IS 14166 : 1994
(Reaffirmed 2002)

भारतीय मानक

श्वसन संरक्षी युक्तियां — सम्पूर्ण चेहरे के मुखौटे — विशिष्टि

Indian Standard

RESPIRATORY PROTECTIVE DEVICES — FULL-FACE MASKS — SPECIFICATION

UDC 614·894·23

BUREAU OF INDIAN STANDARDS
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Price Group 9

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Industrial Safety Sectional Committee had been approved by the Chemical Division Council.

A full face mask is a facepiece which covers the eyes, nose, mouth and chin and provides adequate sealing on the face of the wearer of a respiratory protective device against the ambient atmosphere, when the skin is dry or moist, when the head is moved and when the wearer is speaking. Air enters the full face mask through the facepiece connector(s) and passes either directly through the nose and mouth area or via the eye (visor) area of the full face mask.

The exhaled air flows back either through the facepiece connector into the breathing apparatus (closed-circuit breathing apparatus, pendulum breathing) or directly to the ambient atmosphere, via the exhalation valve(s) (open-circuit breathing apparatus), or by other appropriate means in other types of respiratory protective devices.

An inner mask may be used to separate the nose and mouth from the eye (visor) area(s) of the full face mask.

A given respiratory protective device is considered to be conforming to this standard when the individual components satisfy the requirements of this standard and practical performance tests have been carried out on complete apparatus, specified in the relevant standard. If for any reason a complete apparatus is not tested then simulation of the apparatus is permitted provided the respiratory characteristics and weight distribution are similar to those of the complete apparatus.

This standard covers to full face masks for respiratory protective devices, except escape apparatus and diving apparatus. It specifies requirements for full face masks for use as part of respiratory protective devices.

This standard has been prepared in line with EN 136 : 1989 'Respiratory protective devices; full-face masks; requirements, testing and marking' published by the Committee for European Norms and is technically equivallent with the same.

The composition of the Committee responsible for formulation of this standard is given at Annex L.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

RESPIRATORY PROTECTIVE DEVICES — FULL-FACE MASKS — SPECIFICATION

1 SCOPE

This standard prescribes requirements for full face masks for respiratory protective devices and their methods of sampling and test, except escape apparatus and diving apparatus.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
4905 : 1968	Methods for random sampling
8347 : 1977	Glossary of terms relating to respiratory protective devices
14138 (Part 1) : 1994	Respiratory protective devices; threads for facepieces: Part 1 Standard thread connection
14138 (Part 2) : 1994	Respiratory protective devices; threads for facepieces: Part 2 Centre thread connection

3 TERMINOLOGY

For the purpose of this standard the definitions given in IS 8347 : 1977 shall apply.

4 REQUIREMENTS

4.1 Materials

4.1.1 Exposed parts that is those which may be subjected to impact during use of the apparatus shall not be made of aluminium, magnesium, titanium or alloys containing such proportions of these metals as will, on impact, give rise to frictional sparks capable of igniting flammable gas mixtures.

4.1.2 Where the speech diaphragm is likely to be exposed to the puncturing action of certain transuranium contaminants of high specific activity a suitable material shall be selected to withstand the same.

4.2 Cleaning and Disinfecting

The materials used shall withstand the cleaning and disinfecting agents as recommended by the manufacturer.

4.3 Speech Diaphragm Assembly

4.3.1 Where the facepiece includes a speech diaphragm the latter shall be protected against mechanical damage as assessed by visual inspection. The speech diaphragm shall withstand a differential pressure of 80 m bar[1] (static pressure) with the positive pressure on the outside (ambient atmosphere).

4.3.2 When a speech diaphragm assembly can be subjected to an external force it shall withstand axially a tensile force of 150 N applied for 10 seconds. The test shall be repeated 10 times at intervals of 10 seconds.

4.4 Replaceable Components

Unless integral with the full face mask the following components (when fitted) shall be replaceable:

Inner mask, head harness, lens/visor, connector(s), inhalation and exhalation valves, check valves, speech diaphragm, lens wiper.

4.5 Practical Performance Test

The complete apparatus shall undergo practical performance tests under realistic conditions. These general tests serve the purpose of checking the equipment for imperfections that cannot be determined by the tests described in this standard. In addition to the tests described in this standard details of practical performance tests for breathing apparatus are given in the relevant Indian Standards. Where a full face mask is to be used for filtering devices testing shall be done in accordance with Annex A.

Where in the opinion of the test station, approval is not granted because practical performance tests show the apparatus has imperfections related to wearer's acceptance the test station shall provide full details of those parts of practical performance tests which revealed these imperfections. This will enable other test stations to duplicate the tests and assess the results thereof.

4.6 Resistance to Temperature

After storing in accordance with Annex B and being allowed to return to room temperature the full face mask shall show no appreciable deformation. After the resistance to temperature test the facepiece shall be tested for inward leakage and shall meet the requirements of **4.7**.

4.7 Inward Leakage Facepiece

A full face mask shall fit against the contours of the face so that when tested in accordance with Annex C the inward leakage of the test

[1] 1 bar = 10^5 N/m^2 = 100 kPa.

contaminant shall not exceed an average value of 0·05 percent of the inhaled air for any of the recommended ten test subjects in any of the test exercises. The measured inward leakage includes the exhalation valve leakage. A recommended procedure for measuring the contribution from leakage through an exhalation valve is given in Annex D. Leakage through exhalation valve shall not exceed 0·01 percent. Materials that may come into contact with the wearer's skin shall not be known to be likely to cause irritation or any adverse effect to health and the manufacturer of the face masks shall provide a certificate to this effect along with the consignment.

4.8 Compatibility with Skin

Materials that may come into contact with the wearer's skin shall not be known to be likely to cause irritation or any adverse effect to health, and the manufacturer of the facepiece shall give a declaration to this effect along with each consignment.

4.9 Flammability

4.9.1 When tested in accordance with Annex E the full face mask shall prove to be 'self-extinguishing', that is the material must not be of highly flammable in nature and when tested in accordance with Annex E the facepiece must not continue to burn after removal from the flame.

4.9.2 When tested in accordance with Annex C both before and after the flammability test in accordance with Annex E the leakage shall not exceed that indicated by a change of pressure of 1 m bar in 1 min.

4.10 Carbon Dioxide Content of the Inhalation Air

When tested in accordance with Annex F the carbon dioxide content of the inhaled air (dead space) shall not exceed an average of 1·0 percent (by volume).

4.11 Head Harness

4.11.1 The head harness shall be designed so that the full face mask can be donned and removed easily, when tested in accordance with Annex A.

4.11.2 The head harness shall be adjustable and shall hold the full face mask firmly and comfortably in position, when tested in accordance with Annex A.

4.11.3 Each strap of the head harness shall withstand a pull of 150 N applied for 10 seconds in the direction of pulling when the full face mask is donned.

4.11.4 Each strap shall extend to not more than 100 percent at a pull of 52 N. There shall be no permanent linear deformation of more than 5 percent when tested at a pull of 50 N for 10 seconds.

4.12 Facepiece Connector

The connections between the facepiece and the apparatus may be achieved by a permanent or special type of connection or by a standard thread connection. If a standard thread connection is used, for example, for a single filter mask then it shall conform to the requirements prescribed in IS 14138 (Part 1) : 1994. A facepiece shall not have more than one standard thread connection.

If any other screw thread is used it shall not be possible to connect it to the standard thread.

4.12.1 *Standard Thread Connection*

The standard thread connection in accordance with IS 14138 (Part 1) : 1994 may be used as the full face mask connection for respiratory protective devices, except closed-circuit breathing apparatus and positive pressure demand breathing apparatus.

4.12.2 *Centre Thread Connection*

The centre thread connection in accordance with IS 14138 (Part 2) : 1994 may be used as the full face mask connection for closed circuit breathing apparatus.

4.12.3 The connection between the faceblank and the connector shall be sufficiently robust to withstand axially a tensile force of 500 N when tested in accordance with Annex G.

4.12.4 All demountable connections shall be readily connected and secured, where possible, by hand. Any means of sealing used shall be retained in position when the connection is disconnected during normal maintenance.

4.12.5 Correct and reliable connection between facepiece and other parts of the equipment shall be assured.

4.13 Eyepiece(s) and Visor(s)

4.13.1 Visors and anti-mist discs designed to serve as visors shall be attached in a reliable and gastight manner to the face blank.

4.13.2 Visors shall not distort vision as determined in practical performance tests, when tested in accordance with Annex A.

4.13.3 The field of vision shall be tested in accordance with Annex H and shall meet the requirements prescribed in **4.13.3.1** and **4.13.3.2**.

4.13.3.1 A full face mask equipped with a single visor shall be designed so that the effective field of vision shall be not less than 70 percent, related to the natural field of vision, and the overlapped field of vision related to the natural overlapped field of vision shall be not less than 80 percent.

4.13.3.2 A full face mask with two eyepieces shall be designed so that the effective field of vision shall be not less than 70 percent, and the overlapped field of vision shall be not less than 20 percent.

4.13.4 The manufacturer shall provide means to reduce misting of the eyepiece(s) or visor(s) so that vision is not interfered with when the apparatus is tested for the practical performance tests in accordance with Annex A. Where anti-fogging compounds are used as intended or specified by the manufacturer, they shall be compatible with the eyes, skin and the components of the facepiece.

4.13.5 The impact resistance of the eyepiece(s) or visor shall be tested in accordance with Annex J. At the end of the test the facepiece shall not be damaged in any way that may make it ineffective or cause injury to the wearer. The effectiveness shall be tested in accordance with Annex J by comparing the tightness of the full face mask before and after the test. When tested for leak tightness, the facepiece shall not indicate increased leakage after the test for impact resistance of the eyepiece or visor.

4.14 Inhalation and Exhalation Valves

Valve assemblies shall be such that they can be readily maintained and correctly replaced.

It shall not be possible to fit an exhalation valve assembly into the inspiratory circuit or an inhalation valve assembly into the exhalation circuit.

4.14.1 *Inhalation Valve(s)*

4.14.1.1 A full face mask except one with a centre thread connection should preferably be provided with one or more inhalation valve(s). If a standard thread connection is used, an inhalation valve shall be incorporated in the full face mask. If a full face mask has to be used with filters, it shall be provided with an integral inhalation valve, if there is no valve in the filter.

4.14.1.2 Inhalation valve(s) shall function correctly in all orientations.

4.14.2 *Exhalation Valve(s)*

4.14.2.1 Exhalation valve(s) shall function correctly in all orientations.

4.14.2.2 A full face mask fitted with a standard thread connection shall be designed in such a way so that, it shall have at least one exhalation valve or other appropriate means to allow the escape of exhaled air and, where applicable, any excess air delivered by the air supply.

4.14.2.3 Exhalation valve(s) shall be protected against dirt and mechanical damage and shall be shrouded or shall include any other device that may be necessary to comply with **4.7**.

4.14.2.4 The exhalation valve(s) shall continue to operate correctly after (a) a continuous exhalation flow of 300 l/min and (b) a negative pressure (static) in the mask of 80 mbar (30 s for each test).

4.14.3 When the exhalation valve housing is attached to the face blank it shall withstand axially a tensile force of 150 N applied for 10 seconds. The test is repeated 10 times in intervals of 10 seconds.

4.15 Breathing Resistance

When tested in accordance with Annex K, the breathing resistance of a full face mask (except for positive pressure breathing apparatus) shall meet the requirements of **4.15.1** or **4.15.2**.

4.15.1 Facepieces with connection other than that in **4.15.2** shall not exceed 2·5 mbar for inhalation and 3·0 mbar for exhalation when tested with a breathing machine (25 × 2 l/min) or a continuous flow of 160 l/min.

The inhalation resistance shall not exceed 0·5 mbar at 30 l/min continuous flow and 1·5 mbar at 95 l/min continuous flow.

4.15.2 Facepieces with centre thread connections and without valve(s) shall not exceed 0·6 mbar for inhalation or exhalation.

5 PACKING AND MARKING

5.1 All units of the same model shall be provided with a type identifying marking. Sub-assemblies and components with considerable bearing on safety shall be marked so that they can be identified. The manufacturer shall be identified by name, trade mark or other means of identification.

Where the reliable performance of components may be affected by ageing, means of identifying the date (at least the year) of manufacture shall be marked.

For parts, which cannot be marked with the relevant information shall be included in the instructions for use.

All face masks shall be marked with the date of manufacture.

The marking shall be as clearly visible and as durable as possible.

5.2 Instructions for Use

5.2.1 On delivery instructions for use shall accompany every full face mask.

5.2.2 Instructions for use shall be in a language to the country of application.

5.2.3 The instructions for use for the equipment shall contain all information necessary for trained and qualified persons on:

a) application/limitation;

b) checks prior to use;

c) donning, fitting;

d) use;

e) maintenance (preferably separately printed instructions); and

f) storage.

5.2.4 The instructions shall be unambiguous. If helpful, illustrations, part numbers, marking, etc, shall be added.

5.2.5 Warning shall be given against problems likely to be encountered, for example:

a) fit of facepiece (check prior to use);

b) it is unlikely that the requirements for leakage will be achieved if facial hair or spectacle side arms pass under the face seal;

c) hazards of oxygen and oxygen-enriched air;

d) air quality; and

e) use of equipment in explosive atmosphere.

5.3 BIS Certification Marking

The product may also be marked with the Standard Mark.

5.3.1 The use of the Standard Mark is governed by the provision of Bureau of Indian Standard Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

6 SAMPLING AND CRITERIA FOR CONFORMITY

6.1 Lot

In a single consignment, all the full face masks assembled under uniform conditions of manufacture on the same day, shall constitute a lot.

6.1.1 Each lot shall be tested separately for ascertaining the conformity of the lot to the requirements of the specification. The number of face masks to be selected from the lot shall depend upon the size of the lot and shall be in accordance with Table 1.

6.1.2 The face masks shall be selected at random from the lot. For this purpose, reference may be made to IS 4905 : 1968.

Table 1 Number of Samples to be Tested from a Lot

(*Clause* 6.1.1)

No. of Face Masks in the Lot	No. of Face Masks to be Selected in a Sample
(1)	(2)
Up to 50	8
51 to 150	13
151 and above	20

6.2 Number of Tests

6.2.1 Each of the face masks selected from the lot according to col 2 of Table 1 shall be examined for visual inspection (**4.3**, **4.4**, **4.12**, **4.13.1** and **4.14**) and field of vision (**4.13.3**).

6.2.1.1 The lot shall be considered to have satisfied the above requirements if none of the masks in the sample fails. Otherwise, the lot shall be rejected.

6.2.2 The sample having been found satisfactory as per **6.2.1** shall be further tested for the requirements of carbon dioxide content (**4.10**), breathing resistance (**4.15**), practical performance test (**4.5**), impact resistance and distortion (**4.13.5**) and cleaning and disinfection (**4.2**), in this sequence.

6.2.2.1 The lot shall be considered to have satisfied the above requirements if there is no failure in the sample. Otherwise, the lot shall be rejected.

6.2.3 Approximately half the number of face masks, out of the sample already been found satisfactory as per **6.2.2**, shall be conditioned as per **4.6**/Annex B and shall be tested for inward leakage of face piece (**4.7**), flammability (**4.9**), and exhalation valves (**4.14.2**).

6.2.3.1 The other half of the sample shall be tested for the requirements of speech diaphragm (**4.3.1** and **4.3.2**), inward leakage of face piece (**4.7**), flammability (**4.9**), head harness tests (**4.11.3** and **4.11.4**), face piece connector (**4.12.3**), exhalation valves (**4.14.2**), performance tests (**4.14.2.4**) and exhalation valves housing (**4.14.3**).

6.2.3.2 The lot shall be considered as conforming to the requirements of this specification if all the face masks pass the requirements specified in **6.2.3**. Otherwise the lot shall be rejected.

ANNEX A

(*Clauses* 4.5, 4.11.1, 4.11.2, 4.13.2 *and* 4.13.4)

METHOD OF TEST FOR PERFORMANCE TESTS FOR FULL FACE MASKS

A-1 PRACTICAL PERFORMANCE TESTS

A-1.1 All tests shall be carried out by two test subjects at ambient temperature and the test temperature and humidity shall be recorded.

For the test, persons shall be selected who are familiar with using such or similar equipment.

During the tests the apparatus shall be subjectively assessed by the wearer and after the test, comments on the following shall be recorded:

a) Harness comfort;
b) Security of fastenings and couplings;
c) Accessibility of controls (if fitted);
d) Clarity of vision on the visor of the facepiece;
e) Speech transmission; and
f) Any other comments reported by the wearer on request.

The subjects wearing normal working clothes and wearing the apparatus fitted with a filter simulator (Fig. 3) shall walk at a regular rate of 6 km/h on a level course. The test shall be continuous, without removal of the apparatus, for a period of 10 min.

A-2 WORK SIMULATION TEST

A-2.1 The apparatus fitted with a filter simulator (Fig. 3) shall be tested under conditions which can be expected during normal use. During this test the following activities shall be carried out in simulation of the practical use of the apparatus. The test shall be completed within a total working time of 20 min.

The sequence of activities is at the discretion of the test station. The individual activities shall be arranged so that sufficient time is left for the comments prescribed:

a) Walking on the level with headroom of 1·1 m to 1·5 m for 5 min.
b) Crawling on the level with headroom of less than 0·75 m for 5 min.
c) Filling a small basket (*see* Fig. 1, approximate volume 8 l) with rubber chippings or other suitable material from a hopper which stands 1·5 m high and has an opening at the bottom to allow the contents to be shovelled out and a further opening at the top where the basket full of rubber chippings shall be returned.

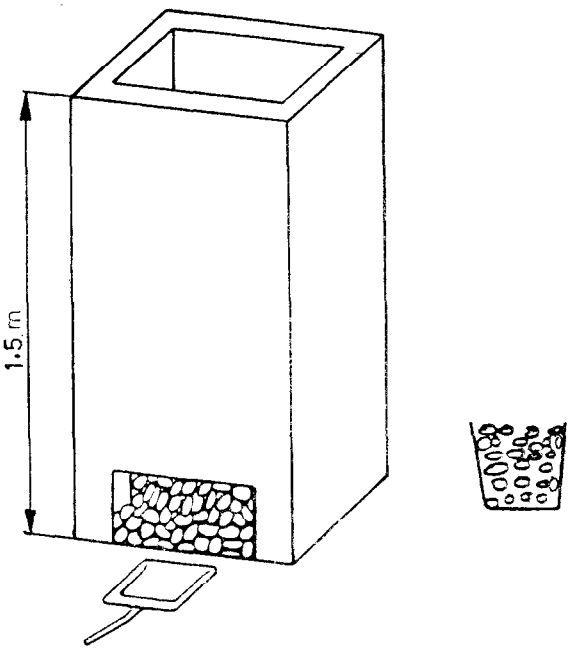


FIG. 1 BASKET AND HOPPER RUBBER CHIPPINGS

The subject shall stoop or kneel as he wishes and fill the basket with rubber chippings. He shall then lift the basket and empty the contents back into the hopper. This shall be repeated 15 to 20 times in 10 min.

ANNEX B

(*Clauses* 4.6 *and* 6.2.3)

METHOD OF TEST FOR RESISTANCE TO TEMPERATURE

B-1 PROCEDURE

Two full face masks shall be exposed during successive tests:

a) For 72 hours to a dry atmosphere of 70 ± 3°C;
b) For 12 hours to an atmosphere of 70 ± 3°C at 95 to 100 percent relative humidily; and
c) For 24 hours to a temperature of − 30 ± 3°C.

B-2 RESULTS

The full face masks after storing at the conditions mentioned above and subsequently allowing them to come under normal atmosphere, shall be checked for every deformation and be recorded in that sequence.

ANNEX C

(*Clauses* 4.7 *and* 4.9.2)

METHOD OF TEST FOR INWARD LEAKAGE OF FACEPIECE

C-1 GENERAL

C-1.1 The laboratory tests shall indicate that the facepiece can be used by the wearer to protect with high probability against the potential hazard to be expected.

C-1.2 The sodium chloride and sulphur hexafluoride methods are equally acceptable options.

C-1.3 Half of the number of samples selected for carrying out the test shall be tested for resistance to temperature in accordance with Annex B. All the samples selected in accordance with col 2 of Table 1 shall be tested for inward leakage.

C-1.4 Prior to the test, there shall be an examination that facepiece is in good working condition and that it can be used without hazard.

For the test, persons shall be selected who are familiar with using such or similar equipment.

C-1.4.1 A panel of ten clean shaven persons (without beard or sideburns) shall be selected covering the spectrum of facial characteristics of typical users (excluding significant abnormalities). It is expected that exceptionally some persons cannot be satisfactorily fitted with a full face mask because of the contour of their face. Such exceptional subjects shall not be used for testing facepieces.

In the test report the faces of the ten test persons shall be described (for information only) by the four facial dimensions (in mm) illustrated in Fig. 2.

C-1.4.2 If more than one size of facepiece is manufactured the test subjects shall be supplied with the appropriate size.

C-2 TEST EQUIPMENT

C-2.1 Test Atmosphere

The test atmosphere shall preferably enter the top of the hood/chamber through a flow distributor and be directed downwards over the head of the test subject at a minimum flow rate of 0·12 m/s. The concentration of the test agent inside the effective working volume shall be checked to be homogeneous. The flow rate should be measured close to the subject's head. The design of the hood/chamber shall be such that the test subject wearing the facepiece under test can be supplied with breathable air (free of test atmosphere).

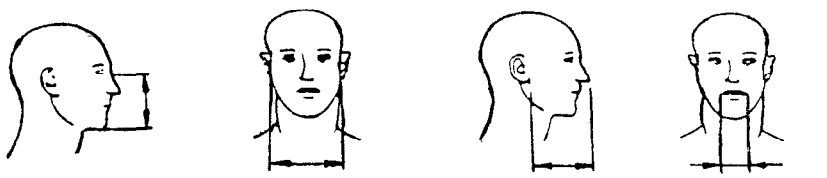
C-2.2 Treadmill

A level treadmill capable of working at 6 km/h shall be used.

C-2.3 Filter Simulator

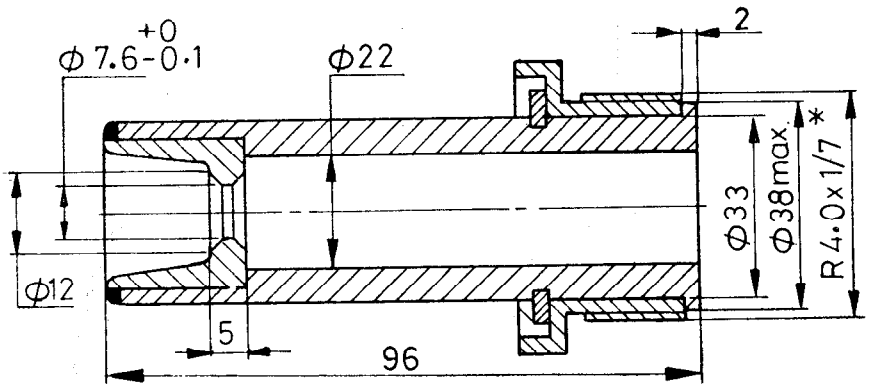
If the facepiece is to be used with a filter having a standard thread, a device is required to simulate the maximum weight and resistance of filters permitted for that type of facepiece (*see* Fig. 3). This simulator shall be connected to a clean air supply by an ultra-lightweight flexible hose. If the facepiece uses a special connection the clean air supply shall be attached to the filter or equipment normally used with the facepiece. It is important that the attachment of the clean air hose to facepiece does not affect the fit of the facepiece and if necessary the hose shall be supported.

The filter simulator shall not weigh more than 500 g and the weight shall be equally distributed along the length. Pressure drop shall be 10 mbar at 95 l/min.



length of face (nasion-menton) | width of face (bizygomatic diameter) | depth of face | width of mouth

FIG. 2 FACIAL DIMENSIONS



*See IS 14138 (Part 1) : 1994.

FIG. 3 FILTER SIMULATOR FOR STANDARD THREAD FILTERS/FACE PIECES

C-3 TEST PROCEDURE

C-3.1 The test subjects shall be asked to read the manufacturers fitting instructions and if necessary shown by the test supervisor how to fit the facepiece correctly, in accordance with the fitting instructions.

C-3.2 The test subjects shall be informed that if they wish to adjust the facepiece during the test they may do so. However, if this is done, the relevant section of the test shall be repeated having allowed the system to re-settle.

C-3.3 The test subjects shall have no indication of the results as the test proceeds.

C-3.4 After fitting the facepiece each test subject shall be asked; 'Does the mask fit ?'. If the answer is 'Yes', continue the test. If the answer is 'NO', take the test subject off the panel and report the fact.

C-3.5 The test sequence shall be as follows.

C-3.5.1 Ensure the test atmosphere is OFF.

C-3.5.2 Place the test subject in the hood/chamber. Connect up the facepiece sampling probe. Have the test subject walk at 6 km/h for 2 min. Measure the test agent concentration inside the facepiece to establish the background level.

C-3.5.3 Obtain a stable reading.

C-3.5.4 Turn test atmosphere ON.

C-3.5.5 The subject shall continue to walk for a further 2 min or until the test atmosphere has stabilized.

C-3.5.6 While still walking the subject shall perform the following exercises:

a) Walking without head movement or talking for 2 min;

b) Turning head from side to side (approximately 15 times), as if inspecting the walls of a tunnel for 2 min;

c) Moving head up and down (approximately 15 times), as if inspecting the roof and floor for 2 min;

d) Reciting the alphabet or an agreed text out loud as if communicating with a colleague for 2 min; and

e) Walking without head movement or talking for 2 min.

C-3.5.7 Turn off the test atmosphere and when the test agent has cleared from the chamber remove the subject.

C-3.5.8 After each test the full face mask shall be cleaned, disinfected and dried before being used for its second inward leakage test.

C-4 RESULTS

C-4.1 Observation against the following perameters shall be recorded as test results:

a) Chamber concentration, and

b) The leakage over each exercise period.

C-5 SULPHUR HEXAFLUORIDE (SF_6) METHOD

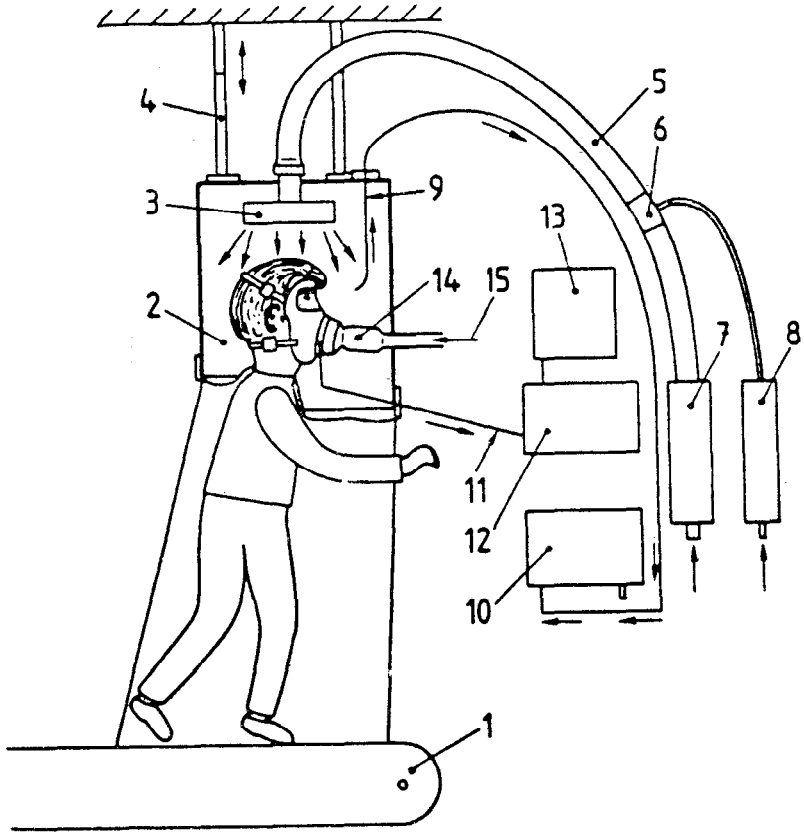
C-5.1 Principle

The subject wearing the apparatus under test shall walk on a treadmill over which is a hood/chamber. Through this hood/chamber flows a constant concentration of SF_6.

The air inside the facepiece is sampled and analysed. The sample is extracted by punching a hole in the faceblank and inserting a probe through which the sample is drawn.

C-5.2 Test Equipment

The schematic diagram along with the details of the equipment is given in Fig. 4.



1 Treadmill
2 Test hood/chamber
3 Flow distributor
4 Suspension
5 Test agent supply hose
6 Mixing point air/SF_6
7 Flow meter for air with superposed control device
8 Flow meter for SF_6 (100% by volume) with superposed control valve
9 Test atmosphere sampling probe
10 Measuring instrument for test agent
11 Sampling tube for the inhaled gas concentration
12 Measuring instrument for inhaled gas concentration
13 Recorder
14 Filter simulator
15 Breathable air

FIG. 4 SCHEME OF THE SF_6-TEST RIG FOR INWARD LEAKAGE

C-5.2.1 *Test Agent*

This method employs SF_6 as a test gas. The subject wearing the facepiece under test standards with his head surrounded by the SF_6 test atmosphere. Accurate determinations of leakage shall be possible within the range from 0·01 percent to approximately 20 percent dependant on the test challenge atmosphere. It is recommended to use a test atmosphere between 0·1 percent and 1 percent by volume.

C-5.2.2 *Detection*

The test atmosphere shall be analysed for SF_6 preferably continuously by means of a suitable analyser (for example, based on thermal conductivity or infrared spectroscopy).

The test atmosphere sampling probe shall not be positioned next to the exhalation valve. The SF_6 concentration inside the mask shall be analysed and recorded by an electron capture detector (ECD) or IR-system. This concentration, measured as near as possible to the mouth of the test subject (approximately 5 mm, in the centre of the facepiece), is a measure of the inward leakage.

The test shall be performed at ambient temperature and humidity.

C-5.2.3 *Sampling*

In order to prepare the full face mask for the test, the faceblank or visor and the inner mask (if available) have to be perforated. A thin

tube, as short as possible, leading into the inner masks shall be connected in a leak-light manner to the analysing instrument. The sampling rate should be constant and in the range between 0·3 and 1·5 l/min.

C-5.2.4 *Calculation of the Leakage*

The leakage P shall be calculated from measurements made over the last 100 s of each of the exercise periods to avoid carry over of results from the exercise to the other.

$$P\,(\%) = \frac{C_2}{C_1} \times 100$$

where

C_1 = challenge concentration, and

C_2 = measured mean concentration.

Measurement of C_2 is preferably made using an integrating recorder.

C-6 SODIUM CHLORIDE (NaCl) METHOD

C-6.1 Principle

C-6.1.1 The subject wearing the apparatus under take walks on a treadmill over which is an enclosure. Through this enclosure flows a constant concentration of NaCl aerosol. The air inside the facepiece is sampled and analysed during the inhalation phase of the respiratory cycle to determine the NaCl content. The sample is extracted by punching a hole in the faceblank and inserting a probe through which the sample is drawn. The pressure variation inside the facepiece is used to actuate a change-over valve so that inhaled air only is sampled. A second probe is inserted into the inner mask for this purpose.

C-6.2 Test Apparatus

C-6.2.1 *Aerosol Generator*

The NaCl aerosol shall be generated from a 2 percent solution of reagent grade NaCl in distilled water. A single large Collison atomiser of the type described shall be used (*see* Fig. 5). This required in air flow rate of 100 l/min at a pressure of 7 bar. The atomiser and its housing shall be fitted into a duct through which a constant flow of air is maintained. It may be necessary to heat or dehumidify the air in order to obtain complete drying of the aerosol particles.

C-6.2.2 *Test Agent*

The mean NaCl concentration within the enclosure shall be 5 $\pm$ 4 mg/m^3 and the variation throughout the effective working volume shall be not more than 10 percent. The particle size distribution shall be 0·02 μm to 2 μm equivalent aerodynamic diameter with a mass median diameter of 0·6 μm.

C-6.2.3 *Flame Photometer*

A flame photometer shall be used to measure the concentration of NaCl inside the facepiece. Essential performance characteristics for a suitable instrument are:

a) It should be a flame photometer specifically designed for the direct analysis of NaCl aerosol.

b) It should be capable of measuring concentrations of NaCl aerosol between 15 mg/m^3 and 0·5 mg/m^3.

c) The total aerosol sample required by the photometer should not be greater than 15 l/min.

d) The response time of the photometer, excluding the sampling system, should not be greater than 500 ms.

e) It is necessary to reduce the response to other elements, particularly carbon, the concentration of which will vary during the breathing cycle. This will be achieved by ensuring that the band pass width of the interference filter is not greater than 3 nm and all necessary side-band filters are included.

C-6.2.4 *Sample Selector*

A system is required which will switch the sample to the photometer only during the inhalation phase of the respiratory cycle. During the exhalation phase clean air shall be fed to the photometer. The essential elements of such a system are:

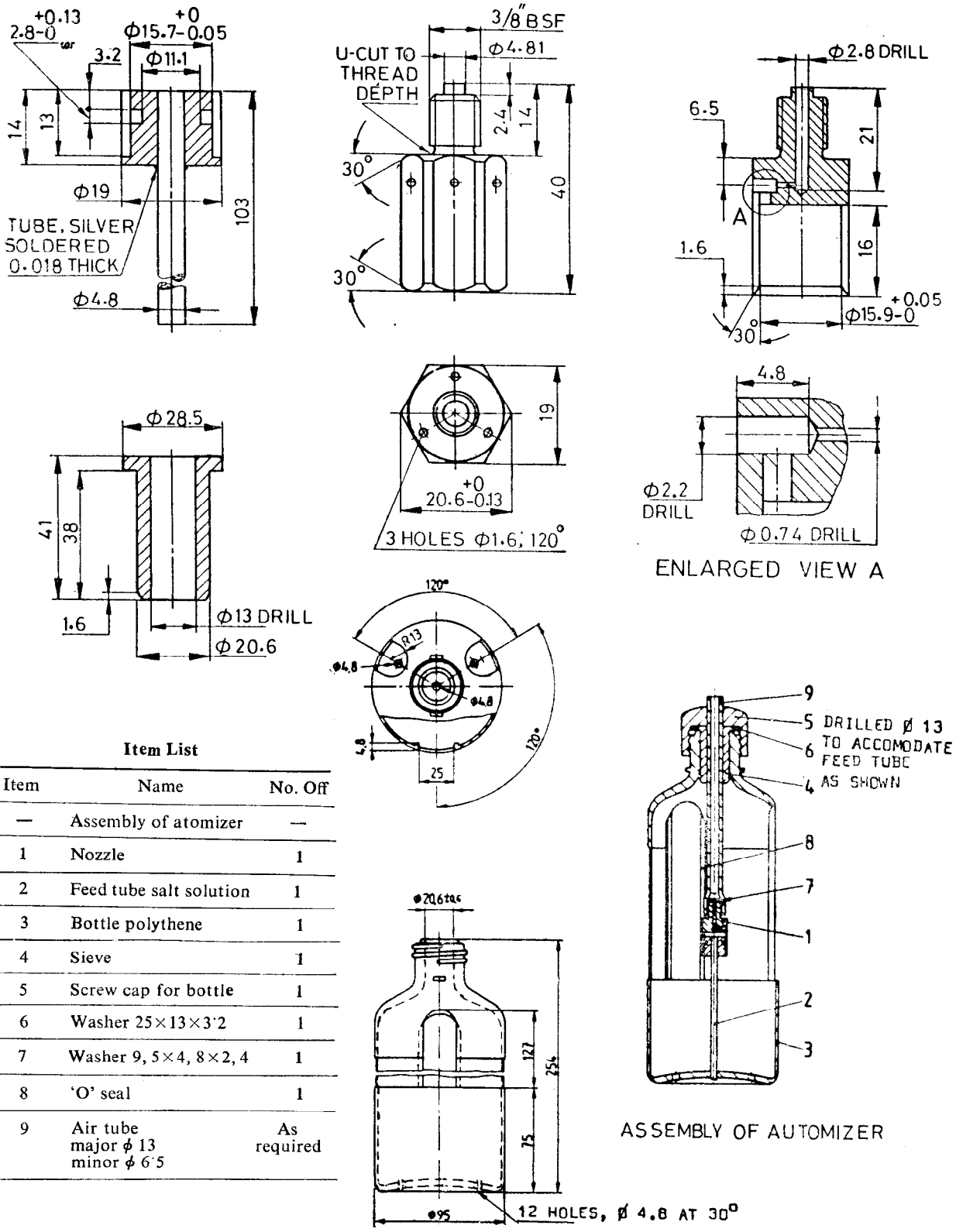
a) An electrically operated valve with a response time of the order of 100 ms. The valve should have the minimum possible dead space compatible with straight-through, unrestricted flow when open;

b) A pressure sensor which is capable of detecting a minimum pressure change of approx 0·05 mbar and which can be connected to a probe inserted in the facepiece cavity. The sensor shall have an adjustable threshold and be capable of differential signalling when the threshold is crossed in either direction. The sensor shall work reliably when subjected to the accelerations produced by the head movements of the subject;

c) An interfacing system to actuate the valve in response to a signal from the pressure sensor; and

d) A timing device to record the proportion of the total respiratory cycle during which sampling took place.

Figure 6 shows a schematic diagram of such a sampling system.



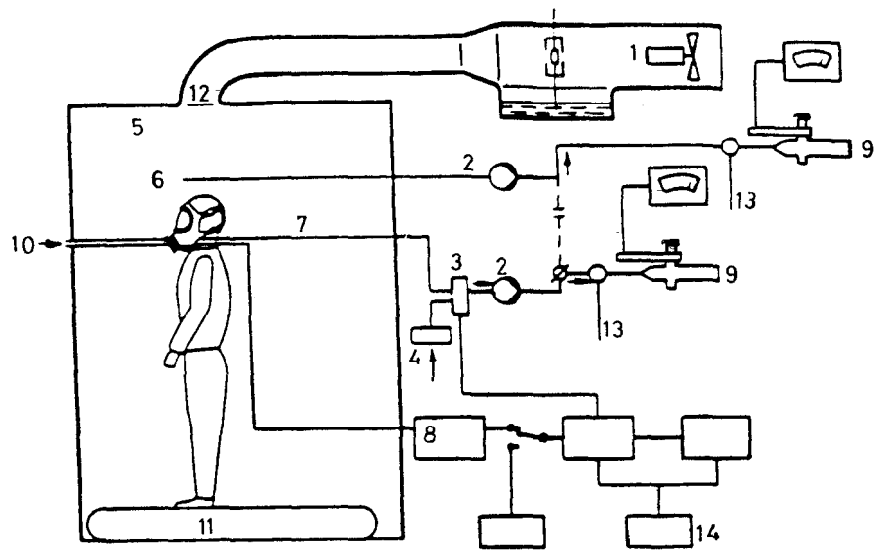
Item List

Item	Name	No. Off
—	Assembly of atomizer	—
1	Nozzle	1
2	Feed tube salt solution	1
3	Bottle polythene	1
4	Sieve	1
5	Screw cap for bottle	1
6	Washer 25×13×3·2	1
7	Washer 9, 5×4, 8×2, 4	1
8	'O' seal	1
9	Air tube major ϕ 13 minor ϕ 6·5	As required

NOTE — All burrs and sharp edges to be removed.
Material : Stainless Steel

All dimensions in millimetres.

FIG. 5 ASSEMBLY OF ATOMIZER



1 Atomiser
2 Pump
3 Change-over Valve
4 Filter
5 Hood/Chamber
6 Hood/Chamber Sample
7 Facepiece Sample
8 Manometer
9 Photometer
10 Reference Simulator Fresh Air
11 Treadmill
12 Ducting and Baffle
13 Additional Air
14 Pulsed Sampling Interface

FIG. 6 APPARATUS USED IN THE DETERMINATION OF INWARD LEAKAGE USING SODIUM CHLORIDE

C-6.2.5 *Sampling Probe*

The probe consists of a length of 1 mm bore hypodermic tube fitted securely in an airtight manner to the facepiece as near as possible to the centre line of the full face mask and extending through the inner mask if fitted. A plastic ball of approximately 20 mm diameter with 8 holes each of 1·5 mm diameter and spaced equidistant around the circumference of the ball is fitted into the hypodermic tube. The probe is adjusted so that the ball just touches the wearer's lips.

C-6.2.6 *Sample Pump*

If no pump is incorporated into the photometer an adjustable flow pump is used to withdraw an air sample from the facepiece under test. This pump is so adjusted as to withdraw a constant flow of 1 l/min from the sample probe. Depending on the type of photometer it may be necessary to dilute the sample with clean air.

C-6.2.7 *Sampling of Hood/Chamber Concentration*

The hood/chamber aerosol concentration is monitored during the tests using a separate sampling system, to avoid contamination of the facepiece sampling lines. It is preferable to use a separate flame photometer for this purpose.

If a second photometer is not available, sampling of the hood/chamber concentration using the separate sampling system and the same photometer may be made. However, time will then be required to allow the photometer to return to a clean background.

C-6.2.8 *Pressure Detection Probe*

A second probe is fitted near to the sampling probe extending into the inner mask and is connected to the pressure sensor.

C-6.3 Calculation of Leakage

The leakage P shall be calculated from measurements made over the last 100 s of each of the exercise periods to avoid carry over of results from one exercise to the other.

$$P\,(\%) = \frac{C_2}{C_1} \times \frac{t_{IN} + t_{EX}}{t_{IN}} \times 100$$

where

C_1 = challenge concentration,
C_2 = measured mean concentration,
t_{IN} = total duration of inhalation, and
t_{EX} = total duration of exhalation.

Measurement of C_2 is preferably made using an integrating recorder.

ANNEX D

(*Clause* 4.7)

RECOMMENDED TEST METHOD FOR EXHALATION VALVE LEAKAGE

(This Annex is for guidance only)

D-1 TEST EQUIPMENT

This consists mainly of:

a) a small volume (volume: 1 to 1·2 l) leak tight box attached to a tube with opening(s) between the box and tube in which the valve assemblies are mounted in suitable adaptors of low dead space (*see* Fig. 14). There are baffle plates in the box to promote smooth test gas flow (100 l/min continuous flow).

b) a breathing machine delivering sinusoidal air flows corresponding to 20 strokes/min and 1·5 l/stroke.

c) a supply of CO_2.

d) a purifier containing absorbsent for CO_2.

e) a unit to saturate the air with water vapour at 37°C.

f) an instrument capable of measuring test gas concentrations.

D-2 TEST PROCEDURE

D-2.1 All the exhalation valve assemblies attached to the facepiece are tested.

D-2.2 The test is performed at ambient temperature and relative humidity. The valve assemblies under test are fitted into the box with a suitable adaptor in a vertical position. The components are arranged according to whether a single or twin cylinder breathing machine is to be used (*see* Fig. 15 and 16).

D-2.3 The inlet valve is adjusted so that the back pressure of the valve(s) is 1 to 10·5 mbar at 30 l/min continuous flow.

D-2.4 The breathing machine is set at 10·5 l/stroke, 20 strokes/min. A flow of test gas is maintained through the box. Samples of the air from before and after the valve assemblies are continuously analysed for test gas concentrations.

D-2.5 The test is run for a sufficient time to obtain a steady reading of the test gas concentration in the inspiratory air stream.

The difference in the test gas concentrations between the two samples is a measure of the total valve leakage. The test shall be carried out using carbon dioxide.

ANNEX E

(*Clauses* 4.9.1 *and* 4.9.2)

METHOD OF TEST FOR FLAMMABILITY

E-1 TEST EQUIPMENT

E-1.1 The facepiece shall be tested for flammability for a short period with a test rig as shown in Fig. 7 and 8. This test rig consists mainly of a propane storage tank with control device and fine pressure gauge, flash back arrester, 6 propane burners being adjustable in height, and with a vertically and horizontally pivotable metal dummy head.

The test rig shall be adjusted as follows.

E-1.1.1 The distance between facepiece and burner tips shall be 250 mm.

E-1.1.2 Fully open the propane control valve on each of the six burners. Initially close the air control valve on each of the six burners. Adjust the propane cylinder output regulator to a pressure[1)] such that a flowmeter in the main propane supply line indicates a total flow to all six burners of 21 ± 0·5 l/min propane.

E-1.1.3 The temperature of the flame at a height of 250 mm above the burner tips and in the centre of the triangle formed by the burners, shall be 950 ± 50°C.

E-1.1.4 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 apparatus from the effect of external air flow.

[1)]Dependent on the gas jet size in the Bunsen burner, the pressure regulator will need to be adjusted in the range 0·3 to 1·25 bar.

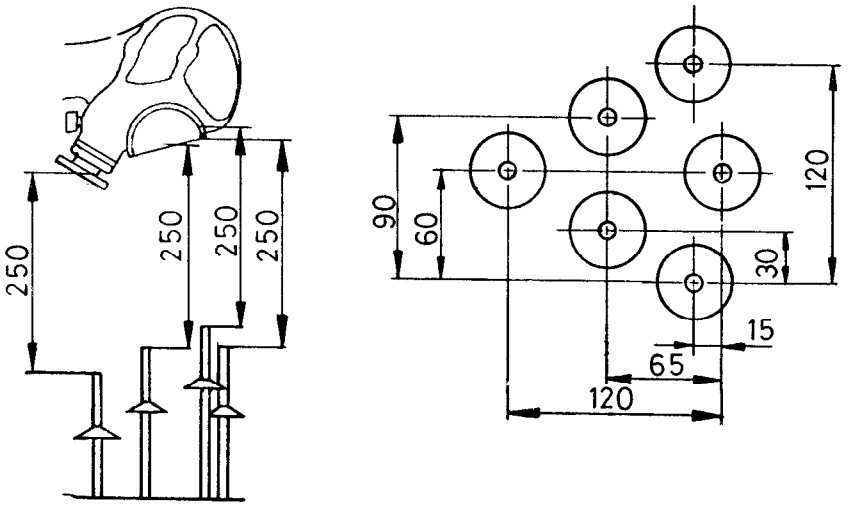
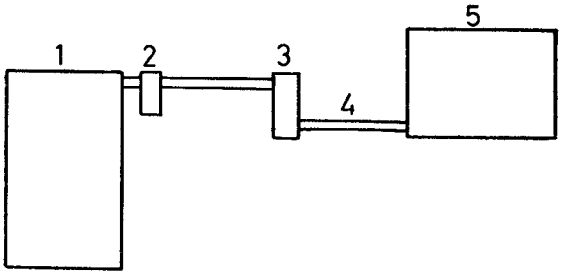


FIG. 7 ARRANGEMENT OF THE SIX PROPANE BURNERS



1 Propane storage tank
2 Fine pressure gauge and control device
3 Flash back arrester
4 Connecting hoses (of same length) leading to the 6 propane burners
5 Propane burners

FIG. 8 SCHEME OF A TEST RIG FOR FLAMMABILITY OF A FULL FACE MASK

E-2 PROCEDURE

E-2.1 For the test, the facepiece shall be put on the metallic dummy head and the free ends of the head straps shall be positioned between dummy head and straps. The facepiece shall be exposed to the flames for a period of 5 s. When components such as valve(s), speech diaphargm(s), etc, are arranged on other parts of the faceblank, the test shall be repeated with other samples of the facepiece orientated in the appropriate position.

E-2.2 For comparing the tightness of the full face before and after the flammability test, the same dummy head (Sheffield-head, metallic dummy head, etc) is used and a pressure of −10 mbar created in the cavity of the mask.

ANNEX F

(*Clause* 4.10)

METHOD OF TEST FOR CARBON DIOXIDE CONTENT OF THE INHALATION AIR

F-1 TEST EQUIPMENT

F-1.1 The apparatus consists essentially of a breathing machine with solenoid valves controlled by the breathing machine, a connector, a CO_2 flowmeter and CO_2 analyser.

F-1.2 The apparatus subjects the full face mask to a respiration cycle by the breathing machine.

F-2 PROCEDURE

F-2.1 For this test the facepiece shall be fitted securely in a leak-tight manner but without deformation on a Sheffield dummy head (*see* Fig. 9).

F-2.2 Air shall be supplied to it from the breathing machine adjusted to 25 strokes/min and 2·0 l/stroke and the exhaled air shall have a carbon dioxide content of 5 percent by volume.

A typical test arrangement is shown in Fig. 10.

F-2.3 To prevent a CO_2 build-up due to design of the test equipment, a CO_2 absorber shall be used in the inhalation branch between solenoid valve and breathing machine.

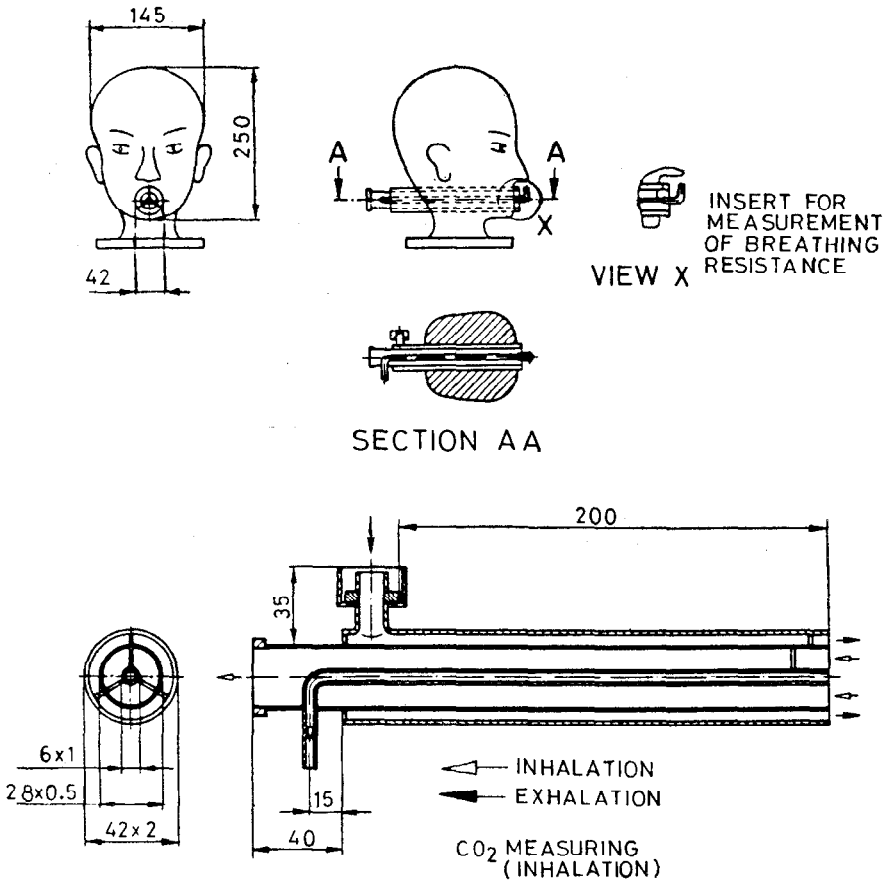


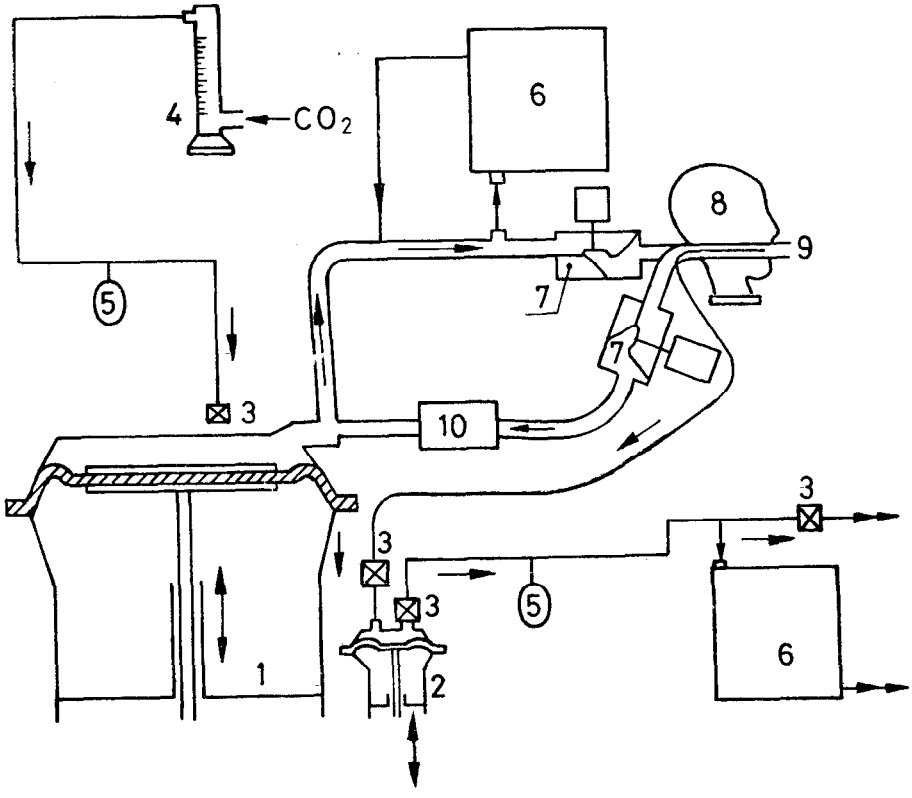
FIG. 9 DUMMY HEAD (SHEFFIELD HEAD) FOR CARBON DIOXIDE CONTENT TEST OF THE INHALATION AIR (DEAD SPACE) FOR A FULL FACE MASK

F-2.4 The CO_2 is fed into the breathing machine via a flowmeter, a compensating bag and a non-return valve.

F-2.5 Immediately before the solenoid valve a small quantity of exhaled air is continuously withdrawn through a sampling line and then fed into the exhaled air via a CO_2 analyser.

To measure the CO_2 content of the inhaled air, 5 percent of the stroke volume of the inhalation phase of the breathing machine is drawn off at the marked place by an auxiliary lung and fed to a CO_2 analyser. The total dead space of the gas path (excluding the breathing machine) of the test installation should not exceed 2 000 ml. The carbon dioxide content of the inhaled air shall be measured and recorded continuously.

This test shall be performed until a constant carbon dioxide content in the inhalation air is achieved.



1 Breathing machine
2 Auxiliary lung
3 Non-return valve
4 Flow meter
5 Compensator
6 Carbon dioxide analyser
7 Solenoid valves
8 Dummy head
9 Sampling tube for inhalation air (*see* Fig. 9)
10 Carbon dioxide absorber

FIG. 10 SCHEME OF TEST RIG FOR CARBON DIOXIDE CONTENT OF THE INHALATION AIR

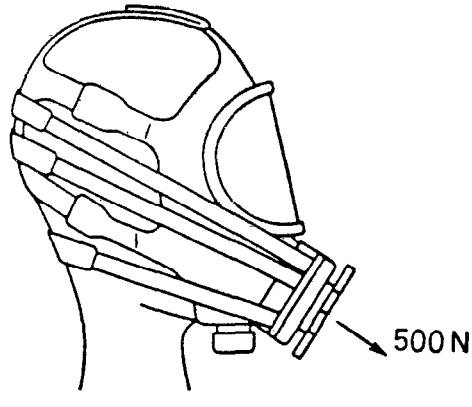


FIG. 11 TEST ARRANGEMENT FOR TENSILE TEST

ANNEX G

(*Clause* 4.12.3)

METHOD OF TEST FOR FACEPIECE CONNECTOR

G-1 PROCEDURE

G-1.1 Test time shall be 10 seconds. The facepiece shall be supported on a dummy head which can be adjusted so that the load can be applied axially to the connection. Additionally, a system of restraining straps or bands shall be fitted over the faceblank around the connection, so that the load is applied as directly as possible to the fitting of the connection in the faceblank and the restraining force is not applied wholly to the head harness.

ANNEX H

(*Clause* 4.13.3)

METHOD OF TEST FOR FIELD OF VISION

H-1 TEST EQUIPMENT

H-1.1 The field of vision shall be measured with an 'apertometer' according to Stoll (Fig. 12). A diagram (Fig. 13) shall be used for the evaluation.

H-2 PROCEDURE

H-2.1 Procedure to measure the field of vision of a full face mask shall be as follows.

H-2.1.1 Carefully fit the full face mask to the dummy head and, with both eyes lit, adjust the facepiece until the outline of the visor is symmetrical on the spherical shell. Adjust the tensions of the straps to obtain a reasonable, secure fit.

H-2.1.2 Map the positions of the field of vision of each eye individually on to the printed diagram, using the grid lines as a guide.

H-2.1.3 Carefully measure the areas of the total field of vision and the overlapped field of vision with a planimeter. The field of vision is the innermost line at any point of either the field of vision of the full face mask, or the natural field of vision of men according to Stoll as shown on the printed diagram.

H-3 TEST RESULTS

Express these results as a percentage of the area of the natural field of vision of men according to Stoll (already marked on the diagram).

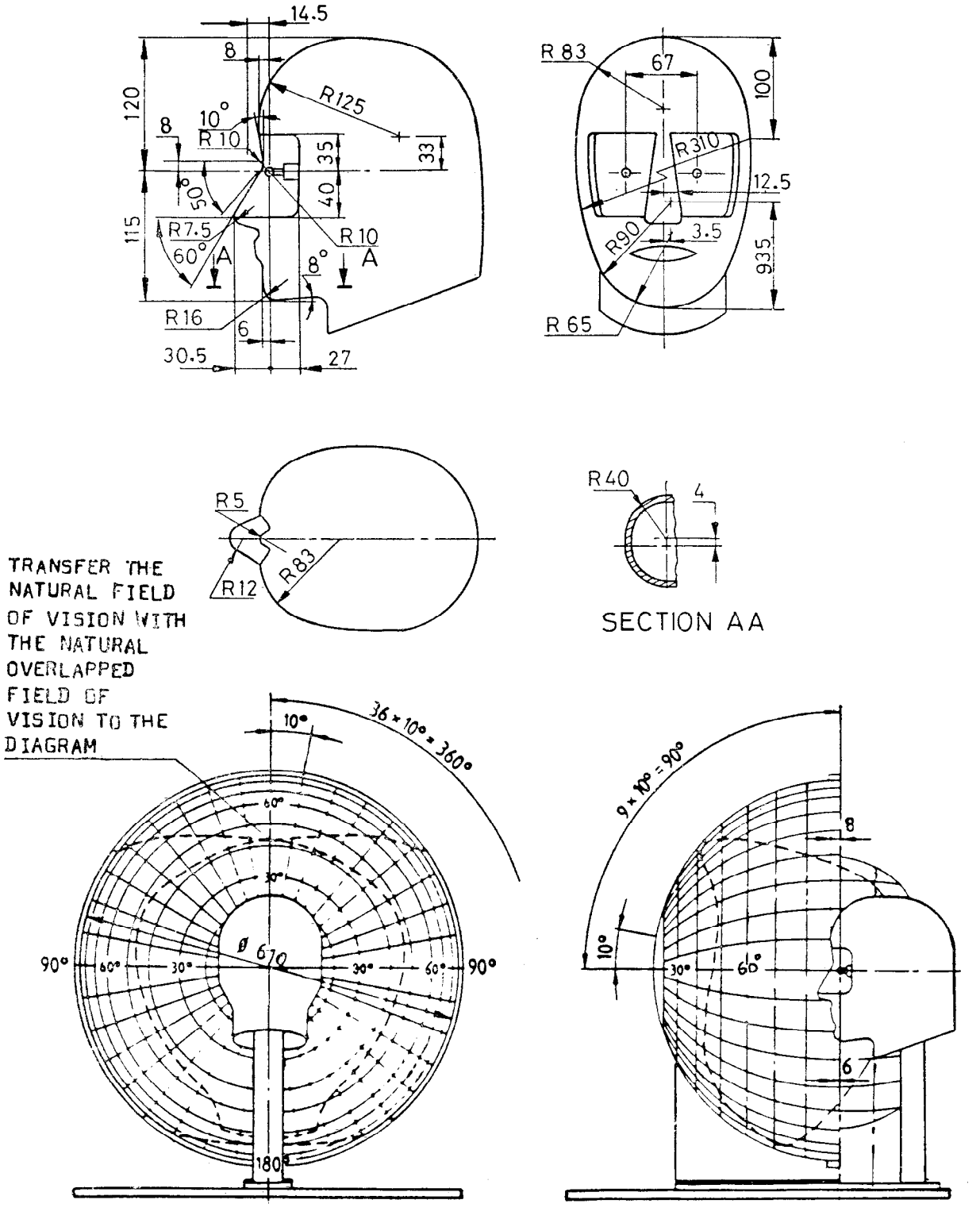
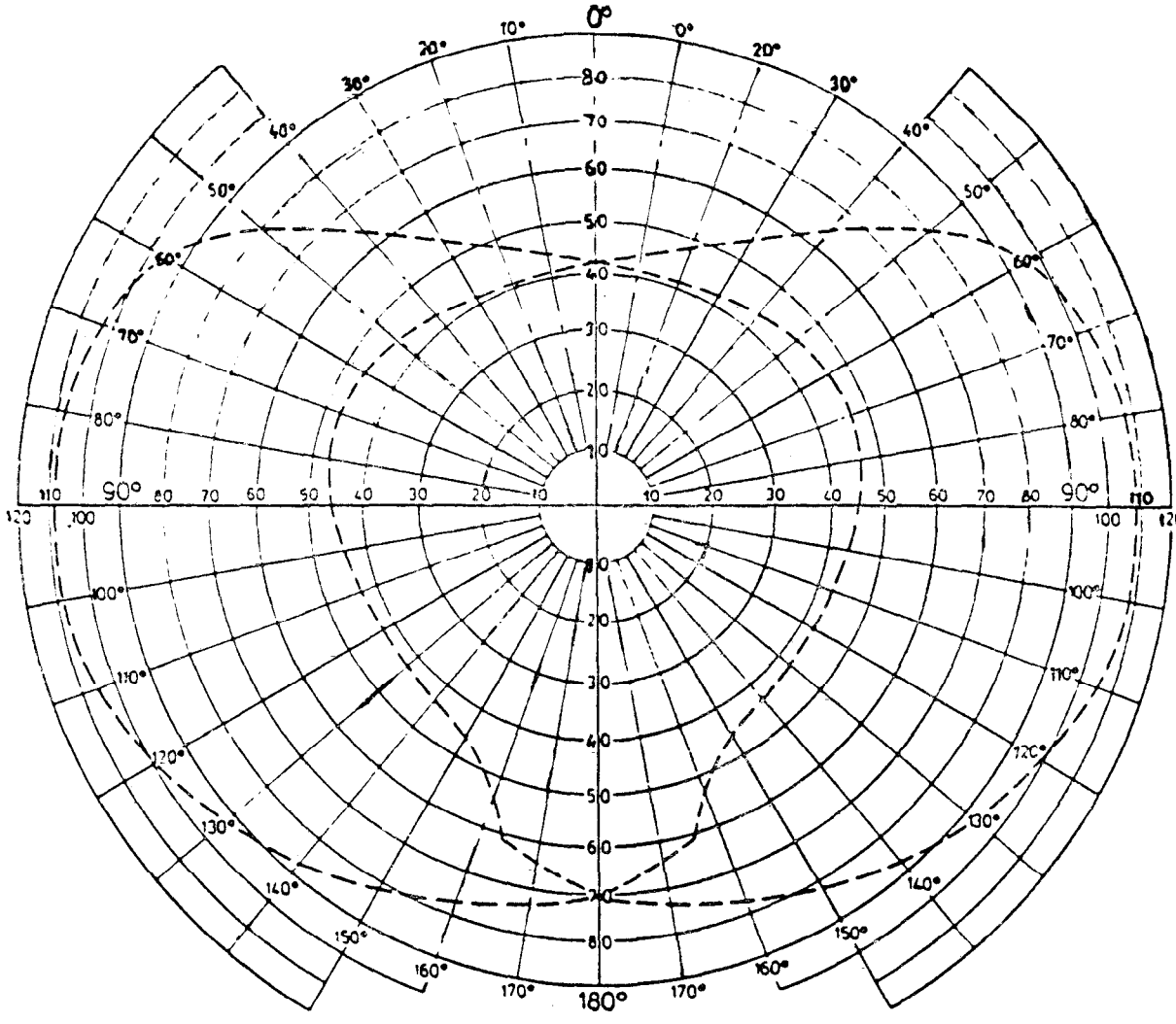


FIG. 12 APERTOMETER



... natural field of vision with natural overlapped field of vision.

The areas enclosed by circular lines of the diagram are proportional to the corresponding areas marked on the spherical shell of the apertometer.

Semi-circular surface represented inside of the 90° circle.....	=	126·9 cm²
Natural field of vision inside of the 90° circle (78·8%)	=	100·0 cm²
Natural field of vision outside of the 90° circle.....	=	12·0 cm²
Natural field of vision totally	=	112·0 cm² ≡ 100%
Natural overlapped field of vision	=	39·0 cm² ≡ 100%

Shape of lenses: _____ facepiece model: _____

(dimensions) _____ _____

Where measurements of the field of vision are taken, the effective field of vision as observed by the apertometer shall be transferred to the diagram. Only the effective field of vision within the natural field of vision respectively the effective overlapped field of vision shall be planimetered and noted in cm².

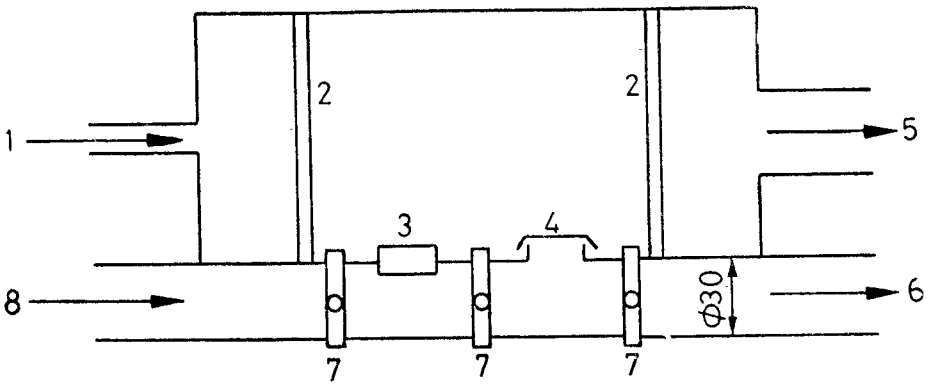
Planimetered area of effective field of vision (totally) ..... cm²

Planimetered area of effective overlapped field of vision ..... cm²

Effective field of vision (totally) ..... %

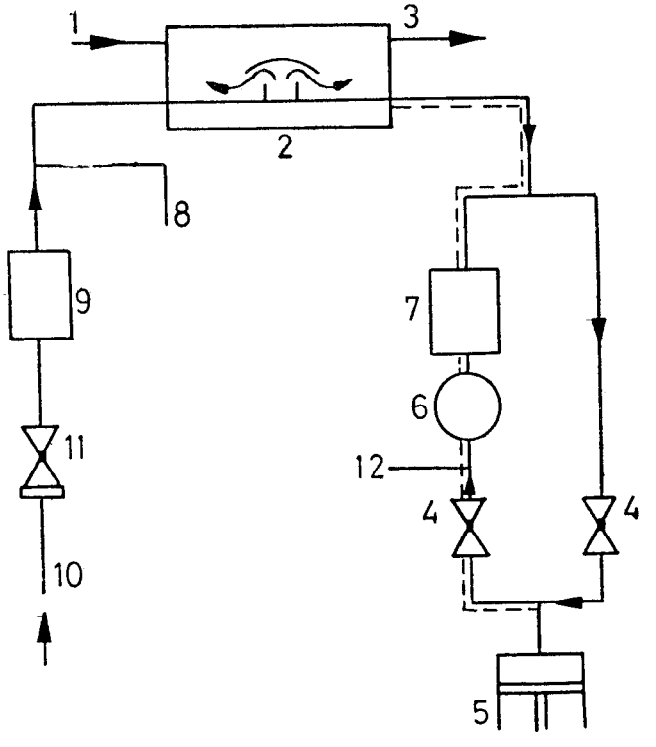
Effective overlapped field of vision..... %

FIG. 13 DIAGRAM OF THE APERTOMETER



1 Test gas in
2 Baffle plates
3 Blanking plate
4 Valve under test
5 Test gas out
6 To breathing machine
7 Pressure measurement ports
8 Saturated gas in

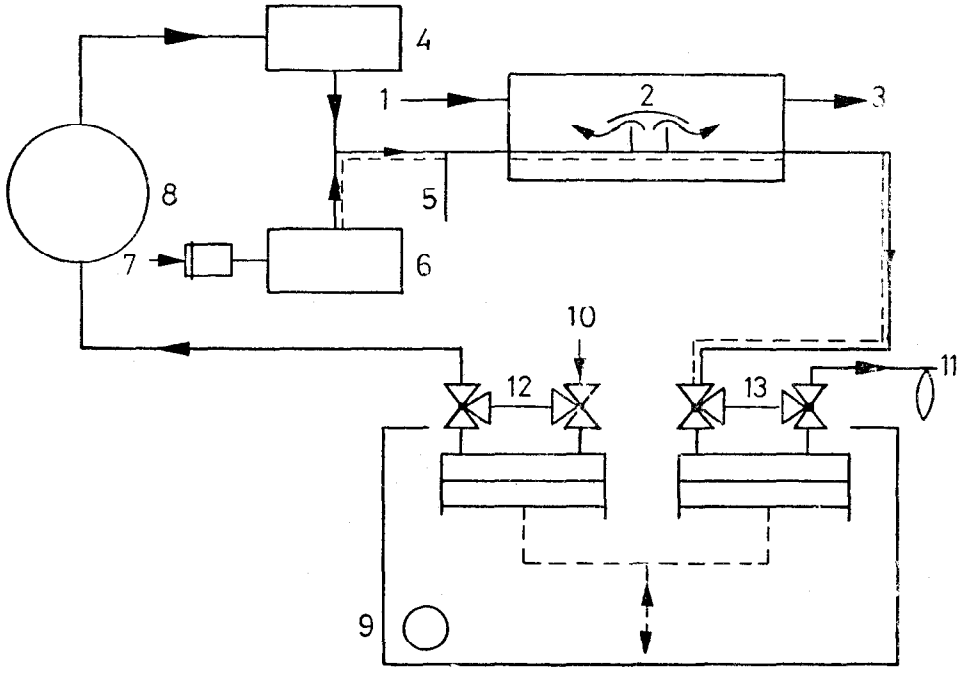
FIG. 14 SCHEME OF EXHALATION VALVE LEAKAGE TEST BOX [*see* **D-1**(a)]



1 Test gas in
2 Valve under test
3 Test gas out
4 Breathing machine valves
5 Breathing machine
6 Saturator
7 Purifier
8 Reference gas sample
9 Purifier
10 Laboratory air in
11 Adjustable non-return valve
12 Test gas sample

The difference between concentrations of samples taken at points 8 and 12 is a measure of the valve leakage.

FIG. 15 SCHEME OF TEST RIG FOR VALVE LEAKAGE USING A SINGLE CYLINDER MACHINE (*see* **D-2.2**)



1 Test gas in
2 Valve under test
3 Test gas out
4 Purifier
5 Reference gas sample
6 Purifier
7 Laboratory air in through adjustable non-return valve
8 Saturator
9 Twin cylinder breathing machine
10 Laboratory air in
11 Test gas sample
12 Breathing machine valves
13 Breathing machine valves

The difference between concentrations of the samples taken at points 5 and 11 is a measure of the valve leakage.

FIG. 16 SCHEME OF TEST RIG FOR VALVE LEAKAGE USING A TWIN CYLINDER BREATHING MACHINE (*see* **D-2.2**)

ANNEX J

(*Clause* 4.13.5)

METHOD OF TEST FOR IMPACT RESISTANCE OF THE EYEPIECE(S) OR VISOR(S)

J-1 PROCEDURE

Impact resistance shall be tested using a completely assembled full face mask mounted on a dummy head such that a steel ball [22 mm diameter, weighing 43·8 g (approx)] falls normally from a height of 1·30 m on the centre of the eyepiece or visor.

For comparing the tightness of the full face mask before and after the test the same dummy head shall be used and a pressure of −10 mbar created in the cavity of the full face mask.

ANNEX K

(*Clause* 4.15)

METHOD OF TEST FOR BREATHING RESISTANCE

K-1 PROCEDURE

The facepiece shall be fitted securely in a leak-tight manner but without deformation on a dummy head. The resistance shall be measured at the opening for the mouth of the dummy head using the adapter shown in Fig. 9 and a breathing machine adjusted to 25 strokes/min and 2·0 l/stroke or a continuous flow of 160 l/min. A suitable pressure transducer shall be used.

The inhalation resistance shall also be measured at 30 and 95 l/min continuous flow.

The resistance value shall be corrected to 27°C and 1 bar absolute.

ANNEX L

(*Foreword*)

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(*Continued on page* 22)

(*Continued from page* 21)

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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition.

This Indian Standard has been developed from Doc : No. CHD 008 (0523).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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