for measuring ceiling surface temperatures, which shall be fabricated from Chromel-alumel (Type K) thermocouple wires not exceeding 0.5 mm diameter welded together. In each test room, one thermocouple shall be embedded within the ceiling tiles, such that the thermocouple bead is located 6.5 mm above the bottom surface of the ceiling, and a second thermocouple shall be located 76 mm below the ceiling surface. To prevent water impingement from affecting thermocouple measurements, thermocouples subject to watermist shall be protected with a shield which is large enough to cover the thermocouple ends. The shield shall be made from metallic tape which is formed into an umbrella shape and attached to the wire above each thermocouple end.

4.15 *Instrumentation* to measure and record the following parameters, as appropriate to the type of test:

- test enclosure temperatures;
- extinguishing agent flow and pressure in the extinguishing system;
- water supply pressure (including tank pressure if applicable) and nozzle discharge pressures;
- extinguishing agent pressure at the most remote nozzle branch line;
- gas pressure at its storage outlet and distribution sources;
- oxygen, carbon monoxide and carbon dioxide concentrations;

- consumption of foam concentrate or other additive, recorded by means of a load cell on which the concentrate/additive tank is placed during the tests;
- gas consumption, measured by means of pressure or load cell on which the gas tank is placed during the tests, or mass flow measurement.

4.16 *Additional baffles or obstructions*, if needed, to prevent the direct impact of mist on the fire.

4.17 *Stopwatch*.

5 Test conditions

5.1 The maximum nozzle spacing (as specified by the manufacturer) shall be used for all tests except the small compartment test with bunk beds (see **7.2**). This includes utilizing the maximum ceiling spacing of nozzles from walls.

5.2 Corridor nozzles for the small compartment test with bunk beds (see **7.2**) shall be installed at the maximum spacing as specified by the manufacturer, at an equal distance from the centreline of the small compartment doorway.

5.3 A target, automatic closed nozzle, with a thermosensitive component rating equal to the four nozzles installed in the enclosure, shall be located in the two exit doorways (see **A.2**), to determine potential operation of these nozzles. For upright and pendent nozzles, the target nozzles shall be installed 102 mm inside the doorway, in the pendent position, such that the centre of the heat responsive element is 51 mm below the ceiling.

5.4 The heat responsive element and temperature rating of the nozzles used in all fire tests shall be identical.

5.5 For all fire tests, the system shall be either:

a) pressurized to the minimum operating pressure specified by the manufacturer. Following activation of the first nozzle, the flowing water pressure shall be maintained at the minimum system operating pressure; or

b) pressurized to the minimum stand-by pressure specified by the manufacturer. Following activation of the first nozzle, the flowing water pressure shall be gradually increased to the minimum system operating pressure specified by the manufacturer. The delay time until the minimum system operating pressure is reached shall correspond to the delay time expected in an actual installation. The delay time recorded during the tests shall be documented and included in the system specifications.

5.6 The air in the test enclosure shall be conditioned to an ambient temperature of (15 ±10) °C, measured with the thermocouple located 76 mm below the ceiling.

5.7 The fuel load materials for the category III test shall be conditioned at normal room temperature (20 ±10) °C for a period of seven days prior to testing commencing. The wood crib sticks shall have a moisture content between 9% and 13%.

6 Principle

The low hazard occupancy tests comprise small, large and open compartments, plus open plan office simulations. The watermist system needs to pass all the tests for the category(ies) for which it is to be used.

7 Procedure

7.1 General

7.1.1 The following individual tests shall be conducted:

a) for category I systems:

   1) small compartment with bunk beds (**7.2**);

b) for category II systems:

   1) large compartment with corner crib and simulated furniture up to maximum coverage of four nozzles (**7.3**);

   2) open space with sofas under one nozzle (**7.4**);

   3) open space with sofas between two nozzles (**7.5**);

   4) open space with sofas between four nozzles (**7.6**);

c) for category III systems:

   1) open space with simulated work station under one nozzle (**7.7**);

   2) open space with simulated work station between two nozzles (**7.8**);

   3) open space with simulated work station between four nozzles (**7.9**).

7.1.2 System components, component locations, operating conditions and test enclosure details shall remain unaltered throughout all of the fire tests for a given application. During each test, all systems shall operate without manual intervention. All tests shall be conducted using the specifications from the manufacturer's design and installation manual with regard to nozzle placement, spray flux, and spray duration.

7.1.3 Prior to the start of each test:

a) the igniter (**4.11**) shall be soaked in 120 mL of heptane (see **4.12**) for the category I and II tests (see **7.2** to **7.6**) and 120 mL of white spirit (see **4.13**) for the category III test (see **7.7** to **7.9**);

b) the room shall be dried and all water from previous testing shall be removed;

c) there shall be no visible water on the floor, ceiling or walls.

7.1.4 The category I and II tests (see **7.2** to **7.6**) shall be conducted for 10 min after the activation of the first nozzle. The category III tests (see **7.7** to **7.9**) shall be conducted for 30 min after the activation of the first nozzle. After this period, any remaining fire shall be extinguished manually.

7.1.5 During each test, the following temperatures shall be measured continuously, at least every 2 s, throughout the tests:

a) the embedded ceiling surface temperature above the ignition source in the room, with the thermocouple bead 6.5 mm above the bottom surface of the ceiling;

b) the ceiling gas temperature, with a thermocouple (75 ±1) mm below the ceiling in the centre of the room;

c) the ceiling surface temperature in the centre of the corridor, directly opposite the doorway, with a thermocouple embedded in the ceiling material such that the thermocouple bead is 6.5 mm above the bottom surface of the ceiling;

d) the ceiling gas temperature, with a thermocouple (75 ±1) mm below the ceiling in the centre of the corridor directly opposite the doorway;

e) for the category III tests (see **7.7** to **7.9**), the gas temperatures:

   1) above each wood crib, centrally positioned and approximately 100 mm above the top of the crib;

   2) above the box files and foam sheet arrangements, approximately 200 mm above the top of the files and protruding 250 mm away from the plywood walls;

   3) at a height of 2.5 m directly above the plywood walls, in the corner of the array and 2 m away on both sides of the fuel load arrangement.

7.1.6 For every 15 temperature measurements, the 15 results shall be added together and the total divided by 15 to obtain the mean value. The highest of the mean values shall then be taken as the maximum temperature recorded during the test.

7.1.7 The following times shall be recorded during testing:

a) start of ignition procedure;

b) start of test fuel ignition;

c) time when the extinguishing system is activated with watermist discharging from the nozzles;

d) time when the fire(s) is extinguished;

   NOTE Use of a thermal imaging camera is recommended.

e) time when the extinguishing system is shut off;

f) time when the test is finished.

7.1.8 The following parameters shall be recorded during testing:

a) temperature of test enclosure;

b) extinguishing agent flow and pressure in the extinguishing system;

c) water supply pressure (including tank pressure if applicable) and nozzle discharge pressure;

d) extinguishing agent pressure at the most remote nozzle branch line;

e) oxygen, carbon monoxide and carbon dioxide concentrations;

f) gas pressure at the gas storage outlet and distribution sources (gas used to drive water from cylinders supplying the watermist system);

g) consumption of foam concentrate or other additive;

h) gas consumption (gas used to drive water from cylinders supplying the watermist system).

7.1.9 The results of the tests shall be documented in a test report prepared in accordance with BS EN ISO/IEC 17025:2005, **5.10**. The test report shall contain at least the following information:

a) a title;

b) the name and address of the laboratory, and the location where the tests were carried out, if different from the address of the laboratory;

c) unique identification of the test report (such as the serial number), an identification on each page in order to ensure that the page is recognized as a part of the test report, and a clear identification of the end of the test report;

d) the name and address of the client;

e) a description of the method used, including details of the test apparatus and a reference to the standard against which the system was tested, i.e. BS 8489-7;

f) a description of, the condition of, and unambiguous identification of the item(s) tested;

g) the date of receipt of the test item(s) where this is critical to the validity and application of the results, and the date(s) of performance of the test;

h) reference to the sampling plan and procedures used by the laboratory or other bodies where these are relevant to the validity or application of the results;

i) the test results, with units of measurement where appropriate, including the percentage of any damage to the system components, test rig or test enclosure, together with the times and parameters recorded during each test;

j) a statement of compliance/non-compliance with the pass/fail criteria specified in Clause **8**;

k) confirmation of system design parameters relevant to the specific application, including, but not limited to, the following:

   1) the discharge duration;

   2) nozzle designation;

   3) a plan view drawing showing the test ceiling and nozzle positions;

   4) the tested ceiling height;

   5) the spacing between the nozzles;

   6) the flow rate to the nozzle(s);

   7) distance between the ceiling and nozzle orifice;

   8) pressure over the duration of the test;

   9) type of detection/actuation method;

   10) additives, propellants and atomizing media used;

   11) details of the test hall geometry;

   12) ventilation conditions during the test;

   13) environmental conditions during the test;

l) the name(s), function(s) and signature(s) or equivalent identification of person(s) authorizing the test report;

m) where relevant, a statement to the effect that the results relate only to the items tested.

7.2 Small compartment with bunk beds

7.2.1 For upright and pendent nozzles, a single nozzle shall be placed in the centre of test room A (see **A.1**).

7.2.2 The apparatus used shall be test room A (**4.3** and **A.1**) and fuel package 1 (**4.7** and **B.1**).

7.2.3 For each test, new acoustical panels (see **A.1**) shall be installed in the (2.4 × 2.4) m area directly over the ignition source.

7.2.4 The test fire shall be ignited in the lower bunk of fuel package 1 (**4.7**), using the igniter (**4.11**) and a lighted match.

7.2.5 The test shall be conducted twice. If the design of the nozzle is such that it might have a best case and worst case orientation or position, then the tests shall be conducted using each orientation or position.

7.3 Large compartment with corner crib and simulated furniture

7.3.1 Nozzles shall be installed in test room B, as described in **A.2**.

7.3.2 The apparatus used shall be test room B (**4.4** and **A.2**) and fuel package 2 (**4.8** and **B.2**).

7.3.3 The heptane in the pan shall be ignited using a suitable open flame heat source. Immediately following ignition of heptane in the pan, the heptane soaked cotton wicks shall be ignited.

7.3.4 The test shall be conducted twice. If the design of the nozzle is such that it might have a best case and worst case orientation or position, then the tests shall be conducted using each orientation or position.

7.4 Open space with sofas under one nozzle

7.4.1 Nozzles shall be installed in the ceiling at the maximum nozzle spacing specified in the manufacturer's design instructions.

7.4.2 The apparatus used shall be test area C (**4.5** and **A.3**) and fuel package 3 (**4.9** and **B.3**).

7.4.3 The ignition source (see **B.3**) shall be centred under one nozzle.

7.4.4 The fuel package shall be ignited with a lighted match using the igniter (**4.11**).

7.5 Open space with sofas between two nozzles

7.5.1 Nozzles shall be installed in the ceiling at the maximum nozzle spacing specified in the manufacturer's design instructions.

7.5.2 The apparatus used shall be test area C (**4.5** and **A.3**) and fuel package 3 (**4.9** and **B.3**).

7.5.3 The ignition source (see **B.3**) shall be centred between two nozzles.

7.5.4 The fuel package shall be ignited with a lighted match using the igniter (**4.11**).

7.6 Open space with sofas between four nozzles

7.6.1 Nozzles shall be installed in the ceiling at the maximum nozzle spacing specified in the manufacturer's design instructions.

7.6.2 The apparatus used shall be test area C (**4.5** and **A.3**) and fuel package 3 (**4.9** and **B.3**).

7.6.3 The ignition source (see **B.3**) shall be centred between four nozzles.

7.6.4 The fuel package shall be ignited with a lighted match using the igniter (**4.11**).

7.7 Open space with simulated work station under one nozzle

7.7.1 Nozzles shall be installed in the ceiling at the maximum nozzle spacing specified in the manufacturer's design instructions.

7.7.2 The apparatus used shall be test area D (**4.6** and **A.4**) and fuel package 4 (**4.10** and **B.4**).

7.7.3 The ignition source (see **B.4**) shall be centred under one nozzle.

7.7.4 The fuel package shall be ignited with a lighted match using the igniter (**4.11**).

7.8 Open space with simulated work station between two nozzles

7.8.1 Nozzles shall be installed in the ceiling at the maximum nozzle spacing specified in the manufacturer's design instructions.

7.8.2 The apparatus used shall be test area D (**4.6** and **A.4**) and fuel package 4 (**4.10** and **B.4**).

7.8.3 The ignition source (see **B.4**) shall be centred between two nozzles.

7.8.4 The fuel package shall be ignited with a lighted match using the igniter (**4.11**).

7.9 Open space with simulated work station between four nozzles

7.9.1 Nozzles shall be installed in the ceiling at the maximum nozzle spacing specified in the manufacturer's design instructions.

7.9.2 The apparatus used shall be test area D (**4.6** and **A.4**) and fuel package 4 (**4.10** and **B.4**).

7.9.3 The ignition source (see **B.4**) shall be centred between four nozzles.

7.9.4 The fuel package shall be ignited with a lighted match using the igniter (**4.11**).

8 Pass/fail criteria

For each individual test, the watermist system shall be deemed to have passed the test if the following criteria are met.

a) For test **7.2**:

- damage to the cushions of the lower bunk bed does not exceed 40% by volume or dry weight, including the horizontal mattress, pillow, and vertical mattress;
- the maximum ceiling surface temperature over ignition does not exceed 260 °C;
- the maximum gas temperature over ignition 76 mm below the ceiling does not exceed 315 °C;
- after 5 min, the mean temperatures (see **7.1.6**) remain steady or decrease until the end of the test.

b) For test **7.3**:

- the target doorway nozzles do not operate;
- the maximum ceiling surface temperature over ignition does not exceed 265 °C;
- the maximum gas temperature over ignition 76 mm below the ceiling does not exceed 315 °C;
- after 5 min, the mean temperatures (see **7.1.6**) remain steady or decrease until the end of the test.

c) For test **7.4**:

- damage to the sofas does not exceed 50% by volume or dry weight;
- the maximum ceiling surface temperature over ignition does not exceed 260 °C;
- the maximum gas temperature over ignition 76 mm below the ceiling does not exceed 315 °C;
- after 5 min, the mean temperatures (see **7.1.6**) remain steady or decrease until the end of the test.

d) For test **7.5**:

- damage to the sofas does not exceed 50% by volume or dry weight;
- the maximum ceiling surface temperature over ignition does not exceed 260 °C;
- the maximum gas temperature over ignition 76 mm below the ceiling does not exceed 315 °C;
- after 5 min, the mean temperatures (see **7.1.6**) remain steady or decrease until the end of the test.

e) For test **7.6**:

- damage to the sofas does not exceed 50% by volume;
- the maximum ceiling surface temperature over ignition does not exceed 260 °C;
- the maximum gas temperature over ignition 76 mm below the ceiling does not exceed 315 °C;
- after 5 min, the mean temperatures (see **7.1.6**) remain steady or decrease until the end of the test.

f) For test **7.7**:

- damage to the plywood walls does not extend to the full height at the ends of the walls;
- damage to the foam and box files does not extend to all areas;
- the maximum gas temperature in the centre of the ceiling, 76 mm below the ceiling, does not exceed 80 °C, for a duration longer than 3 min for the 30 min system discharge;
- after 5 min (measured either from the start of system operation or the ignition of both wood cribs, whichever takes the longer), the mean ceiling temperatures remain steady or decrease until the end of the test.

g) For tests **7.8** and **7.9**:

- damage to the plywood walls does not extend to the full height at the ends of the walls;
- damage to the foam and box files does not extend to all areas;
- the maximum gas temperature over ignition 76 mm below the ceiling does not exceed 80 °C, for a duration longer than 3 min for the 30 min system discharge;
- after 5 min (measured either from the start of system operation or the ignition of both wood cribs, whichever takes the longer), the mean ceiling temperatures (see **7.1.6**) remain steady or decrease until the end of the test.

Annex A (normative) Test rooms

A.1 Test room A: small compartment

The small compartment shall measure (3 × 4) m and shall be 2.4 m in height. A (1.2 × 1.2) m compartment shall be provided within this space to simulate a lavatory. The compartment shall have a doorway with dimensions of 0.8 m wide and 2.2 m high. This doorway shall not include a door.

The walls of the compartment shall be fabricated from a 12 mm nominal thickness non-combustible wall board backed with 45 mm nominal thickness mineral wool insulation. The wall board shall be covered with 3 mm to 4 mm nominal thickness Elliotis pine plywood (or decorative panelling having a Class 3 surface spread of flame in accordance with BS 476-7:1997).

The ceiling of the test room shall be covered with acoustical panels or gypsum board attached to furring strips. The panels shall be installed in the (2.4 × 2.4) m area directly over the ignition source and shall measure (0.6 × 1.2) m. The panels shall be 12 mm to 16 mm thick, have a density of (216 ±24) kg/m^3, and have a Class 0 surface spread of flame in accordance with BS 476-7:1997.

The thermocouples (**4.14**) shall be centred directly over the ignition source as shown in Figure A.1.

The panelling shall be conditioned at (20 ±5) °C and (50 ±10)% relative humidity for at least 72 h.

A.2 Test room B: large compartment

For watermist systems using pendent or upright nozzles, including flush, recessed and concealed pendent nozzles, the large compartment shall be the minimum required room size for four nozzles at the maximum nozzle spacing, with one half the maximum nozzle spacing to the walls, and 2.4 m in height. The compartment shall have equal length sides, as specified by the manufacturer, and shall include a minimum area of 37 m^2. See Figure A.2.

NOTE Approval applies to rooms up to the maximum size of the one tested.

The compartment shall have two doorways located in diagonally opposite corners of the room as shown in Figure A.2. Each doorway shall measure 0.8 m wide and 2.2 m high. These doorways shall not include doors.

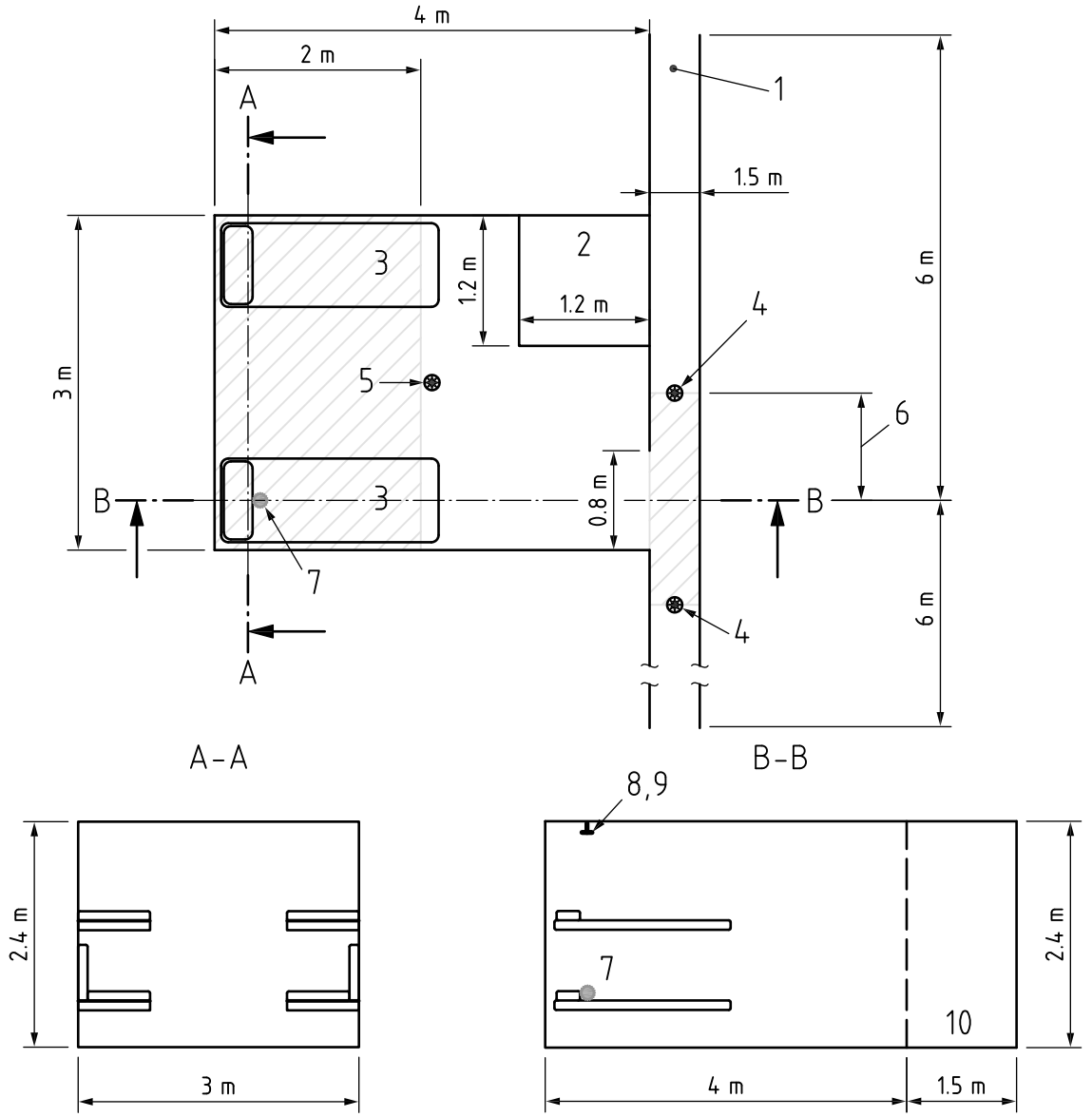
The walls of the compartment shall be fabricated from a 12 mm nominal thickness non-combustible wall board, backed with 45 mm nominal thickness mineral wool insulation. Sheets of plywood panelling measuring (1.2 × 2.4) m shall cover two of the test enclosure walls at a common corner. The panelling shall be 6 mm thick, with each ply constructed of Elliotis pine. Two sheets shall be attached to each wall at the common corner using 12.7 mm thick wood furring strips (see Figure A.2).

The ceiling of the test room shall be covered with acoustical panels or gypsum board attached to furring strips. The panels shall be installed in the (2.4 × 2.4) m area directly over the ignition source and shall measure (0.6 × 1.2) m. The panels shall be 12 mm to 16 mm thick, have a density of (216 ±24) kg/m^3, and have a Class 0 surface spread of flame in accordance with BS 476-7:1997.

The panelling shall be conditioned at (20 ±5) °C and (50 ±10)% relative humidity for at least 72 h.

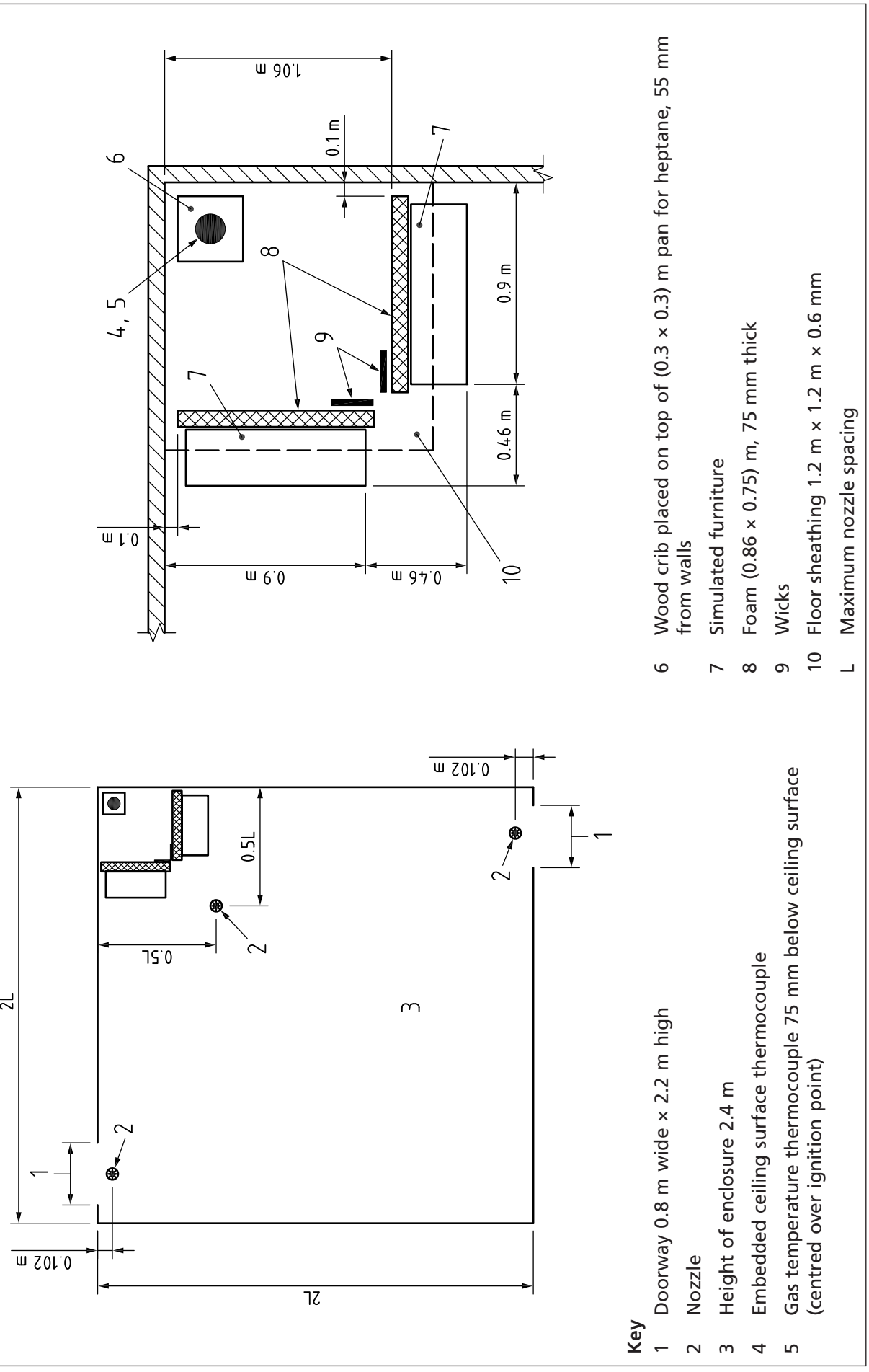
The thermocouples (**4.14**) shall be centred directly over the ignition source as shown in Figure A.2.

Figure A.1 **Test room A (small compartment)**



Key

1 Corridor minimum length 12 m
2 Lavatory
3 Bunk bed
4 Corridor nozzle
5 Centre nozzle
6 Half × spacing between nozzles
7 Ignition point
8 Embedded ceiling surface thermocouple
9 Gas temperature thermocouple 75 mm below ceiling surface
10 Corridor



Key

1 Doorway 0.8 m wide × 2.2 m high
2 Nozzle
3 Height of enclosure 2.4 m
4 Embedded ceiling surface thermocouple
5 Gas temperature thermocouple 75 mm below ceiling surface (centred over ignition point)
6 Wood crib placed on top of (0.3 × 0.3) m pan for heptane, 55 mm from walls
7 Simulated furniture
8 Foam (0.86 × 0.75) m, 75 mm thick
9 Wicks
10 Floor sheathing 1.2 m × 1.2 m × 0.6 mm
L Maximum nozzle spacing

Figure A.2 **Test room B (large compartment test room) and fuel package 2 (corner crib and simulated furniture) for pendent and upright nozzles**

A.3 Test area C: open space

The test area shall have a ceiling of at least 80 m^2 in order to simulate an uninterrupted open space, and shall be 5 m in height or the maximum ceiling height specified in the manufacturer's design instructions, whichever is the lowest.

The ceiling directly over the fire, for a minimum area of 1 m^2, shall be constructed of cellulose acoustical tiles. The tiles shall be 16 mm thick and shall have a Class 0 surface spread of flame in accordance with BS 476-7:1997.

The thermocouples (**4.14**) shall be centred directly over the ignition source.

A.4 Test area D: simulated work station

The test area shall have a ceiling of at least 36 m^2 in order to simulate an uninterrupted open space, and shall be 5 m in height or the maximum ceiling height specified in the manufacturer's design instructions, whichever is the lowest. There shall be a clear space of a minimum of 3 m around all sides of the test ceiling.

The ceiling shall be constructed from 12 mm calcium silicate board.

The thermocouples (**4.14**) shall be centred directly over the ignition source.

Annex B (normative) Fuel packages

B.1 Fuel package 1: Bunk beds

The bunk bed shall consist of two units designated as the upper and lower bunks. Each bunk shall consist of three components: a steel frame, a mattress and a pillow.

The steel frame for the bunk beds shall be constructed of rectangular steel, 2 mm thick. The primary supporting structure shall be constructed to support the two mattress frames and bunk beds (see Figure B.1). The top and bottom mattress frames shall be constructed of similar steel stock, with dimensions of (2 000 × 800) mm. Eleven gauge (3 mm) sheet steel, with dimensions of (2 000 × 800) mm, shall be welded to the top and bottom mattress frames. These two assemblies shall be attached to the primary bunk bed support structure in an appropriate manner that allows the mattresses to be placed flat and square, and without deformation.

NOTE Additional brackets may be provided on the primary frame to provide support for the vertical mattress.

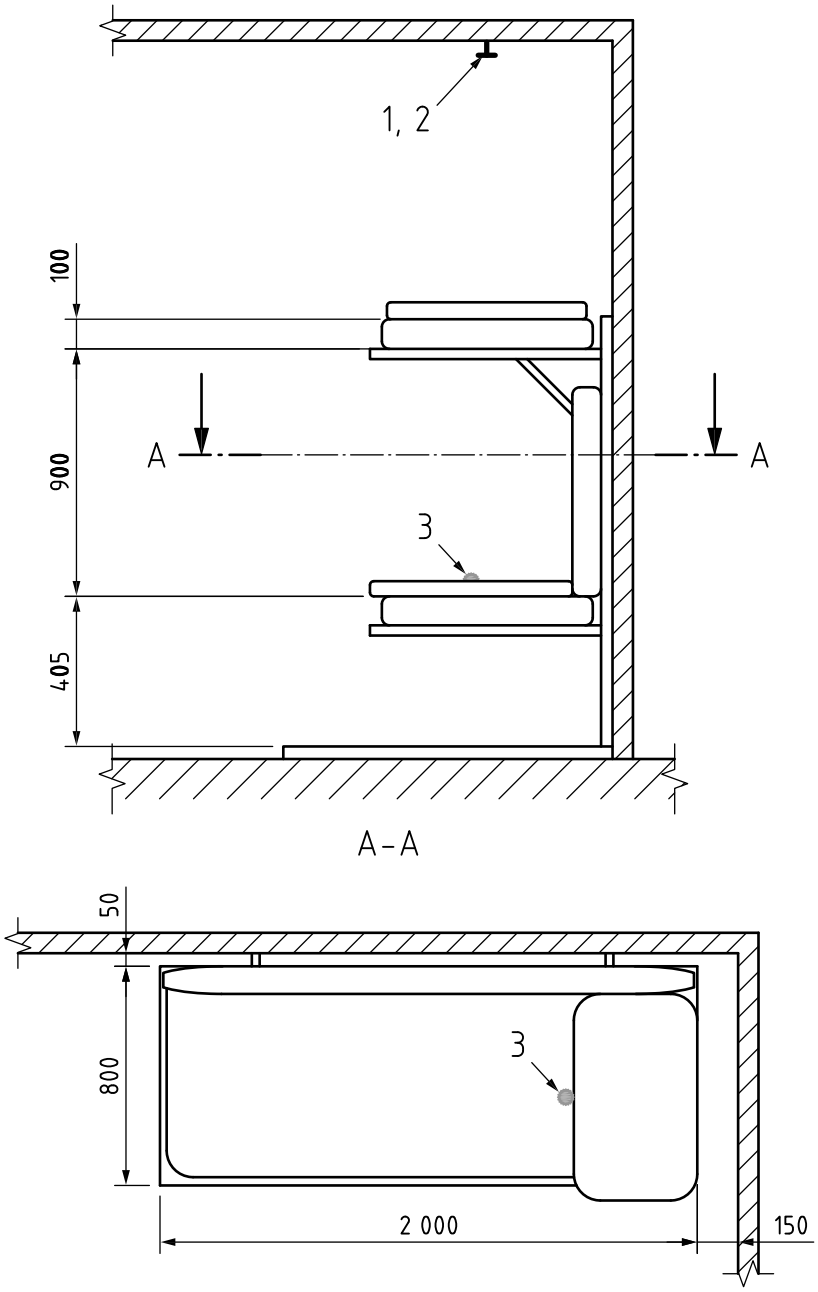
The bottom mattress frame assembly shall be located such that the top of the frame is 300 mm above the floor. The top mattress frame assembly shall be located 1 000 mm above the bottom mattress frame assembly.

Each mattress shall consist of a (2 000 × 800 × 1 000) mm piece of polyether foam with a cotton fabric cover. Each pillow shall consist of a (500 × 800 × 100) mm piece of polyether foam with a cotton fabric cover cut from the end of a mattress. The cotton fabric covers shall not be fire-retardant-treated and shall have an area weight of 140 g/m^2 to 180 g/m^2. The covers shall be one-ply and shall contain a thread count of approximately 0.186 threads per square millimetre (120 threads per square inch). The cut end of the pillow shall be positioned such that it faces the doorway of the test room.

The lower bunk shall have an additional mattress with a cotton fabric cover positioned as a back rest (see Figure B.1). Two bunk beds shall be used, one on each side of the test room.

Figure B.1 **Fuel package 1 (bunk beds)**

Dimensions in millimetres



Key

1 Embedded ceiling surface thermocouple

2 Gas temperature thermocouple 75 mm below ceiling surface

3 Ignition point

The mattress/pillow material shall be made of non-fire-retardant polyether foam and shall have a density of approximately 33 kg/m^3. When tested in accordance with ISO 5660-1 at 35 kW/m^2 in the horizontal position, the mean values shall be as specified in Table B.1.

Table B.1 **Burning characteristics of foam mattress material**

Property	Requirement
Time to ignition	2 to 6 s
3 min average HRR, q180	270 ±50 kW/m^2
Minimum heat of combustion	28 ±3 MJ/kg
Total heat release (MJ/m^2)	50 ±12 MJ/m^2

After being soaked in heptane (see **7.1.3**), the igniter (**4.11**) shall be wrapped in a plastic bag and positioned as shown in Figure B.1.

B.2 Fuel package 2: corner crib and simulated furniture

The large compartment corner fuel package shall consist of a wood crib and simulated furniture (see Figure B.2).

The wood crib shall be (305 × 305) mm × 150 mm high and shall consist of four layers of lumber. Each layer shall consist of four 300 mm long pieces of (38 × 38) mm kiln-dried spruce or fir lumber. The lumber in each layer shall be placed at right angles to the adjacent layers. Individual wood members in each layer shall be evenly spaced along the 300 mm length and stapled to adjacent layers. The mass of the crib shall be 2.5 kg to 3.2 kg.

After assembly, the wood crib shall be conditioned at a temperature of (20 ±5) °C for 24 h to 72 h.

After conditioning, the wood crib shall be placed on top of a nominal (305 × 305 mm) × 100 mm high, 2.5 mm thick steel pan (see Figure B.2), which shall contain 0.47 L water and 0.24 L heptane and shall be located on the floor in a corner of the test enclosure. The wood crib shall be centred on the pan and positioned 55 mm from each wall (see Figure A.2).

The simulated furniture shall consist of foam cushions attached to a plywood backing and supported by a steel frame. The cushions shall consist of two pieces of uncovered pure polypropylene oxide polyol, polyether foam having a density of (30 ±5) kg/m^3 and measuring (864 × 762 × 76) mm. When tested in accordance with ISO 5660-1 at 35 kW/m^2 in the horizontal position, the mean values shall be as specified in Table B.1.

Each foam cushion shall be fixed to a (890 × 787) mm, nominal 13 mm thick, plywood backing using an aerosol urethane foam adhesive. The location of the foam on the plywood shall give a 13 mm gap between the sides of the cushion and the sides of the backing, and a 25.4 mm gap between the bottom of the cushion and the bottom of the backing, as shown in Figure B.2.

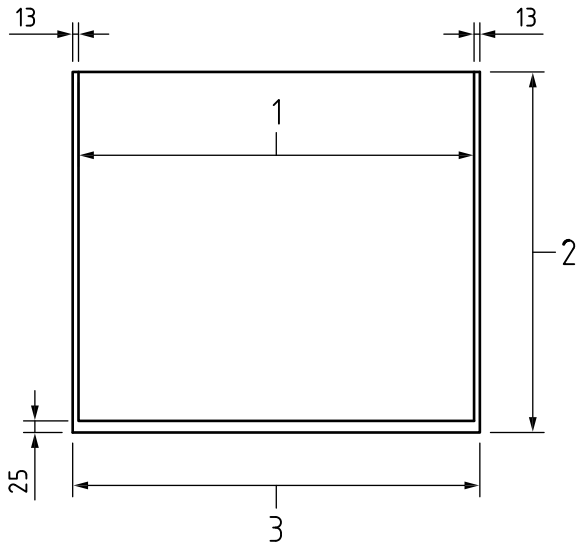
The foam cushion and plywood backing assembly shall be conditioned at (21.1 ±2.8) °C and (50 ±10)% relative humidity for at least 24 h prior to testing, and shall then be placed in a steel support frame that holds the assembly in the vertical position.

The simulated furniture, wood crib, and steel pan shall be placed as illustrated in Figure A.2 on a piece of cement board sheathing or equivalent non-combustible sheathing material measuring (1 200 × 1 200 × 6) mm.

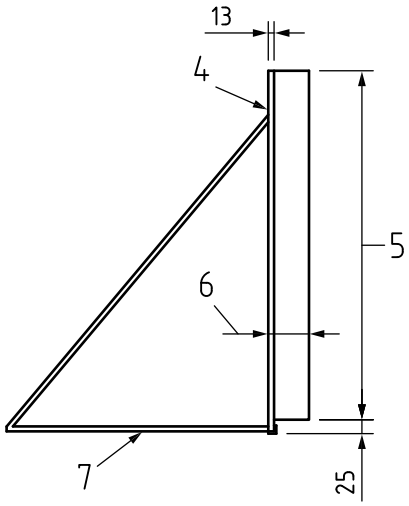
Two (150 × 50 × 30) mm bricks shall be placed on the cement board sheathing against the foam cushions, with their ends flush with the edge of the foam. Two cotton wicks, 150 mm long × 6 mm diameter, shall be soaked in heptane and placed on bricks, with their ends flush with the edge of the bricks and foam (see Figure A.2).

Figure B.2 **Fuel package 2 (corner crib and simulated furniture)**

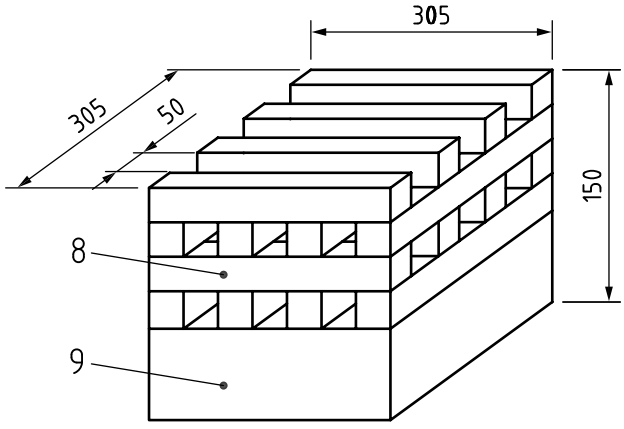
Dimensions in millimetres



a) Simulated furniture: front



b) Simulated furniture: side



c) Wood crib

Key

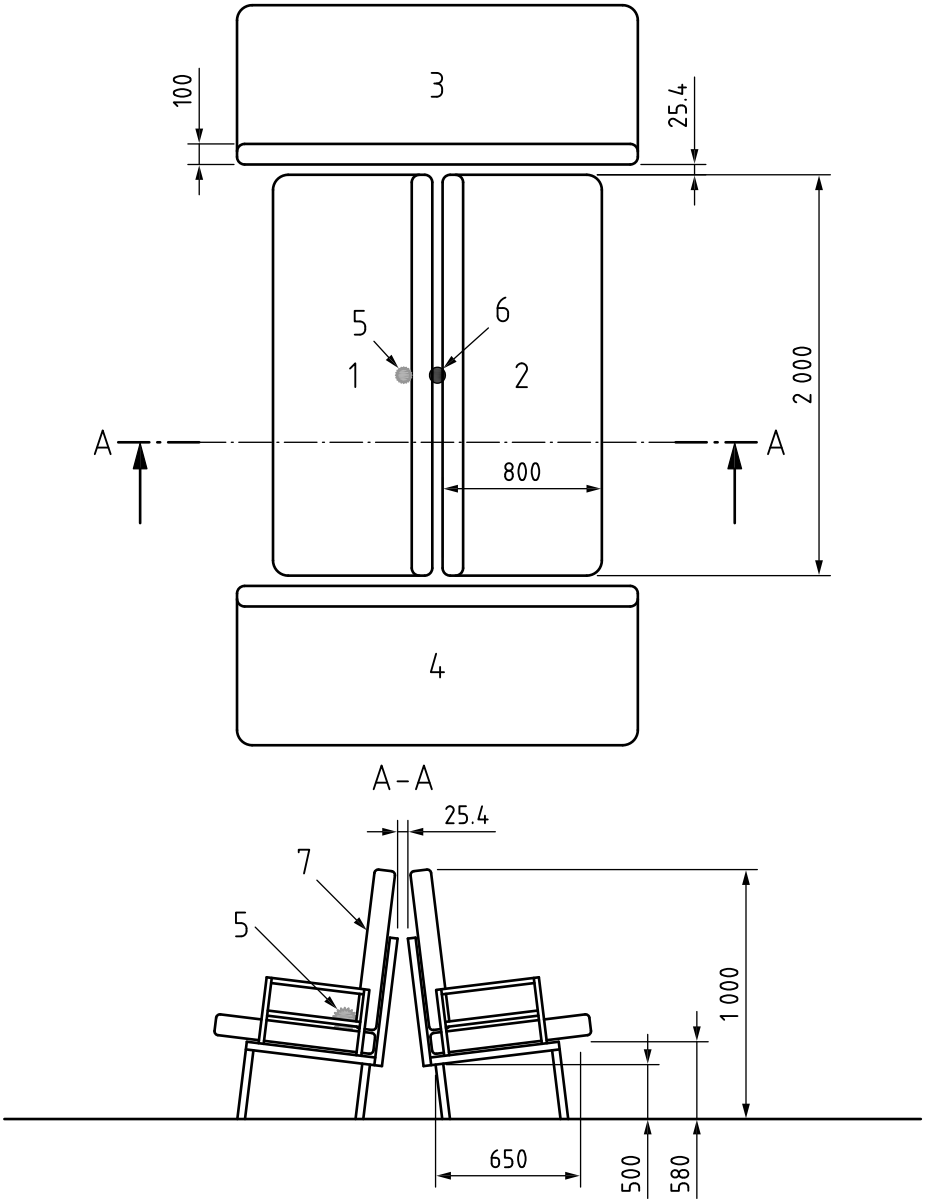
1 Foam, 864 mm wide
2 Plywood, 787 mm high
3 Plywood, 890 mm wide
4 Plywood backing, 13 mm thick
5 Foam, 762 mm high
6 Foam, 76 mm thick
7 Metal angle frame, 3 mm thick
8 Timber, (38 × 38) mm nominal size
9 Steel pan, (605 × 305 × 104) mm

B.3 Fuel package 3: sofas

There shall be four sofas, each consisting of three components: two mattresses and a steel frame. Each mattress shall consist of a (2 000 × 800 × 100) mm piece of polyether foam with a cotton fabric cover. The test configuration shall be as shown in Figure B.3.

Figure B.3 **Fuel package 3 (sofas)**

Dimensions in millimetres



Key

1 Sofa number 1
2 Sofa number 2
3 Sofa number 3
4 Sofa number 4
5 Ignition point
6 Ceiling surface and gas temperature thermocouples
7 Sofa material (2 000 × 800 × 100) mm

The steel frames shall consist of rectangular bottom and backrest frames constructed of steel angles, channels or rectangular stock of at least 3 mm thickness. The frame dimensions shall be (2 000 × 650) mm. The seat and backrest cushions shall be supported on each frame by three steel bars, 20 mm to 30 mm wide × 650 mm long, spaced every 500 mm and welded to the frames. Steel plates shall not be used to support the cushions. The assembled frames shall be supported by four legs constructed of similar steel stock. The two rear legs shall be 500 mm in height and the front legs shall be 580 mm in height. Each sofa shall have a rectangular armrest on each end. The armrest shall be constructed of similar steel stock and shall be 200 mm in height and 500 mm in length. The rear section of the armrest shall be attached to the bottom frame 50 mm from the backrest.

Each mattress shall consist of a (2 000 × 800 × 100) mm piece of polyether foam with a cotton fabric cover. The cotton fabric covers shall not be fire-retardant-treated and shall have an area weight of 140 g/m^2 to 180 g/m^2. The covers shall be one ply and shall contain a thread count of approximately 0.186 threads per square millimetre (120 threads per square inch).

The mattress/pillow material shall be made of non-fire-retardant polyether foam and shall have a density of approximately 33 kg/m^3. When tested in accordance with ISO 5660-1 at 35 kW/m^2 in the horizontal position, the mean values shall be as specified in Table B.1.

The mattresses shall be positioned in each sofa frame such that the vertical mattress rests on top of the horizontal mattress. After being soaked in heptane (see **7.1.3**), the igniter (**4.11**) shall be wrapped in a plastic bag and positioned as shown in Figure B.3.

B.4 Fuel package 4: simulated work station

The simulated work station fuel load arrangement shall be as shown in Figure B.4.

Two walls shall be constructed 2 400 mm wide × 1 800 mm high from two layers of plasterboard attached to a timber frame. The walls shall be positioned to form a corner arrangement. The front face of the walls shall be clad with 12 mm thick Elliotis pine plywood panels.

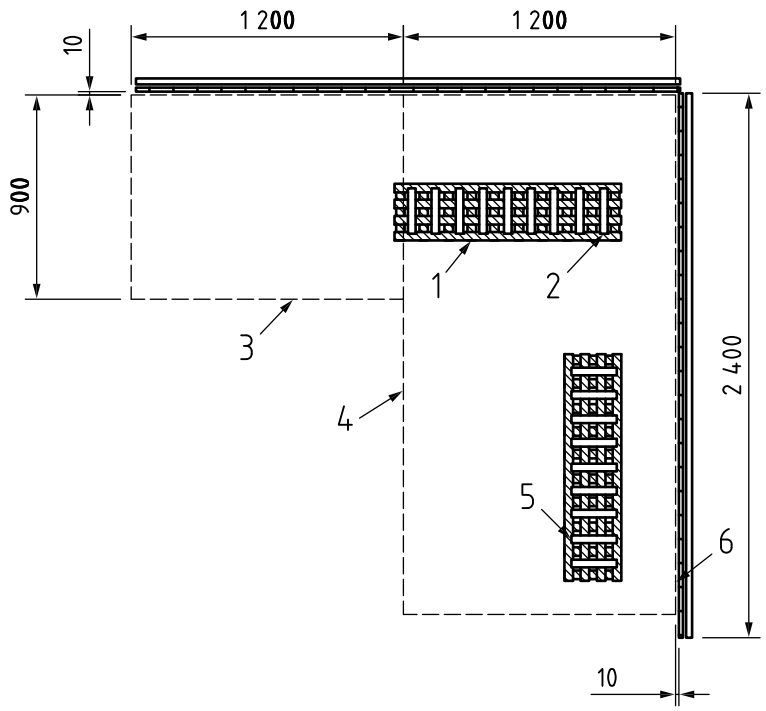
The table arrangement shall be formed from two differently sized tables, each constructed from 22 mm thick chipboard with a metal angle support frame. The large table shall measure 2 400 mm long × 1 200 mm wide × 760 mm high, and the small table 1 200 mm long × 900 mm wide × 760 mm high. The two tables shall be butted together, and aluminium foil tape shall be used to seal the joint. The chipboard tables shall be separated from the plywood walls by a gap of (10 ±2) mm (see Figure B.4).

Two separate wood/plastic cribs (a corner crib and a target crib) shall be located underneath the table arrangement. Each crib shall be formed from 40 sticks of *pinus silvestris* (European redwood) measuring 38 mm wide × 38 mm high × 250 mm long, and 16 sticks of *pinus silvestris* measuring 38 mm × 38 mm × 1 000 mm, arranged in alternate layers. Four layers of ten of the short sticks shall be equally spaced over the length of the crib with the bottom layer forming the bottom of the crib. Four layers of four of the long sticks shall be equally spaced over the width of the crib, with the top layer forming the top of the wood crib. Additionally, 27 sticks of natural polypropylene shall be inserted in the gaps formed by the wood crib sticks on the top two layers of the crib and on top of the crib itself (that is three rows of nine sticks). The polypropylene sticks shall measure 35 mm × 200 mm × 10 mm.

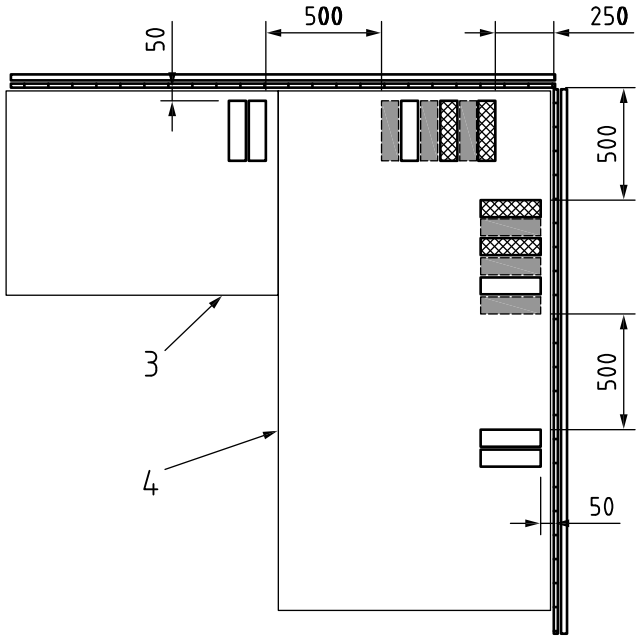
The corner crib shall be positioned 400 mm away from the plywood wall, with the length of the crib positioned parallel to the wall. The end of the crib (closest to the corner) shall be 250 mm away from the other plywood wall.

Figure B.4 **Fuel package 4 (simulated work station)** (*1 of 2*)

Dimensions in millimetres

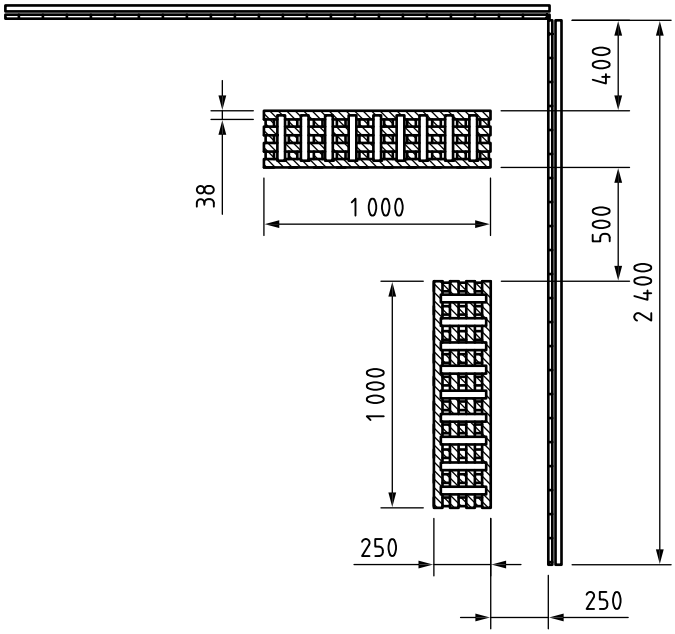


a) Plan view showing the position of the walls, tables and cribs (on the floor)

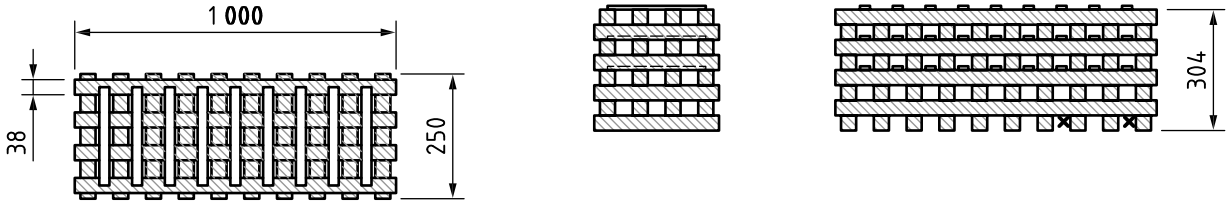


b) Plan view showing the position of the walls, tables and table fire load (on the tables)

Figure B.4 **Fuel package 4 (simulated work station)** (*2 of 2*)



c) Plan view showing the position of the cribs in relation to the walls



Plan Side elevation Front elevation

d) Crib arrangement

Key

1 Corner crib
2 Ignition location
3 Small table
4 Large table
5 Target crib
6 Wall

× Ignition location (corner crib)
Foam sheet
Box file, empty
Box file, full
Wood sticks
Polypropolene sticks

The target crib shall be positioned 250 mm away from the plywood wall, with the length of the crib positioned parallel to the wall. The end of the crib (closest to the corner crib) shall be 500 mm away from the corner crib.

The target table fuel loading shall consist of cardboard box files, polyurethane foam and paper, as follows:

- ten cardboard box files measuring (370 × 265 × 75) mm;
- six sheets of polyurethane foam having a density of 17 kg/m^3 to 19 kg/m^3 and measuring (370 × 265 × 75) mm;
- four batches of 500 sheets of white size A4 paper having a density of approximately 80 g/m^2.

Two sets of box files and foam sheets shall be used, each of three box files spaced with three foam sheets. For each arrangement, the two box files closest to the corner shall each be filled with 500 sheets of white size A4 paper. The box files and foam sheets shall be positioned 50 mm away from the adjacent plywood walls.

- For the box files above the corner crib, the face of the box file closest to the corner shall be 250 mm away from the plywood wall.
- For the box files above the target crib, the face of the box file closest to the corner shall be 500 mm away from the plywood wall.

Additionally, two target box files shall be positioned 500 mm away from the face of the end foam sheet and shall also be positioned 50 mm away from the plywood walls.

After being soaked in white spirit (see **7.1.3**), igniters shall be positioned in the corner crib (at the end close to the wall) at the base of the crib as shown in Figure B.4d).

Bibliography

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 8489-4, *Fixed fire protection systems – Industrial and commercial watermist systems – Part 4: Tests and requirements for watermist systems for local applications involving flammable liquid fires*

BS 8489-5, *Fixed fire protection systems – Industrial and commercial watermist systems – Part 5: Tests and requirements for watermist systems for the protection of combustion turbines and machinery spaces with volumes up to and including 80 m^3*

BS 8489-6, *Fixed fire protection systems – Industrial and commercial watermist systems – Part 6: Tests and requirements for watermist systems for the protection of industrial oil cookers*

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