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Respiratory protective devices — Methods of test and test equipment —

Part 10: Resistance to ignition, flame, radiant heat and heat

Appareils de protection respiratoire — Méthodes d'essai et équipement d'essai —

Partie 10: Résistance à la combustion, à la flamme, à la chaleur radiante et à la chaleur

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 15, *Respiratory protective devices*.

ISO 16900 consists of the following parts, under the general title *Respiratory protective devices — Methods of test and test equipment*:

— *Part 1: Determination of inward leakage*

— *Part 2: Determination of breathing resistance*

— *Part 3: Determination of particle filter penetration*

— *Part 4: Determination of gas filter capacity and migration, desorption and carbon monoxide dynamic testing*

— *Part 5: Breathing machine, metabolic simulator, RPD headforms and torso, tools and verification tools*

— *Part 6: Mechanical resistance/strength of components and connections*

— *Part 7: Practical performance test methods*

— *Part 8: Measurement of RPD air flow rates of assisted filtering RPD*

— *Part 9: Determination of carbon dioxide content of the inhaled air*

— *Part 10: Resistance to ignition, flame, radiant heat, and heat*

— *Part 11: Determination of field of vision*

— *Part 12: Determination of volume-averaged work of breathing and peak respiratory pressures*

— *Part 13: RPD using regenerated breathable gas and special application mining escape RPD: Consolidated test for gas concentration, temperature, humidity, work of breathing, breathing resistance and duration*

— *Part 14: Measurement of sound level*

Introduction

This part of ISO 16900 is intended as a supplement to the relevant performance standards for respiratory protective devices. Test methods are specified for complete or parts of devices. If deviations from the test method given in this part of ISO 16900 are necessary, these deviations will be specified in the relevant performance standard.

The following definitions apply in understanding how to implement an ISO International Standard and other normative ISO deliverables (TS, PAS, IWA):

— "shall" indicates a requirement;

— "should" indicates a recommendation;

— "may" is used to indicate that something is permitted;

— "can" is used to indicate that something is possible, for example, that an organization or individual is able to do something.

3.3.1 of the ISO/IEC Directives, Part 2 (sixth edition, 2011) defines a requirement as an "expression in the content of a document conveying criteria to be fulfilled if compliance with the document is to be claimed and from which no deviation is permitted".

3.3.2 of the ISO/IEC Directives, Part 2 (sixth edition, 2011) defines a recommendation as an "expression in the content of a document conveying that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others or that a certain course of action is preferred, but not necessarily required, or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited".

Respiratory protective devices — Methods of test and test equipment —

Part 10: Resistance to ignition, flame, radiant heat and heat

1 Scope

This part of ISO 16900 specifies the methods for resistance to ignition, flame, radiant heat, and heat.

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.

ISO 6941, *Textile fabrics — Burning behaviour — Measurement of flame spread properties of vertically oriented specimens*

ISO 13506, *Protective clothing against heat and flame — Test method for complete garments — Prediction of burn injury using an instrumented manikin*

ISO 16900-5[1)], *Respiratory protective devices — Methods of test and test equipment — Part 5: Breathing machine/metabolic simulator/RPD headforms/torso, tools and transfer standards*

ISO 16972, *Respiratory protective devices — Terms, definitions, graphical symbols and units of measurement*

ASTM D6413, *Standard Test Method for Flame Resistance of Textiles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16972 and the following apply.

3.1
static test
where the specimen is maintained still over the flame for the exposure

3.2
dynamic test
where the specimen is moving over the flame for the exposure

4 Prerequisites

The performance standard shall indicate the conditions of the test. This includes the following:

— type of test method(s);

— RPD exposure area to be tested;

— number of specimens;

1) To be published.

— temperature and time for exposure;

— any preconditioning;

— mounting and orientation of specimens.

5 General test requirements

Unless otherwise specified, the values stated in this part of ISO 16900 are expressed as nominal values. Except for temperature limits, values which are not stated as maxima or minima shall be subjected to a tolerance of ±5 %. Unless otherwise specified, the ambient temperature for testing shall be between 16 °C and 32 °C, (50 ± 30) % RH and any temperature limits specified shall be subjected to an accuracy of ±1 °C.

Where the assessment of the pass/fail criterion depends on a measurement, an uncertainty of measurement as described in Annex A will be given.

6 Test methods

6.1 Resistance to hot particles (embers/sparks/ash)

6.1.1 Principle

To determine the effect of the exposure, the test consists of exposing those parts specified in the performance standards to a heated wire.

6.1.2 Apparatus

The test rig consists of a loop of Nichrome wire as shown in Figure 1.

The Nichrome wire shall be connected to a power supply. A wire temperature of (500 $^{+50}_{0}$) °C shall be maintained.

6.1.3 Procedure

The RPD shall be mounted on the manikin (e.g. RPD torso and head form in accordance with ISO 16900-5) to simulate the correct wearing position.

The RPD test locations chosen shall include each material and material interface that is exposed during use.

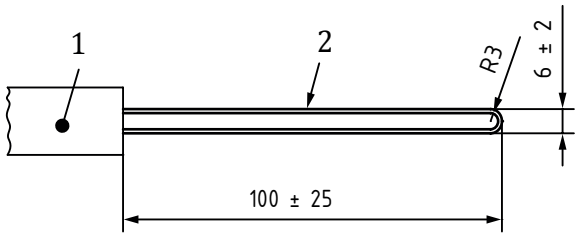
The heated wire shall be placed on each test location for (3 $^{+1}_{0}$) s.

Carry out a visual inspection during the test in order to establish whether the test specimen ignites or melts through as specified in the RPD performance standard.

Observe whether or not the specimen melts or ignites.

6.1.4 Test report

The test report shall include information regarding those parameters specified in Clause 4, together with information, whether or not the specimen melts or ignites.



Key

1 handle

2 nichrome wire with a diameter of 1 mm

Figure 1 — Nichrome wire configuration

6.2 Resistance to flame

6.2.1 Six burner static

6.2.1.1 Principle

The test consists of exposing the specimen specified in the performance standards to a flame of an array of six burners at (950 ± 50) °C for the required time exposure of 5 s.

6.2.1.2 Apparatus

The test rig consists mainly of a propane cylinder with flow control device, flow meter, pressure gauge, flashback arrester, RPD head form size medium in accordance with ISO 16900-5, and six propane Teclu burners which are adjustable in height. Figures 2 and 3 show schematic diagrams of the apparatus and the top view of the arrangements of the burners. The purity of the propane shall be a minimum of 95 %.

6.2.1.3 Procedure

Mount the specimen on the RPD head form size medium or any suitable alternative such that the external parts have direct exposure to the flame. Before lighting the burners, position the specimen centrally above the array of burners and individually adjust the height of each burner such that the distance between the burner tip and specimen is 250 mm. Figure 2 shows the adjustment of the burner tips of one example of specimen.

Determine the leakage of the test specimen for type T respiratory interfaces by applying 1 000 Pa negative pressure and measuring the pressure drop within one minute.

For type L respiratory interfaces, the pressure in the respiratory interface prior to the flame exposure shall be measured when a positive pressure is applied by a flow of 1,5 l/min.

With the specimen removed from above the burners, fully open the propane control valve on each of the burners. Initially, close the air control valve on each of the burners. Ignite the burners and adjust the propane cylinder output regulator to a pressure such that a flow meter in the main propane supply line indicates a total flow to all burners of (21 ± 0,5) l/min propane.

A mineral insulated thermocouple probe with a diameter of 1,5 mm shall be used to measure flame temperature. The temperature shall be measured at a point 250 mm above the upper tip of any burner in the centre of the flame. All burners shall give flame temperature within the tolerance required (950 ± 50) °C. The burners shall be adjusted to their correct position (height) before measuring any flame temperature.

In order to achieve the correct temperature, it may be necessary to adjust the air control valve on each burner to an optimum and to shield the whole test rig from the effect of external air flows.

Expose the specimen to the flames for the required time exposure ±0,5 s.

Determine again the leakage of the test specimen for type T respiratory interfaces by applying at 1 000 Pa negative pressure and measuring the pressure drop within one minute.

For type L respiratory interfaces, the pressure in the respiratory interface following the flame exposure shall be measured when a positive pressure is applied by a flow of 1,5 l/min.

Observe whether or not the specimen drips, burns through, the duration of any after-flame, and the results of the leak tightness determination

6.2.1.4 Test report

The test report shall include information regarding those parameters specified in Clause 4 together with information whether or not the specimen drips, burns through, the duration of any after-flame, and the results of the leak tightness determination.

Dimensions in millimetres

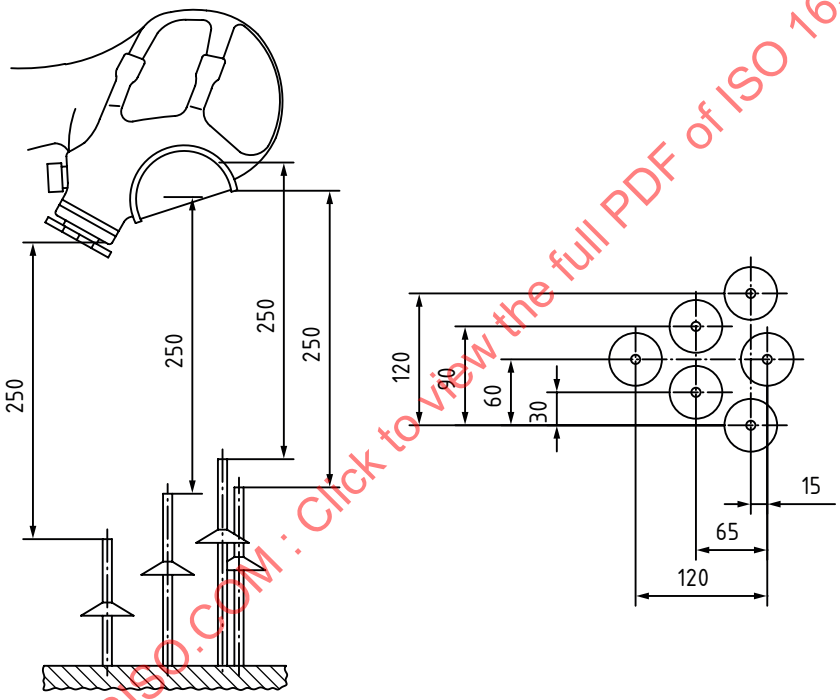
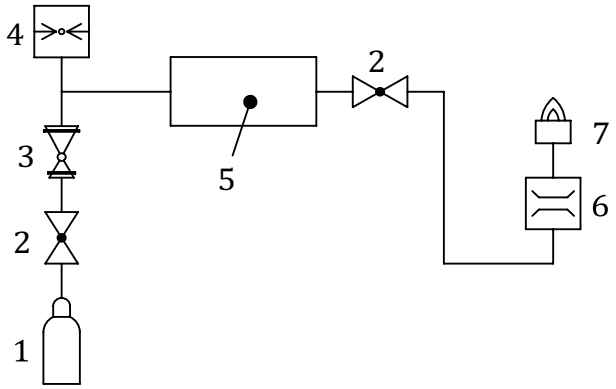


Figure 2 — Typical schematic diagram of arrangement of six burner static test



Key

1	propane cylinder	5	flame arrester
2	valve	6	flow meter
3	pressure reducer	7	six burner array
4	pressure gauge		

Figure 3 — Schematic diagram of propane supply for six burner static test

6.2.2 Six burner dynamic

6.2.2.1 Principle

The test consists of exposing the specimen specified in the performance standards through a flame at (800 ± 50) °C to determine the effect of the exposure.

6.2.2.2 Apparatus

The test rig consists mainly of a propane cylinder with flow control device, flow meter, pressure gauge, flashback arrester, propane Teclu burners which are adjustable in height and specimen support, and rotation motor with speed controller. Figures 4 and 5 show schematic diagrams of the apparatus and the top view of the arrangements of the six burners. The purity of the propane shall be a minimum of 95 %.

6.2.2.3 Procedure

The specimen shall be fitted on the specimen support which may be an RPD head form size medium in accordance with ISO 16900-5. If the specimen is not equipped with a head harness, the material of the specimen shall be clamped in an appropriate clamping device such that the material is horizontal. The distance between the outer surface of the specimen and the burner tips shall be adjusted to 250 mm. Figure 4 shows the adjustment of the burner tips of one example of specimen.

The pressure reducer shall be adjusted to approximately 15 kPa. It shall be ensured that the control device for propane gas on the burners is fully opened and that the control device for air is fully closed. The temperature of the flame 250 mm above the burner tip shall be (800 ± 50) °C.

A mineral insulated thermocouple probe with a diameter of 1,5 mm shall be used to measure flame temperature. The temperature shall be measured at a point 250 mm above the upper tip of any burner in the centre of the flame. All burners shall provide a flame temperature of (800 ± 50) °C. The burners shall be adjusted to their correct position (height) before measuring any flame temperature.

The specimen (on the head form size medium) or the specimen material (in the clamp) shall be rotated once through the flame at a velocity of (6 ± 0,5) cm/s.

Observe whether or not the specimen drips, the duration of any after-flame, or any other damage to the specimen.

Dimensions in millimetres

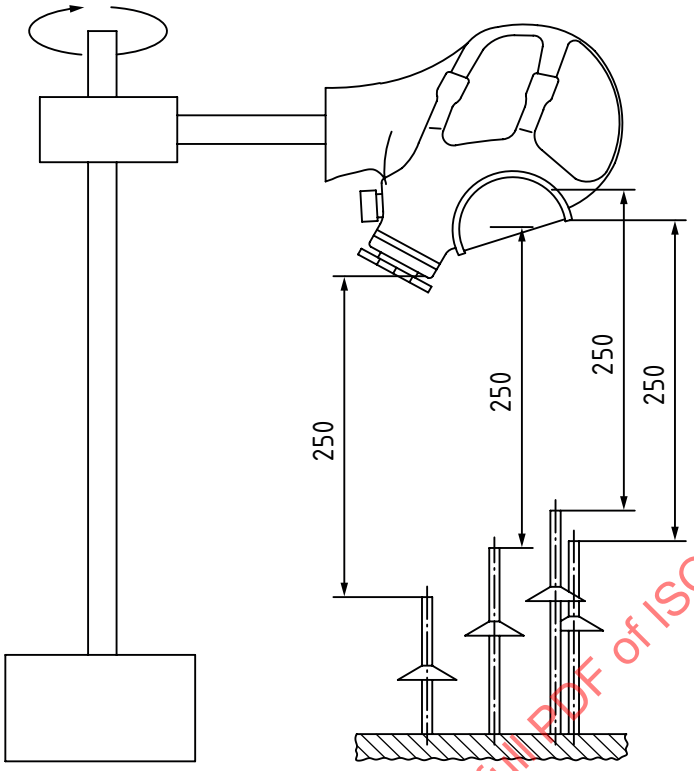
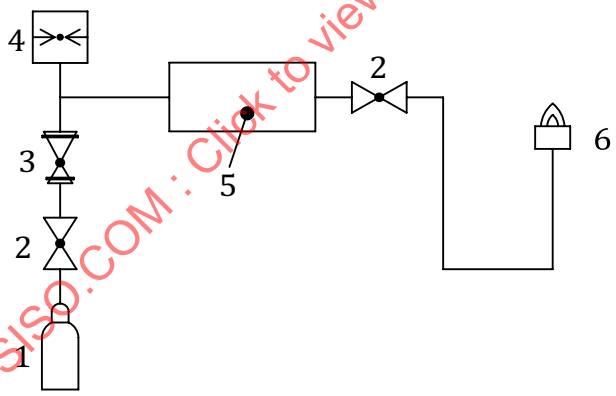


Figure 4 — Schematic diagram of arrangement for six burner dynamic test for RPD



Key

1	propane cylinder	4	pressure gauge
2	valve	5	flame arrester
3	pressure reducer	6	six burner array

Figure 5 — Schematic diagram of propane supply for six burner dynamic test

6.2.2.4 Test report

The test report shall include information regarding those parameters specified in Clause 4 together with information whether or not the specimen drips, the duration of any after-flame, and any other damage to the specimen.

6.2.3 Fabric material flame resistance performance

6.2.3.1 Principle

The test consists of exposing samples of the fabric component(s) of a specimen specified in the performance standards to a flame at 950 °C for the required time exposure of 5 s such that the centre of the flame impinges on the edge of the specimen under test to determine the effect of the exposure.

6.2.3.2 Apparatus

The test apparatus specified in ASTM D6413 shall be used.

6.2.3.3 Procedure

6.2.3.3.1 Test samples

Test samples shall consist of a 75 mm × 305 mm rectangle. In cases where the material is not available in the required dimensions, the original part of the RPD shall be tested.

If the fabric components are not available in the width specified above, the width of the test samples shall be the width as used on the RPD, but shall have a minimum length of 305 mm. The test frame in Figure 6 shall be utilized to hold samples not available in the width specified.

6.2.3.3.2 Test samples preparation

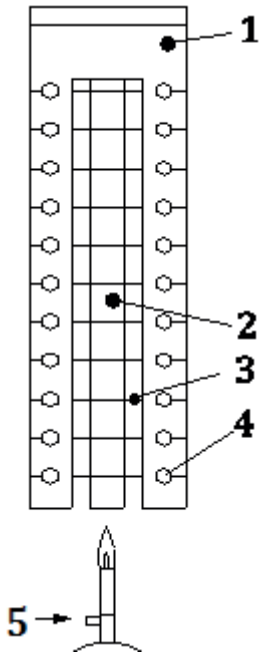
Test samples shall be tested in accordance with ASTM D6413.

Each test sample shall be examined for evidence of melting, dripping, or after-flame to determine pass/fail.

After-flame time and char length shall be recorded for each test sample.

6.2.3.4 Test Report

The test report shall include information regarding those parameters specified in Clause 4 together with information whether or not the specimen melts or drips, the duration of any after-flame, and the char length.



Key

1 clamping plates
2 test samples
3 bare wire, maximum diameter 0,3 mm
4 clamping screw (22 times)
5 gas supply

Figure 6 — Test frame for fabric flame tests

6.2.4 Single burner dynamic

6.2.4.1 Principle

The test consists of passing the specimen specified in the performance standards through a flame at (800 ± 50) °C to determine the effect of the exposure.

6.2.4.2 Apparatus

The test rig consists mainly of a propane cylinder with flow control device, pressure gauge, flash back arrester, specimen support, rotation motor with speed controller, timer, and burner (see Figure 7). The burner shall be in accordance with ISO 6941. The purity of the propane shall be a minimum of 95 %.

6.2.4.3 Procedure

Mount the specimen on the specimen support and adjust the position such that the specimen under test passes directly over the tip of the burner when the support is rotated.

With the specimen is directly over the burner, adjust the height between the tip of the burner and the lowest part of the specimen to (20 ± 2) mm.

Adjust the rotation speed of the motor such that the linear speed of the specimen measured at the burner is (60 ± 5) mm/s.

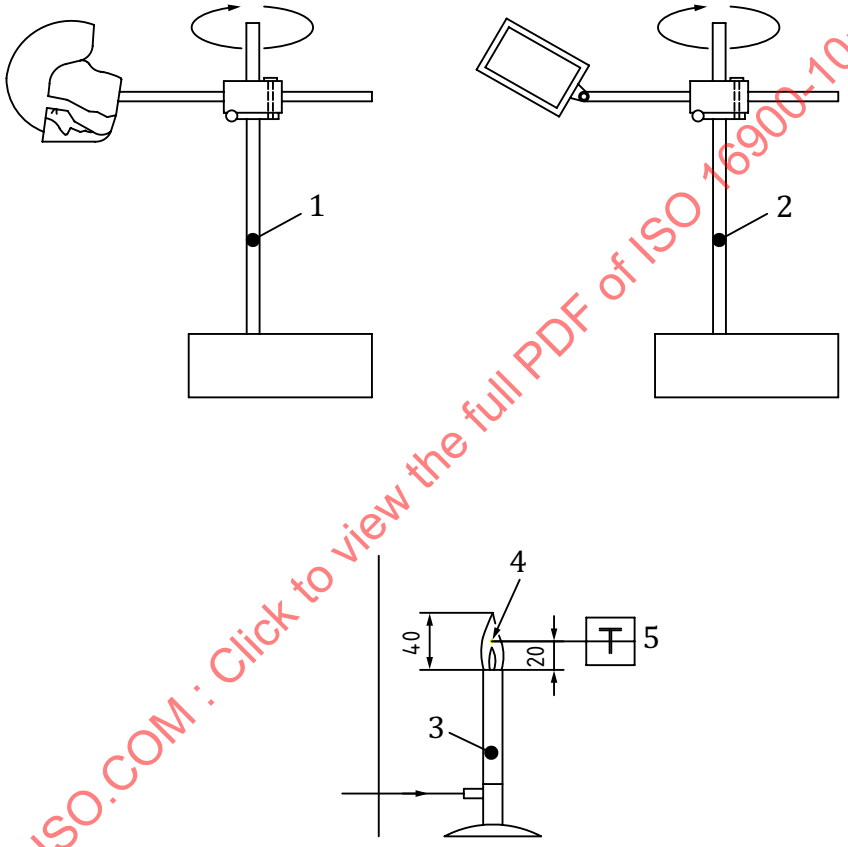
With the specimen removed from above the burner, ignite the burner and adjust the flame height with the propane flow control valve to (40 ± 4) mm. Check that these settings provide the required

flame temperature 800 ± 50 °C at a point (20 ± 2) mm above the burner tip, measured with a mineral insulated thermocouple probe, and with a diameter of 1,5 mm (see Figure 7). In order to achieve the correct flame temperature at the correct flame height, it can be necessary to shield the whole test rig from the effect of external airflows.

Pass the specimen once through the flame. Repeat the test with the specimen mounted in a different orientation or with other specimens so that an assessment can be made of all materials or components as specified by the performance standards. It is important that no part of the specimen passes through the flame more than once.

Observe whether or not the specimen drips, combusts completely, and the duration of any after-flame.

Dimensions in millimetres



Key

1 rotating motor device (respiratory interface)
2 rotating motor device (component)
3 burner
4 thermocouple (with a diameter of 1,5 mm)
5 temperature measuring device

Figure 7 — Typical arrangement of apparatus for single burner dynamic test

6.2.4.4 Test report

The test report shall include information regarding those parameters specified in Clause 4 together with information whether or not the specimen drips, combusts completely, and the duration of any after-flame.

6.2.5 Flame engulfment

6.2.5.1 Principle

The specimen shall be mounted on a manikin (which can be the RPD torso and head form, size medium, in accordance with ISO 16900-5), pre-heated in an oven, followed by the exposure to flame, and finally subjected to a drop.

Details of the related test equipment and the burner are shown in Figures 8 and 9.

The manikin shall have protective coverings during testing. The following have been found to be suitable:

— torso: weld blanket made of fireproof silica cloth of a weight of (650 ± 50) g/m^2 or Aramid;

— head form: un-dyed Aramid hood.

The protective hood, when placed on the test head form, shall not affect the seal of the respiratory interface (RI) to the head form.

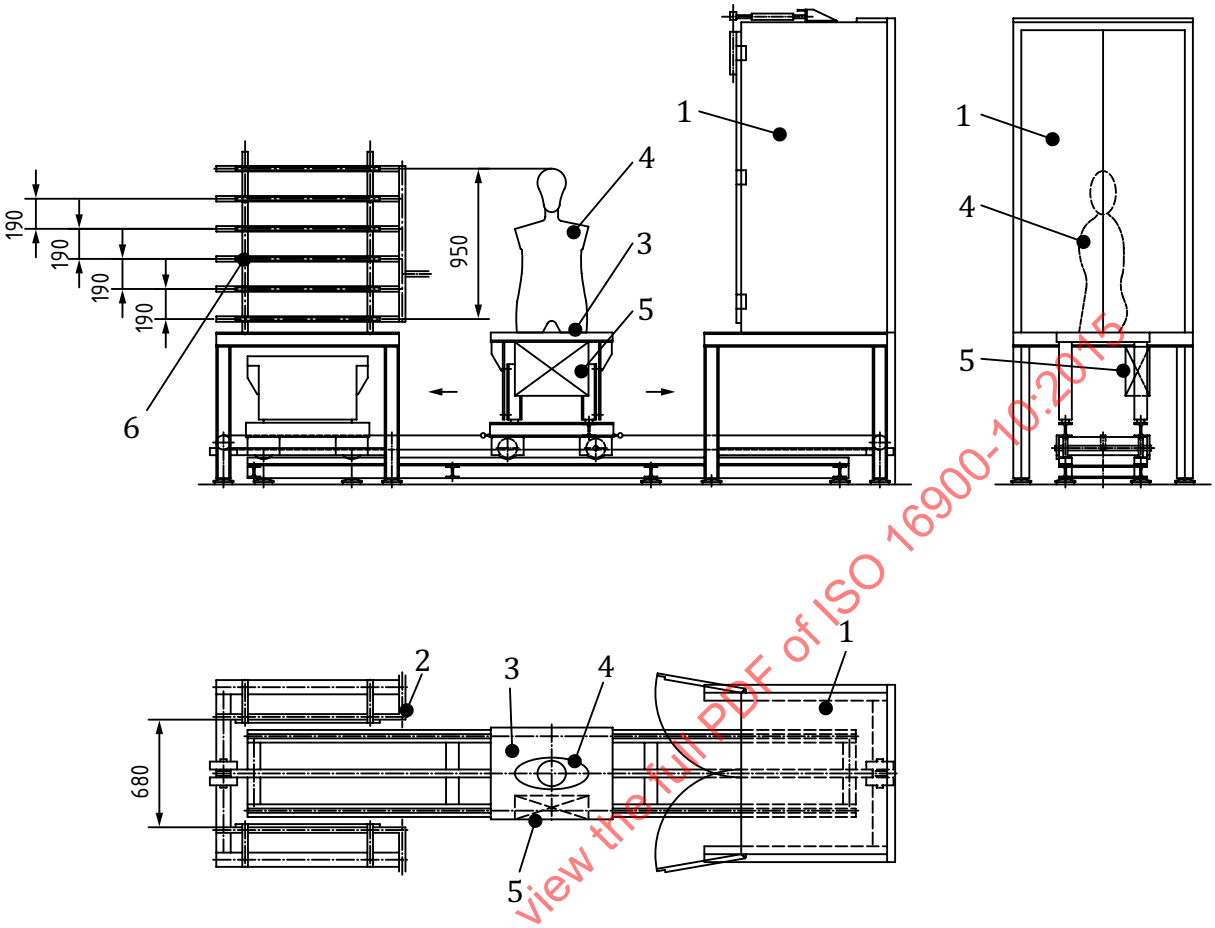
Another hood shall be used to cover the RI retention system that holds the RI to the head form.

During this test, no helmet shall be fitted to the manikin's head, unless the helmet is an integral part of the RI.

6.2.5.2 Apparatus

This subclause sets out some general design principles for the apparatus which are intended to ensure equivalent results from different laboratories.

Dimensions in millimetres



Key

1 pre-heating oven
2 burners
3 transport trolley with drop device
4 manikin (torso and head form)
5 breathing machine
6 burner array

Figure 8 — Typical Flame engulfment test rig

6.2.5.2.1 Pre-heating oven

The pre-heating oven shall be designed to receive the manikin equipped with the RPD and to maintain a homogeneous temperature around it. This can be achieved by circulating air heating. The power shall be sufficient to enable the oven to reheat to the required temperature within one minute after the door has been closed.

The test oven shall have a minimum volume of 1,0 m^3

6.2.5.2.2 Burners

The flame engulfment is achieved by means of a two burner array at the front and the back of the manikin. Each burner array is made by six rows of linear burners spaced 190 mm apart from each other. The length of each burner is 900 mm. The injection(s) of propane and compressed air to the burners shall be such that the temperature of the flames is homogeneous across the burner array.

Dimensions in millimetres

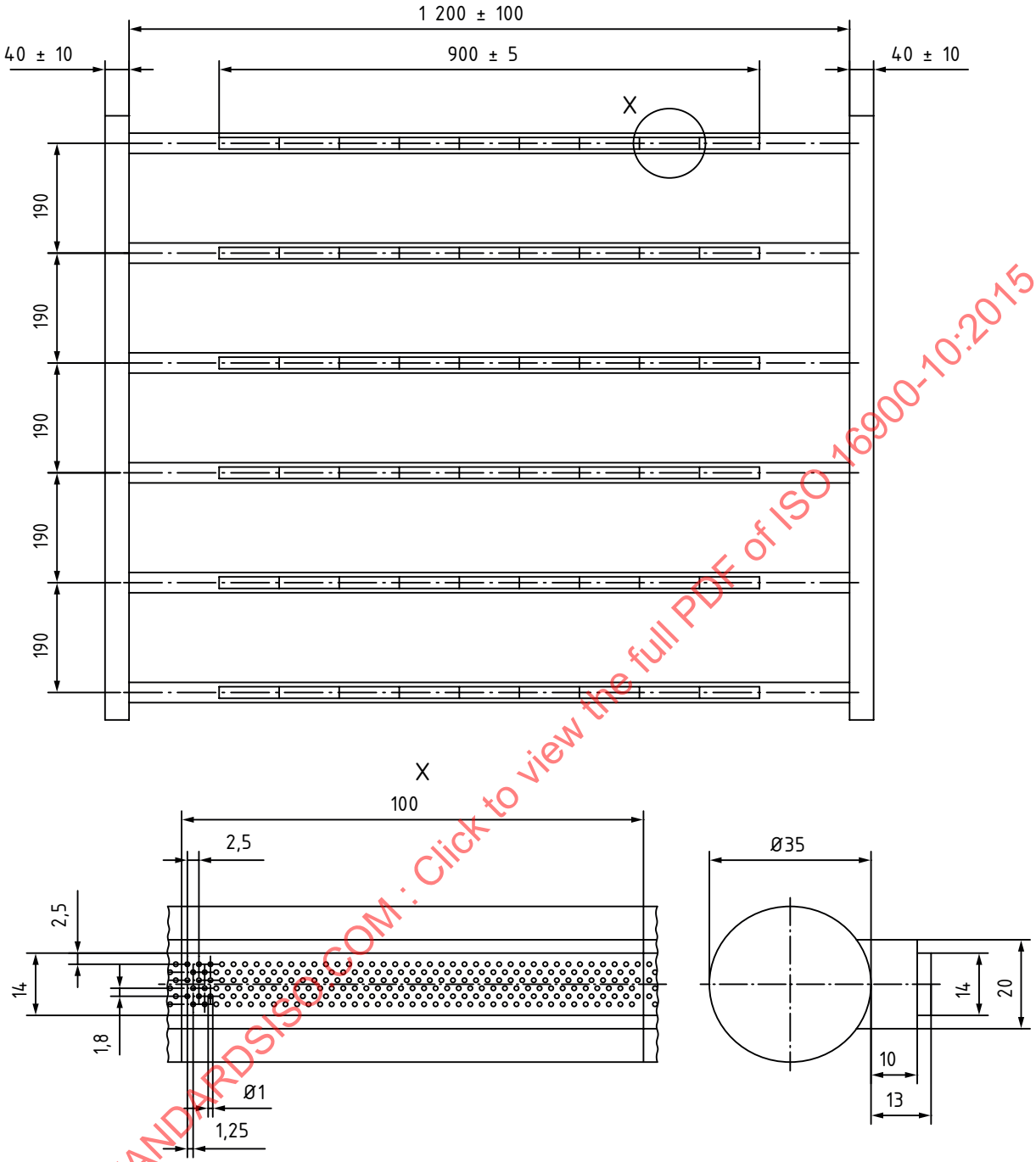


Figure 9 — Details of the burner and burner array for flame engulfment test rig

6.2.5.2.3 Gas mixture

Each burner array is supplied with a gas mixture of at least 95 Vol.-% purity of propane and compressed air.

6.2.5.2.4 Flame conditions

All linear burners shall be ignited and extinguished simultaneously. Time to measure the after-flame starts when there is no more flame contact to the test specimen.

The flame temperature at a distance of 250 mm horizontally from the centre of the burner tip opening shall be (950 ± 50) °C.

6.2.5.2.5 Transport trolley and drop device

The trolley is used

— to move, manually or automatically, the specimen in test into and from the oven to the engulfment part, and

— to drop the specimen in test.

6.2.5.3 Procedure

The RPD shall be mounted on the test manikin to simulate the normal wearing position.

Adjust the burner(s) position(s) so that the minimum distance between the nearest point of the RPD and the burner(s) is 50 mm. This shall be achieved without changing the manikin's position which shall remain in the centre of the original configuration of the burners.

RPD shall be activated and connected to the breathing machine. The breathing machine shall be adjusted to the required breathing rate setting for the pre-heating.

The RPD mounted on the test manikin shall be placed in the oven which has been pre-heated to the required temperature. After the door is closed and the temperature is recovered, the test exposure time shall start. The test oven recovery time shall not exceed 1 min. At the completion of the exposure time, the RPD mounted on the test manikin shall be moved from the oven to the centre of the burner array.

The breathing machine shall be adjusted to the required breathing rate setting for flame exposure and drop test.

The RPD shall be exposed to direct flame contact for (10 $^{+0,25}_{0}$) s. The exposure shall begin (30 ± 5) s after removal of the RPD from the test oven.

Within (20 ± 5) s after completing the flame exposure, the test manikin with the RPD mounted on the manikin shall be raised to (150 $^{+50}_{0}$) mm and dropped freely (without damping) using the same ventilation rate as during the flame exposure. The specimen shall be observed to determine pass/fail as specified.

The breathing resistance during the entire test shall be recorded.

Observe whether or not the specimen drips, combusts completely, the duration of any after-flame, any damage caused by the drop, and any additional hazard to the wearer.

For RPD using compressed breathable gas cylinders, the filling pressure may be reduced such that only sufficient gas for the test is available.

6.2.5.4 Test report

The test report shall include information regarding those parameters specified in Clause 4 together with the following:

— dripping;

— complete combustion;

— duration of any afterflame;

— breathing resistance;

— damage or separation caused by the drop;

— any other damage.

6.3 Radiant heat

6.3.1 Radiant heat level 1 and 2

6.3.1.1 Principle

To determine the effect of the exposure, the RPD is exposed to thermal radiation from a source with calibrated radiation output at a specified radiant heat flux, exposure time, and the required work rate.

6.3.1.2 Apparatus

The specimen, mounted on a manikin (which can be the RPD torso and head form, size medium, in accordance with ISO 16900-5) located on a moveable and height adjustable table, a breathing machine, and a source of thermal radiation. A calorimeter may be used for calibration. A reference calorimeter is described in ISO 6942. Any other suitable calorimeter may be used.

A typical test arrangement is shown in Figure 10.

6.3.1.3 Procedure

The front side of the RPD is tested with two flat radiant heat panels located as shown in Figure 10.

After this test, once the RPD has cooled to ambient temperature, the back side of the RPD is tested with the panels located at the back and the top of the RPD. The radiation shall be homogeneous across the complete area of the RPD to be tested.

A typical source of thermal radiation as shown in Figure 10 provides the relevant thermal energy flux.

The specimen is mounted on a manikin which shall have protective coverings during the test:

— torso: weld blanket made of fireproof silica cloth of a weight of (650 ± 50) g/m^2 or Aramid;

— head form: un-dyed Aramid hood.

The protective hood, when placed on the test head form, shall not affect the seal of the respiratory interface (RI) to the head form.

Another hood shall be used to cover the RI retention system that holds the RI to the head form.

During this test, no helmet shall be fitted to the manikin's head, unless the helmet is an integral part of the RI.

Away from the heat source, the complete RPD shall be mounted on the test manikin to simulate the normal wearing position and connected to the breathing machine. The breathing machine is set to the required setting, but not yet switched on. Using the calorimeter, the source of required thermal radiation shall be adjusted to the required level and shall be demonstrated to be homogeneous across the complete tested area. It can be necessary to adjust the distance between the calorimeter and the heat source to obtain the required thermal radiation.

The calorimeter is removed and, after switching on the breathing machine, the manikin, facing forwards, is positioned such that the most exposed part of the RPD is in the position of the required radiant heat level. The RPD shall be tested for the relevant time.

After this time and after the RPD has cooled down to room temperature, the test shall be repeated with the manikin facing backwards under the same conditions.

Observe after removal of the heat source, whether or not the specimen melted through or burned through. The breathing resistance during the entire test shall be recorded.

