BRITISH STANDARD

BS EN 404:2005

Respiratory protective devices for self-rescue — Filter self-rescuer from carbon monoxide with mouthpiece assembly

The European Standard EN 404:2005 has the status of a British Standard

ICS 13.340.30

BSI British Standards

National foreword

This British Standard is the official English language version of EN 404:2005. It supersedes BS EN 404:1993 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee PH/4, Respiratory protection, to Subcommittee PH/4/12, Filtering devices which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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Respiratory protective devices for self-rescue - Filter self-rescuer from carbon monoxide with mouthpiece assembly

Appareils de protection respiratoire pour l'évacuation - Auto-sauveteur avec ensemble embout buccal à filtre monoxide de carbone

Atemschutzgeräte für Selbstrettung - Filterselbstretter mit Mundstückgarnitur zum Schutz gegen Kohlenmonoxid

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Foreword

This document (EN 404:2005) has been prepared by Technical Committee CEN/TC 79 “Respiratory protective devices”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2005, and conflicting national standards shall be withdrawn at the latest by October 2005.

This document supersedes EN 404:1993.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 89/686 EEC.

For relationship with EU Directive 89/686 EEC, see informative Annex ZA, which is an integral part of this document.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

A given respiratory protective device can only be approved when the individual components satisfy the requirements of the test specification which may be a complete standard or part of a standard, and practical performance tests have been carried out successfully on complete device where specified in the appropriate standard. If for any reason a complete device is not tested then simulation of the device is permitted provided the respiratory characteristics and mass distribution are similar to those of the complete device.

1 Scope

This document refers to filtering devices designed for protection against carbon monoxide (filter self-rescuer). It specifies minimum requirements for filter self-rescuers. This document does not apply to apparatus for work and rescue or to diving apparatus. Laboratory and practical performance tests are included for the assessment of compliance with the requirements.

2 Normative references

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

EN 132:1998, *Respiratory protective devices – Definitions of terms and pictograms*

EN 134:1998, *Respiratory protective devices – Nomenclature of components*

EN 13274-2:2001, *Respiratory protective devices – Methods of test – Part 2: Practical performance test*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 132:1998 and the nomenclature given in EN 134:1998 apply.

4 Description

A filter self-rescuer is a respiratory protective filtering device in a suitable packing for use in personal escape, and designed to protect the wearer against carbon monoxide. It is dependent on ambient atmosphere and does not provide protection against oxygen deficient atmospheres. The filtering device consists of a mouthpiece assembly with a filter. The mouthpiece assembly of the filtering device is connected directly or indirectly to the filter(s).

5 Classification

Filter self-rescuers are classified according to the minimum test duration which is defined by performing a breathing machine test in accordance with 7.6.1.

Table 1 — Classes of filter self-rescuers

Class		**Minimum duration** min
FSR 1 A	FSR 1 B	60
FSR 2 A	FSR 2 B	75
FSR 3 A	FSR 3 B	90
FSR 4 A	FSR 4 B	120

In the class, the numbers 1 - 4 indicate the minimum duration time as seen in the Table 1. The letters A and B indicate the flow rates 30 l/min and 40 l/min. Devices passing “rough usage” requirements shall be marked “R”.

NOTE The effective duration time may vary according to the work rate.

6 Requirements

6.1 General

In all tests, all test samples shall meet the requirements.

Wherever a test clause is referenced, all sub-clauses of the test clause shall apply, unless otherwise stated.

NOTE The requirements and test methods are based on experience with existing design of filter self-rescuers incorporating Hopcalite and drier. Consideration should be given to the behaviour of designs incorporating other filtering materials.

6.2 Ergonomics

The requirements of this document are intended to take account of the interaction between the wearer, the respiratory protective device, and where possible the working environment in which the respiratory protective device is likely to be used. The device shall satisfy 6.3 and 6.19.

6.3 Design

The design of the device shall be such as to allow its inspection in accordance with the information supplied by the manufacturer.

The device shall be sufficiently robust to withstand the rough usage it is likely to receive in use with respect to its classification.

The device shall be designed so that there are no protruding parts, sharp edges or burrs likely to be caught on projections in narrow passages or that may harm the wearer.

No part of the device likely to be in contact with the wearer shall have sharp edges or burrs.

The filter self-rescuer shall be designed such that the outside of carrying container can be cleaned easily.

If the filtering device is fitted with a coarse dust filter bag this filter bag shall be easily detachable.

The device shall be designed to ensure its full function in any orientation.

Testing shall be done in accordance with 7.3 and 7.5.

6.4 Materials

The carrying container and the locking device shall be adequately protected against corrosion. The materials used shall be able to withstand temperatures and mechanical stress expected when carried on the person or stored on machines and vehicles.

Testing shall be done in accordance with 7.4.3 and 7.5.2.

Exposed parts, i.e. those which may be subjected to impact during use of the device, shall not be made of aluminium, magnesium, titanium or their alloys.

Materials that may come into contact with the wearer's skin and the inhaled air shall not be known to be likely to cause irritation or any other adverse effect to health.

Testing shall be done in accordance with 7.3 and 7.5.

To prevent electrostatic charges on non-metallic carrying containers the insulation resistance shall not exceed 10^9 ohm.

Testing shall be done in accordance with 7.6.6.

6.5 Cleaning and disinfecting

All material shall be visibly unimpaired after cleaning and disinfection by the agents and procedures specified by the manufacturer.

Testing shall be done in accordance with 7.3.

6.6 Mass

That part of the mass of the filtering device supported by the head, ready for use, shall not exceed 750 g.

The mass of the complete device including carrying case shall not exceed 2 000 g.

The determination of the mass shall be carried out where appropriate.

Testing shall be done in accordance with 7.1.

6.7 Connections

All connections of the filtering device shall be gas tight.

Testing shall be done in accordance with 7.6.1 and 7.6.2.

All the connections of the filtering device shall be sufficiently robust and withstand a force of 50 N applied for 10 s. Connections of unprotected breathing hoses shall withstand a force of 250 N applied for 10 s.

Testing shall be done in accordance with 7.3, 7.5.1 and 7.6.10.2.

6.8 Means of carrying

The carrying container shall be provided with means of carrying, which ensures comfortable, safe and - if required - continuous carrying on the person. This may also be achieved by additional measures, e.g. a carrying bag.

Testing shall be done in accordance with 7.5.2.

When the device is designed to be carried on the person the tear-off force of the carrying means shall be not less than 400 N and shall not exceed 800 N.

Testing shall be done in accordance with 7.6.10.3.

6.9 Harness

The filter self-rescuer shall have a harness which ensures comfortable and safe wearing of the device when donned. The harness shall be adjustable or elastic or a suitable combination of both.

Testing shall be done in accordance with 7.5.1.

Each strap of the harness shall withstand a pull of 50 N for 10 s in the direction in which the harness is pulled when the device is donned.

Testing shall be done in accordance with 7.6.10.2.

6.10 Handling

The filter self-rescuer shall be capable of being donned in accordance with the information supplied by the manufacturer in a quick and simple manner within maximum of 20 s without undue exertion. The locking device shall be protected against being opened inadvertently. It shall be apparent whether or not the device has been opened and therefore requires inspection.

Testing shall be done in accordance with 7.5.1.

Any part of the filter self-rescuer used to pull the filtering device from its carrying or storage container shall withstand a force of 400 N applied for 10 s in the direction in which the part is subjected to such force during normal withdrawal of the filtering device.

Testing in shall be done accordance with 7.6.10.2.

6.11 Leak tightness

Leakages into any container designed to protect the device from exposure to contamination shall be detectable by a means specified by the manufacturer.

Testing shall be done in accordance with 7.6.4.

6.12 Facepiece

6.12.1 Mouthpiece assembly

The facepiece shall be a mouthpiece assembly, held by the teeth, sealing against the lips, and through which air is inhaled and exhaled while the nose is blocked by a nose clip. The mouthpiece shall ensure reliable sealing and shall not inadvertently be able to block the airways when in operation.

The nose clip shall provide an airtight seal of the nose. It shall be flexibly attached to the filtering device such that when fitting the mouthpiece the wearer's attention is automatically drawn to the nose clip.

Testing shall be done in accordance with 7.3 and 7.5.1.

6.12.2 Breathing hose

Where fitted, breathing hoses shall permit free head movement and shall not restrict or close off the air supply under chin or arm pressure. The hose may be extensible or compressible. The hose shall not collapse and the temporary elongation shall be at least 20 %, while the permanent linear deformation of the hose shall not exceed 10 %.

Testing shall be done in accordance with 7.5.1 and 7.6.9.

6.13 Inhalation and exhalation valves

If valves are fitted, they shall function in all orientations. When tested in accordance with 7.6.7 the requirements of 6.18.1, 6.18.2, and 6.18.4 shall be met.

Testing shall be done in accordance with 7.6.1, 7.6.2 and 7.6.7.

6.14 Saliva trap

The filtering device shall be designed such that saliva or condensate shall not interfere with the function of the filtering device or cause any harmful effect to the wearer.

Testing shall be done in accordance with 7.5.1.

6.15 Integrity of device at high carbon monoxide concentrations

When tested in accordance with 7.6.2 subsequent to 7.3 the device shall maintain its mechanical integrity and shall not present a hazard to the wearer.

6.16 Conditioning

6.16.1 Mechanical strength

After conditioning the filter self-rescuer in accordance with 7.4.2 the requirements of 6.15 and 6.18 shall be met.

6.16.2 Rough usage (optional)

The test is optional.

If a device is claimed to be resistant to rough usage, the filter-rescuer shall be subjected to a cement mixer test.

After conditioning the filter self-rescuer in accordance with 7.4.3 the performance requirements of 6.18 shall be met.

Markings shall be in accordance with 8.1.4.

6.16.3 Temperature

After conditioning in accordance with 7.4.4 and returning to room temperature the performance requirements of 6.18 shall be met.

6.16.4 Transport

After conditioning the filter self-rescuer in accordance with 7.5.2, the filter-rescuer shall pass the tests mentioned in Table 3.

6.17 Carbon dioxide content of inhalation air (dead space)

The carbon dioxide content of inhalation air (dead space) shall not exceed an average of 2 % by vol.

Testing shall be done in accordance with 7.6.8.

6.18 Performance requirements

6.18.1 Minimum test duration

The filtering device shall meet the appropriate requirements laid down for its class when tested at the minute volume given in Table 2.

Table 2 — Minimum test duration

Class	Minute volume l/min		Minimum test duration min
	Type A	Type B	
FSR 1	30	40	60
FSR 2	30	40	75
FSR 3	30	40	90
FSR 4	30	40	120

NOTE The minute volume for testing filter self-rescuers is based on practical experiences in many countries where such devices are in use for various mining applications.

Testing shall be done in accordance with 7.6.1.

6.18.2 Carbon monoxide - breakthrough criteria

The carbon monoxide concentration of the inhalation air for type B shall not exceed 200 ml/m^3 time weighted average in any single 5 min interval. The total carbon monoxide slip of inhalation air for type A shall not exceed 400 ml during the minimum test duration. The total carbon monoxide slip of inhalation air for type B shall not exceed 200 ml during the minimum test duration.

Testing shall be done in accordance with 7.6.1 and 7.6.2.

6.18.3 Temperature and humidity

The temperature of inhalation air for type A shall not exceed 90 °C dry bulb and 50 °C wet bulb during the minimum test duration.

The temperature of the inhalation air for type B shall not exceed 85 °C dry bulb and 50 °C wet bulb during the minimum test duration.

Testing shall be done in accordance with 7.6.1 and 7.6.2.

6.18.4 Breathing resistance

The inhalation resistance for type A shall not exceed 12 mbar during the minimum test duration. The exhalation resistance shall not exceed 3,5 mbar during the minimum test duration.

The inhalation resistance for type B shall not exceed 7 mbar during the minimum test duration. The exhalation resistance shall not exceed 2,5 mbar during the minimum test duration.

Testing shall be done in accordance with 7.6.1, 7.6.2 and 7.6.3.

6.19 Practical performance

In addition to the machine tests described, the device shall also undergo simulated practical performance tests under realistic conditions. These practical performance tests serve the purpose to check the device for imperfections that cannot be determined by the tests described elsewhere in this document.

If during any activity, by any test subject the test subject fails to finalise the selected activity due to the apparatus being not fit for the purpose for which it has been designed, the apparatus shall be deemed to have failed.

After completion of the activities the test subjects are asked to answer the questions in 6.6 of EN 13274-2:2001. These answers will be used by the test house to determine if the apparatus passes or fails.

If for any reason practical performance tests underground are not permissible, then the test house shall conduct simulated realistic equivalent tests, describe these tests, and provide the results thereof so that other test houses can duplicate the tests and assess the results.

Testing shall be done in accordance with 7.5.

7 Testing

7.1 General

If no special measuring devices or measuring methods are specified, commonly used methods and devices should be applied.

Before performing tests involving human subjects, account should be taken of any national regulations concerning the medical history, examination or supervision of the test subjects.

NOTE For summary of testing see Table 6.

7.2 Nominal values and tolerances

Unless otherwise specified, the values stated in this document are expressed as nominal values. Except for temperature limits, values which are not stated as maxima or minima shall be subject to a tolerance of ± 5 %. Unless otherwise specified, the ambient temperature for testing shall be from 16 °C to 32 °C, but for the mechanical tests from 10 °C to 30 °C, and the temperature limits shall be subject to an accuracy of ± 1 °C.

7.3 Visual Inspection

The visual inspection shall be made by the test house prior to laboratory or practical performance tests. This may entail a certain amount of dismantling in accordance with the manufacturer's instructions for maintenance. The visual inspection shall include the assessment of the device marking and information supplied by the manufacturer and any safety data sheets (if applicable) or declarations relevant to the materials used in its construction.

7.4 Conditioning

7.4.1 General

Where, as specified in Table 6, conditioning before subsequent testing is required, the procedure shall be one of those described in 7.4.2, 7.4.3, 7.4.4 or 7.5.2.

7.4.2 Mechanical strength test

Three filter self-rescuers shall be tested.

The apparatus is shown schematically in Figure 7 and consists of a steel case (K) which shall be fixed on a vertically moving piston (S), capable of being lifted up 20 mm by a rotating cam (N) and dropping down onto a steel plate (P) under its own mass as the cam rotates. The mass of the steel case shall be more than 10 kg.

The weight of the steel plate onto which the steel case falls should be at least 10 times the weight of the steel case. This may be achieved by bolting the base plate to a hard solid floor.

The filter self-rescuers shall be placed on their sides in the case (K) such that they do not touch each other during the test, allowing 6 mm horizontal movement and free vertical movement.

The test rig shall be operated at the rate of approximately 80 to 100 rotations per min for a total of 50 000 rotations. The filter self-rescuers shall be tested as received including carrying container and sealing.

7.4.3 Rough usage test

Three filter self-rescuers shall be tested.

The cement mixer[1)] used for the test shall satisfy the following conditions:

— bucket diameter approximately 70 cm;

— bucket depth approximately 70 cm;

— two inner blades at approximately 17 cm from the bottom;

— rotating at approximately 25 revolutions per min.

Three filter self-rescuers, as received, shall be placed in the cement mixer and tested for a total of 800 revolutions.

NOTE It may be necessary to protect the closure device from accidental opening during the test.

7.4.4 Temperature conditioning

Eight filter self-rescuers shall be tested. For the escape test underground (optional) 2 additional filter self-rescuers shall be tested.

The filter self-rescuer shall be exposed during successive tests:

a) for 72 h to an atmosphere of (70 ± 3) °C; at less than 20 % relative humidity

b) for 72 h to an atmosphere of (70 ± 3) °C at 95 % to 100 % relative humidity and

c) for 24 h to a temperature of (-30 ± 3) °C.

1) Information can be obtained from the secretariat of CEN/TC 79.

7.5 Practical performance test

7.5.1 Escape test

7.5.1.1 General

Escape test in the test house shall be performed with 4 devices and 4 test subjects.

Escape test underground (optional) shall be performed with 4 devices and 4 test subjects.

By escape test, during which the filter self-rescuer is used by a test subject under conditions that are expected to prevail during escape situations, it shall be determined whether the filtering device operates satisfactorily, but without carbon monoxide in the ambient atmosphere. During the test the test subjects perform at different work loads.

Prior to the test, the test subjects shall be instructed in accordance with the information supplied by the manufacturer in the correct method of opening and donning the filter self-rescuer.

During the test, the test subject shall be accompanied by an assistant.

Prior to the test, the following should be recorded:

— name;

— age;

— height;

— weight.

Temperature and relative humidity of the atmosphere shall be noted at various points of the test route as well as the mass of the ready-for-use filtering device.

During these tests the following shall be recorded: activities and duration of the activities. During the test the filter self-rescuer shall be subjectively assessed by the wearer, and after the test, comments on the following shall be recorded:

— design;

— materials;

— compatibility with skin;

— harness;

— ease of donning;

— handling;

— facepiece;

— saliva trap.

7.5.1.2 Devices to be tested

For escape test, only devices of the type which passed the laboratory testing shall be worn.

7.5.1.3 Test subjects

The device shall be worn by test subjects who were medically examined and certified fit to undertake the test procedures.

7.5.1.4 Escape test in test house

The test shall be conducted in a training gallery.

The tests shall be carried out at ambient temperature of between 20 °C and 30 °C and normal relative humidity. The ambient atmosphere shall be free of smoke. Air flow shall be negligible.

Exercises shall be terminated when the minimum test duration is reached or when there is evidence that the test subject is no longer capable of completing the exercise.

The practical performance test shall be subdivided into consecutive sections (activity 7, 9, 13 and 8 in EN 13274-2). During each of these sections the test subject shall perform the following activities:

— 1 min walking on a treadmill at 8,0 km/h (total distance 133 m) - activity 7;

— 4 min walking on a treadmill at 4,0 km/h (total distance 267 m) - activity 9;

— 23 min walking through the training gallery - activity 13.

  Exercises in the training gallery include level and rising roadways of varying heights and a climb of 15 m on a ladder at a rate of approximately 10 m/min. Using a fixed ladder it may be necessary to ascend and descend the ladder several times in order to cover the 15 m climb.

— 2 min walking on a treadmill at 2,4 km/h (total distance 80 m) and 20 % incline - activity 8.

The number of sections depends on the class of device.

7.5.1.5 Escape test underground (optional)

For mining applications additional tests underground shall be carried out with filter self-rescuers. If it is not possible to carry out these tests underground they shall be performed in a training gallery.

The total test duration for all exercises shall meet the minimum duration according to the class given in Table 1. All the following exercises shall be performed at least once.

Specification of the exercise:		**Duration in per cent of the minimum duration of the filter self-rescuer:**
Gallery, approximately 15 gon, (13,5 degree)	inclining	25
	declining	25
Seam, max. 1 m height	horizontal	20
Seam approximately 15 gon, (13,5 degree)	inclining	10
	declining	10
Climbing in a shaft	vertical	10

The sequence of the different parts of the exercise may be changed due to feasibility. The different exercise sections need not be coherent.

7.5.2 Transport test

A total of 20 devices shall be tested; 10 devices shall be carried on the person and 10 devices shall be transported on vehicles or machines.

The test house shall pass on the filter self-rescuers to an appropriate mine for testing. The transport test shall be carried out underground preferably at a depth of at least 500 m and shall include different wearer activities.

A visual inspection of the transported filter self-rescuers shall be carried out by the test house at least once per month and daily by the mine. Any event or maintenance action shall be recorded with reference to the date and the serial number of the device.

The device shall be carried on the person, or transported on vehicles or machines for 120 shifts. Typical wearers shall be vehicle drivers, face and heading workers, supervisors, and maintenance personnel. The filter self-rescuers carried on the person shall be carried during the whole shift.

The environmental conditions of the tests, like temperature, relative humidity, depth, carrying conditions on the person and on vehicles, shall be described such to enable other test houses to verify and assess the results thereof.

Maintenance of the devices under test shall be carried out in accordance with the manufacturer's instructions. Devices exhibiting abnormal damage shall be segregated and removed from the continuation of the tests. These devices shall be submitted to the test house, and the reason for damage shall be given, if possible.

After completion of the tests the persons involved shall be asked for comments. These comments will be taken into consideration by the test house for final evaluation of the filter self-rescuer.

After 120 shifts the filter self-rescuers shall be examined by the test house

— devices exhibiting abnormal damage shall be removed;

— samples taken at random from the remainder shall be tested in accordance with Table 3. For each test the same numbers of filter self rescuers carried on the person and transported on vehicles or machines shall be used.

Table 3 — Testing of devices after completion of transport test

Clause	Number of samples
7.3	all
7.6.1 and 7.6.3	2
7.6.2	2
7.6.7	2
7.5.1.4	2
7.5.1.5 (optional)	(2)

Devices previously removed as exhibiting abnormal damage shall be further examined in greater detail. The results of the examination will be taken into consideration by the test house for final evaluation of the filter self-rescuers.

7.6 Laboratory test

7.6.1 Protection against carbon monoxide

A total of 8 filtering devices shall be tested. If a filtering device after rough usage (optional) shall be tested this shall be done with two additional filtering device.

Schematic arrangements of equipment required for this test are shown in Figures 1 and 5. The equipment consists mainly of a breathing machine with solenoid valves controlled by the breathing machine, humidifiers, a test chamber, a connector, flowmeters for air and carbon monoxide, an exhaust, sampling ports, analysers for carbon monoxide and meters for pressure and temperature.

The connector design (Figures 2 to 4 and 6) is not mandatory, but the sampling ports or measuring spots are specified in detail.

The filtering device shall be tested at the test rig using a breathing machine which is adjusted before starting the test in accordance with Table 4.

Table 4 — Setting of breathing machine

Type	Minute volume at 23 °C and 1 bar		
	l/min	cycles/min	l/stroke
A	30	20	1,5
B	40	20	2,0

For testing the filtering device shall be fitted to a suitable connector. Test conditions shall be as given in Table 5.

Table 5 — Test conditions

Test conditions	Unit	Type A	Type B
Continuous flow of test atmosphere	l/min	$\geq$ 100	$\geq$ 130
Temperature of exhalation air	°C	37 ± 0,5	37 ± 0,5
Relative humidity of exhalation air	%	95 to 100	95 to 100
Water vapour content in test chamber	g/m^3	20,7	27,0
Temperature of test atmosphere	°C	25 ± 1	28 ± 1
Carbon monoxide concentration	% by vol.	0,25	0,25

A continuous flow of test atmosphere shall be fed into the test chamber. The test atmosphere and the exhalation air shall be humidified using suitable humidifiers. Carbon monoxide shall be fed into the test chamber via a control valve and a flowmeter. The carbon monoxide concentration in the test chamber shall be measured and recorded continuously close to the air inlet of the filtering device.

The temperature of the exhaled air shall be checked at the temperature measuring point of the connector and adjusted before starting the test. The water vapour content of the test atmosphere in the test chamber shall be monitored continuously close to the air inlet of the filtering device.

NOTE It should be taken into consideration that the test atmosphere in the test chamber may be affected by the filtering device under test.

The total dead space of the gas path (excluding the breathing machine) of the test rig should not exceed 2 000 ml.

The temperature of the inhaled air shall be measured as specified in Figure 3 by means of a fast response thermocouple (e.g. thermowire NiCr-Ni, 0,2 mm diameter).

The wet bulb temperature of the inhaled air shall be measured at the point marked in Figure 2 or 5. A suitable method for determination of wet bulb temperature of inhalation air is given in Annex B.

Breathing resistance, wet and dry bulb temperature of inhalation air, and carbon monoxide slip (ml/m^3 and ml) shall be measured and recorded continuously.

7.6.2 Testing at high CO concentrations

A total of three filtering devices shall be tested. If a filtering device after rough usage (optional) shall be tested this shall be done with an additional filtering device.

Testing in accordance with 7.6.1 but with the variation to use 1,5-%-by vol. carbon monoxide in air as test atmosphere. An assessment of any hazard to the wearer shall be made when the maximum inhalation temperature is reached. This may be achieved by removing the device from the test equipment and having it tested by a test subject for tolerable breathing comfort.

7.6.3 Breathing resistance

The breathing resistance shall be measured at the relevant port of the connector (Figure 2) by means of a fast response pressure meter.

Results shall be corrected for any effect of the design of the connector.

7.6.4 Leak tightness

This test shall be carried out in accordance with the method specified by the manufacturer.

7.6.5 Materials

The test for material characteristics takes place in connection with the temperature conditioning and mechanical strength as well as during carriage or transport.

7.6.6 Insulation resistance of non-metallic carrying containers

Two devices shall be tested.

The insulation resistance shall be tested on the carrying container if size permits, or on a test piece comprising a rectangular plate with dimensions in accordance with Figure 8 on which two parallel electrodes shall be painted on the surface, using a conducting paint with a solvent which shall have no significant effect on the insulation resistance.

The test piece shall have an intact surface and shall be cleaned with distilled water, then with isopropyl alcohol (or any other solvent that can be mixed with water and will not affect the material of the test piece), then once more with distilled water before being dried. Untouched by bare hands, it shall then be conditioned for 24 h at the temperature of (23 ± 2) °C and (50 ± 5) % relative humidity.

The test shall be carried out under the same ambient conditions.

The direct voltage applied for 1 min between the electrodes shall be equal to (500 ± 10) V.

During the test, the voltage shall be sufficiently steady such that the charging current due to voltage fluctuation will be negligible compared with the current flowing through the test piece. In certain cases this requires the use of batteries or accumulators.

The insulation resistance is the quotient of the direct voltage applied at the electrodes to the total current flowing between them when the voltage has been applied for 1 min.

Suitable test methods are described in Annex A.

7.6.7 Inhalation and exhalation valves

Two filtering devices shall be tested.

The filtering device shall be tested using a breathing machine in accordance with 7.6.1 with the variation that the filtering device shall be fitted into the test chamber and shall be turned to the orientation which is judged by the test house to be the most critical using a special connector (if necessary). A typical design of such a connector is shown in Figure 9.

7.6.8 Carbon dioxide content of inhalation air (dead space)

Two filtering devices shall be tested.

The equipment consists mainly of a breathing machine with solenoid valves controlled by the breathing machine, a connector, a CO_2 flowmeter, and CO_2 analysers.

The equipment subjects the filtering device to a respiration cycle by the breathing machine. For this test the filtering device shall be fitted securely in a leak-tight manner to a suitable connector (Figures 11 to 13).

Air shall be supplied to it from the breathing machine adjusted to 20 cycles/min and 1,75 l/stroke, and the exhaled air shall have a carbon dioxide content of 4,5 % by vol.

A typical test arrangement is shown in Figure 10.

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

The CO_2 shall be fed into the breathing machine via a flowmeter, a compensating bag, and a non-return valve.

Immediately before the solenoid valve a small quantity of exhaled air shall be 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, 4,5 % of the stroke volume of the inhalation phase of the breathing machine shall be 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 rig should not exceed 2 000 ml.

The carbon dioxide content of the inhalation air shall be measured and recorded continuously.

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

7.6.9 Breathing hoses

7.6.9.1 General

Two devices shall be tested according to 7.6.9.2 and 7.6.9.3.

Four devices shall be tested during the escape test in house.

Four devices shall be tested during the escape test underground (optional).

7.6.9.2 Temporary elongation

For testing the ductility of a corrugated hose it shall be suspended. Its length (without couplings) shall be measured (length a). Afterwards a force of 10 N shall be applied to the hose (length b) for a period of 5 min.

The elongation (b-a) shall be calculated (%).

7.6.9.3 Permanent linear deformation

For testing the permanent linear deformation of the corrugated hose it shall be submitted immediately after the test described in 7.6.9.1 to a force of 10 N for 48 h. After a recovery period of 6 h the length of the hose shall be measured again (length c).

The permanent linear deformation (c-a) shall be calculated (%).

The permanent linear deformation test shall be repeated after a further 7 d.

7.6.10 Pull test and tear-off force

7.6.10.1 General

Two devices shall be tested.

The pull test and the tear-off force shall be determined on a tensile-testing machine which is equipped with a meter.

7.6.10.2 Pull test

The filtering device or the parts specified to be tested respectively shall be attached to the tensile-testing machine by means of suitable adapters.

7.6.10.3 Tear-off force

The weakest part and orientation of the means for carrying (strap, rivets, seams, buckles etc.) shall be tested. The force shall be increased by approximately 10 N/s.

8 Marking

8.1 General

8.1.1 The filter self-rescuer shall be clearly and durably marked with the following information:

8.1.2 The name, trademark, or other means of identification of the manufacturer or supplier.

8.1.3 Type identifying marking.

8.1.4 The symbols according to class.

Examples:

Marking of a filter self-rescuer complying with a minimum test duration of 60 min at a minute volume of 30 l/min and the rough usage requirement:

FSR 1 AR

Marking of a filter self-rescuer complying with a minimum test duration of 90 min at a minute volume of 40 l/min:

FSR 3 B

8.1.5 The number and year of publication of this document.

8.2 The marking shall be provided with the following particulars:

a) Filter self-rescuer

- serial number;
- date of manufacture (year and month);
- mass.

b) Filtering device

- serial number;
- mass.

8.3 Where the reliable performance of piece parts may be affected by ageing, means of identifying the date (at least the year) of manufacture shall be given.

8.4 Sub-assemblies and piece parts with considerable bearing on safety shall be marked such that they can be identified.

8.5 For parts, which cannot be marked, the relevant information shall be included in the information supplied by the manufacturer.

9 Information supplied by the manufacturer

9.1 On delivery, information supplied by the manufacturer shall accompany every device.

9.2 The information supplied by the manufacturer shall be in the official language(s) of the country of destination.

9.3 The information supplied by the manufacturer shall contain all information necessary for trained and qualified persons on

- application/limitation;
    - the information, for single use only;
    - R, if the device meets the rough usage requirement, which shall form part of the class designation;

— checks prior to use;

— donning and fitting;

— maintenance (preferably separately printed instructions);

  — inspection intervals;

— storage;

  — shelf life, if applicable;

— disposal.

9.4 Special attention shall be drawn to

— the fact that the device is for use for personal escape only;

— the fact that no protection against oxygen deficiency is provided;

— that after a contact with open flames the protection may not be achieved.

9.5 Warning shall be given concerning problems likely to be encountered, for example

— the unit shall not be damaged in any way;

— donning procedure shall be carried out in accordance with the information supplied by the manufacturer;

— speaking is not permissible.

9.6 The information supplied by the manufacturer shall be unambiguous. If helpful, illustrations, part numbers, marking etc. shall be added.

9.7 Explanation of the used symbols shall be given.

9.8 The name and address of the manufacturer or his authorized representative shall be given.

Table 6 — Testing schedule

Require-ment clause	Title	Conditioning according	Test clause	Title	Number of samples [a]
6.3	Design	A.R.	7.3	Visual inspection	All
		A.R. T.T.	7.5.1.4 7.5.1.4	Escape test in test house	2 2
		A.R. T.T.	7.5.1.5 7.5.1.5	Escape test underground	(2) (2)
		A.R.	7.5.2	Transport test (on the person)	10
		A.R.	7.5.2	Transport test (on the vehicle or machine)	10
6.4	Materials	A.R.	7.3 7.4.4	Visual inspection	All
		A.R. T.T.	7.5.1.4 7.5.1.4	Escape test in test house	2 2
		A.R. T.T.	7.5.1.5 7.5.1.5	Escape test underground	(2) (2)
		A.R.	7.5.2	Transport test (on the person)	10
		A.R.	7.5.2	Transport test (on the vehicle or machine)	10
		A.R.	7.6.6	Insulation resistance of non-metallic carrying containers	2
6.5	Cleaning and disinfection		7.3	Visual inspection	All
		A.R.	7.5.2	Transport test (on the person)	10
		A.R.	7.5.2	Transport test (on the vehicle or machine)	10
6.6	Mass	A.R.	7.1	General	3
6.7	Connections		7.3	Visual inspection	All
		A.R. T.T.	7.5.1.4 7.5.1.4	Escape test in test house	2 2
		A.R. T.T.	7.5.1.5 7.5.1.5	Escape test underground	(2) (2)
		A.R.	7.6.10.2	Pull test	2
6.8	Means of carrying	A.R.	7.5.2	Transport test (on the person)	10
		A.R.	7.6.10.3	Tear-off force	2
6.9	Harness	A.R. T.T.	7.5.1.4 7.5.1.4	Escape test in test house	2 2
		A.R.	7.5.1.5 7.5.1.5	Escape test underground	(2) (2)
		A.R.	7.6.10.2	Pull test	2

6.10	Handling	A.R. T.T.	7.5.1.4 7.5.1.4	Escape test in test house	2 2
		A.R. T.T.	7.5.1.5 7.5.1.5	Escape test underground	(2) (2)
		A.R.	7.5.2	Transport test (on the person)	10
		A.R.	7.5.2	Transport test (on the vehicle or machine)	10
		A.R.	7.6.10.2	Pull test	2
6.11	Leak-tightness	T.T.	7.6.4	Leak tightness	20
6.12.1	Mouthpiece assembly		7.3	Visual inspection	All
		A.R. T.T.	7.5.1.4 7.5.1.4	Escape test in test house	2 2
		A.R. T.T.	7.5.1.5 7.5.1.5	Escape test underground	(2) (2)
6.12.2	Breathing hose	A.R. T.T.	7.5.1.4 7.5.1.4	Escape test in test house	2 2
		A.R. T.T.	7.5.1.5 7.5.1.5	Escape test underground	(2) (2)
		A.R.	7.6.9	Breathing hoses	2
6.13	Inhalation and exhalation valves	T.T.	7.6.7	Inhalation and exhalation valves	2
6.14	Saliva trap	A.R. T.T.	7.5.1.4 7.5.1.4	Escape test in test house	2 2
		A.R. T.T.	7.5.1.5 7.5.1.5	Escape test underground	(2) (2)
6.15	Integrity of device at high carbon monoxide concentrations	M.S. T.T. R.U	7.6.2 7.6.2 7.6.2	Testing at high CO concentrations	1 2 (1)
6.16.1	Mechanical strength	A.R.	7.4.2	Mechanical strength test	3
6.16.2	Rough usage	A.R.	7.4.3	Rough usage test	(3)
6.16.3	Temperature	A.R.	7.4.4	Temperature conditioning	8+(2)
6.16.4	Transport	A.R.	7.5.2	Transport test (on the person)	10
				Transport test (on the vehicle or machine)	10
6.17	Carbon dioxide content of inhalation air (dead space)	A.R.	7.6.8	Carbon dioxide content of inhalation air (dead space)	2
6.18.1	Minimum test duration	A.R. M.S. T.T. T.C. R.U.	7.6.1 7.6.1 7.6.1 7.6.1 7.6.1	Protection against CO	2 2 2 2 (2)

6.18.2	Carbon monoxide – breakthrough criteria	A.R T.T. T.C. M.S. R.U. M.S. T.T. R.U.	7.6.1 7.6.1 7.6.1 7.6.1 7.6.1 7.6.2 7.6.2 7.6.2	Protection against CO Testing at high CO concentrations	2 2 2 2 (2) 1 2 (1)
6.18.3	Temperature and humidity	A.R T.T. T.C. M.S. R.U. M.S. T.T. R.U.	7.6.1 7.6.1 7.6.1 7.6.1 7.6.1 7.6.2 7.6.2 7.6.2	Protection against CO Testing at high CO concentrations	2 2 2 2 (2) 1 2 (1)
6.18.4	Breathing resistance	A.R T.T. T.C. M.S. R.U. M.S. T.T. R.U.	7.6.1/7.6.3 7.6.1/7.6.3 7.6.1/7.6.3 7.6.1/7.6.3 7.6.1/7.6.3 7.6.2 7.6.2 7.6.2	Protection against CO Testing at high CO concentrations	2 2 2 2 (2) 1 2 (1)
6.19	Practical performance test	A.R. T.T. A.R. T.T. A.R. A.R.	7.5.1.4 7.5.1.4 7.5.1.5 7.5.1.5 7.5.2 7.5.2	Escape test in test house Escape test underground Transport test (on the person) Transport test (on the vehicle or machine)	2 2 (2) (2) 10 10
8	Marking	A.R.	7.3	Visual inspection	All
9	Information supplied by the manufacturer	A.R.	7.3	Visual inspection	All

Abbreviations:

A.R. as received

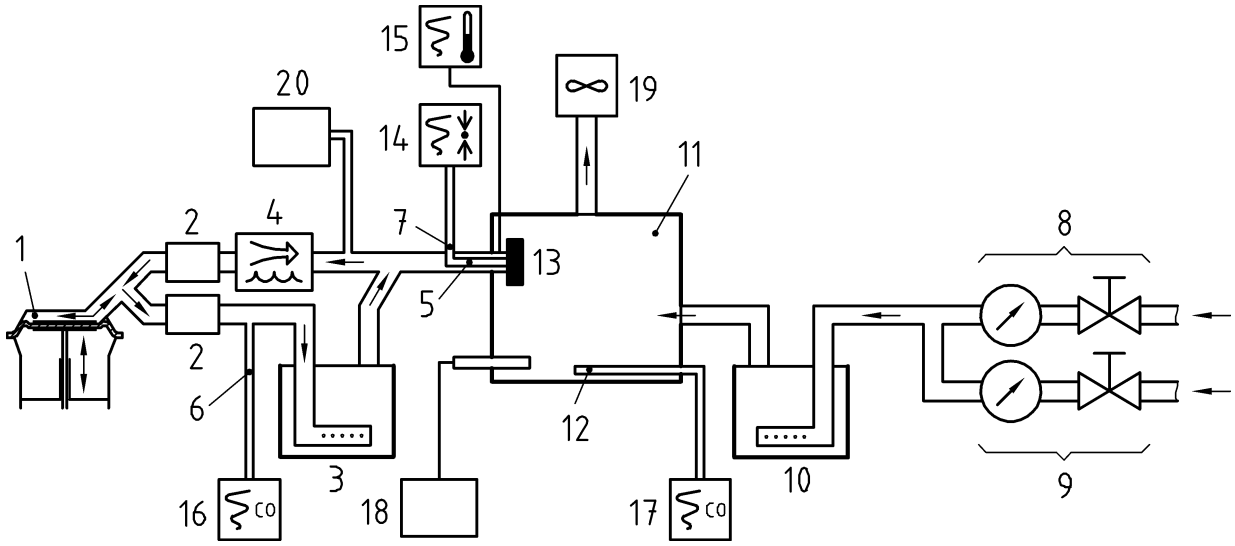
M.S. mechanical strength (7.4.2)

R.U. rough usage test, optional (7.4.3)

T.C. temperature conditioned (7.4.4)

T.T. Transport test (7.5.2)

[a] Most samples are used for more than one test, test with number of samples in brackets are optional.

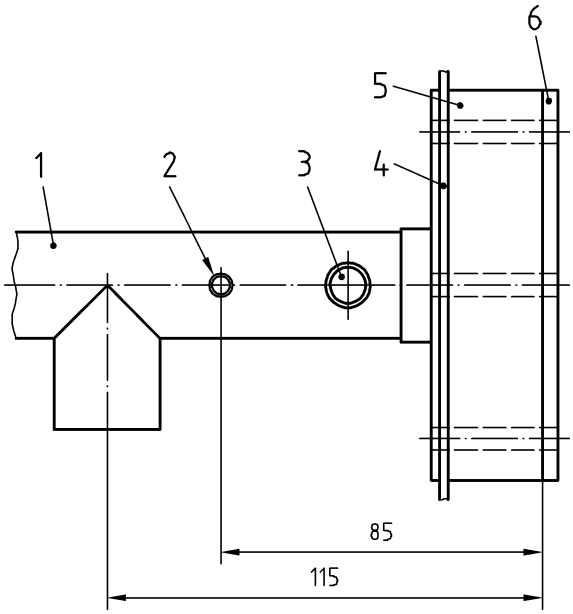


Key

1 Breathing machine
2 Solenoid valves
3 Humidifier (exhaled air)
4 Cooler
5 Connector
6 Sampling port CO-content (inhaled air)
7 Orifice of pressure probe
8 Flow meter for test atmosphere
9 Flow meter for carbon monoxide
10 Humidifier (test atmosphere)
11 Test chamber (dimensions approximately 30 cm x 30 cm x 26 cm)
12 Sampling port, CO-content of test atmosphere at filtering device inlet
13 Test specimen under test (max. pressure difference at filtering device inlet with regard to ambient in the test chamber ± 0,5 mbar)
14 Pressure meter with plotter
15 Temperature measurement equipment with plotter
16 Carbon monoxide analyser & recorder (inhaled air ml/m^3 and ml)
17 Carbon monoxide analyser (test atmosphere)
18 Humidity meter (test atmosphere)
19 Exhaust
20 Humidity meter (inhaled air)

Figure 1 — Scheme of test equipment for testing carbon monoxide performance using filter adapter

Dimensions in millimetres

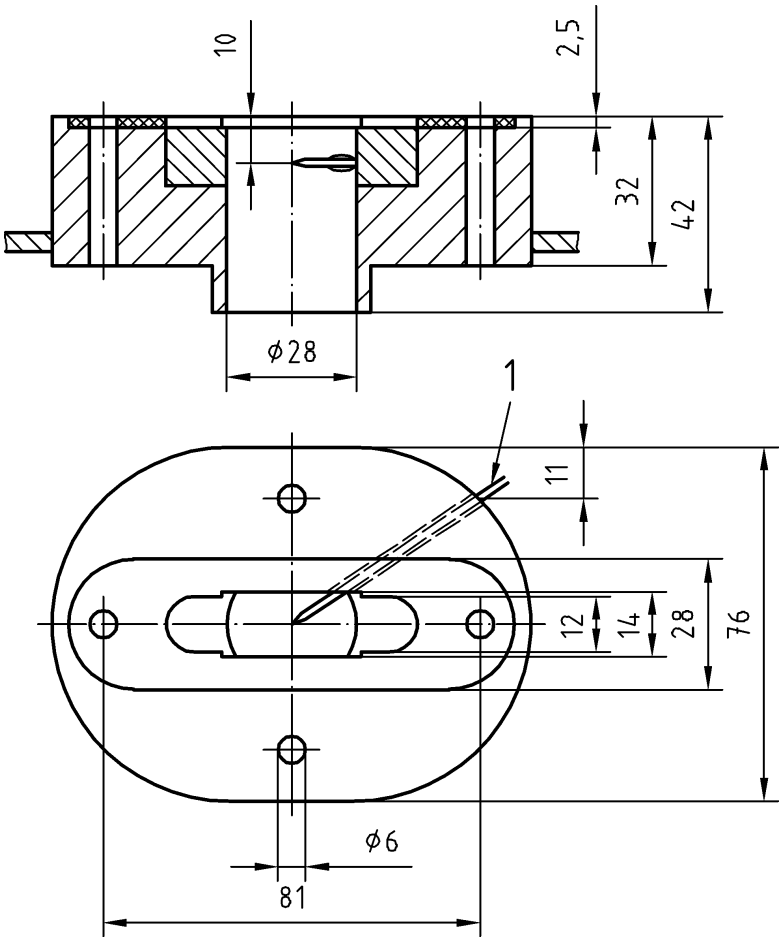


Key

1 Tube
2 Orifice for pressure probe
3 Additional temperature measuring point (wet bulb temperature)
4 Test chamber wall
5 Connecting piece (part of connector)
6 Counter part (part of connector)

Figure 2 — Schematic of a typical connector

Dimensions in millimetres

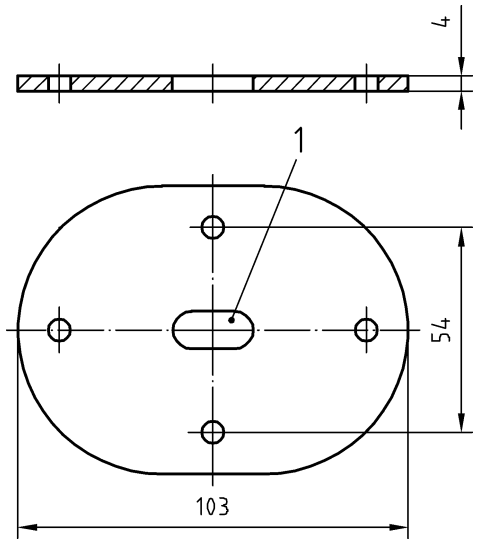


Key

1 Thermocouple (thermowire NiCr – Ni, ∅ 0,2 mm)

Figure 3 — Schematic of a typical connecting piece

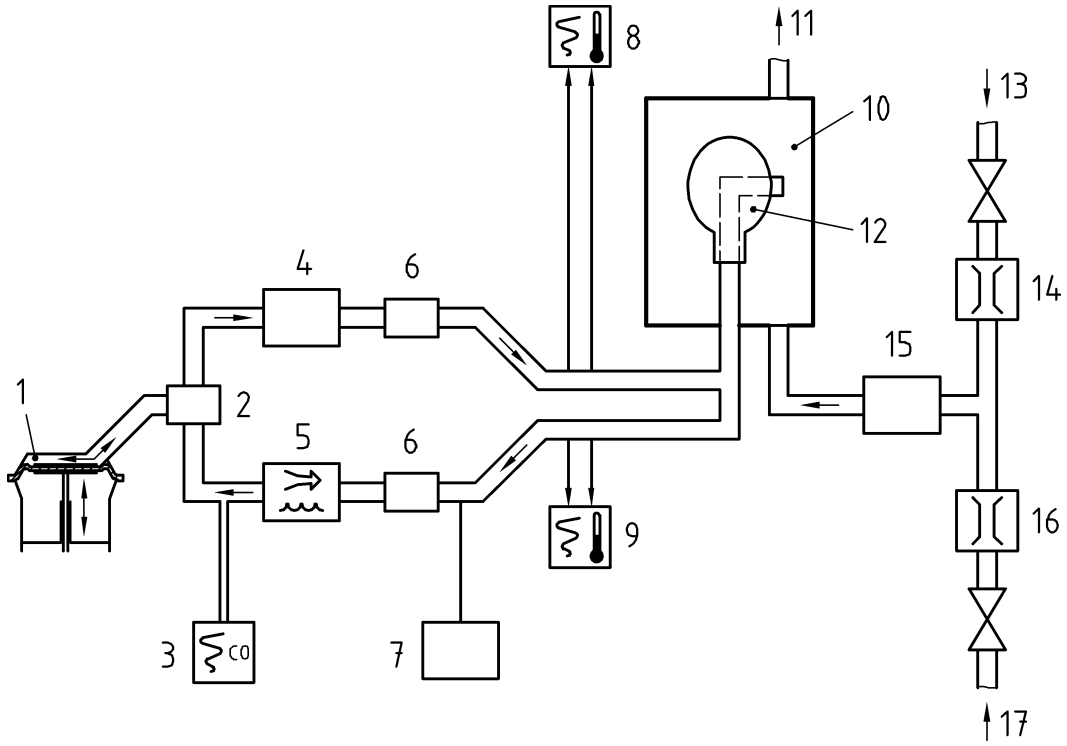
Dimensions in millimetres



Key

1 Cross section according to mouthpiece contours

Figure 4 — Schematic of a typical counter part

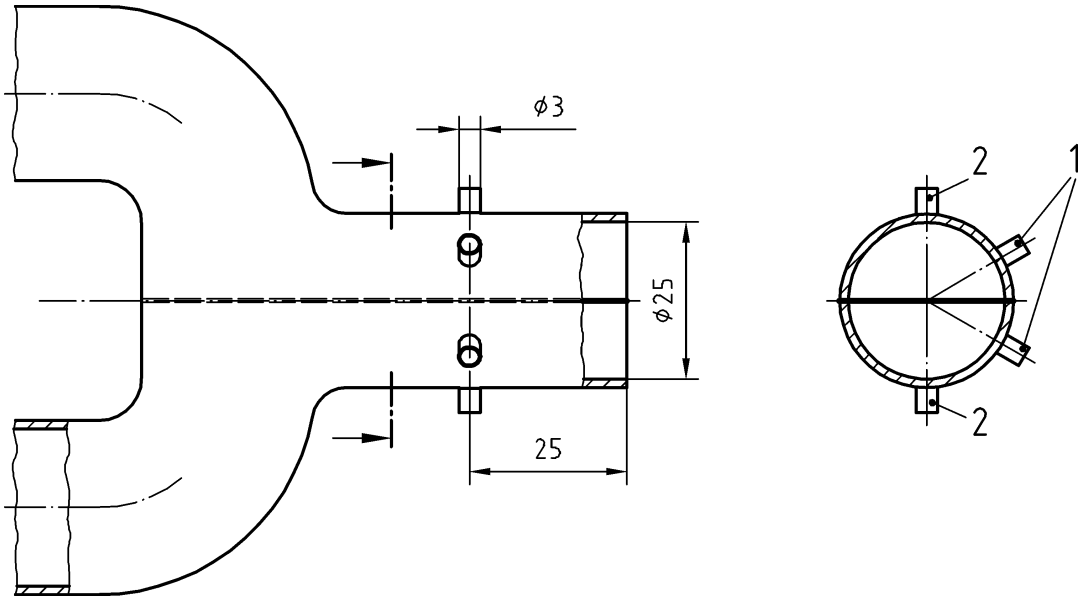


Key

1 Breathing machine
2 Valve system
3 CO-analyser
4 Humidifier
5 Cooler
6 Solenoid valves
7 Dew point meter
8 Exhalation temperature and pressure measuring equipment
9 Inhalation temperature and pressure measuring equipment
10 Test chamber
11 Exhaust
12 Test head for filtering device
13 CO in
14 Flow meter
15 Humidifier
16 Flow meter
17 Air in

Figure 5 — Scheme of test equipment for testing carbon monoxide performance using dummy head

Dimensions in millimetres



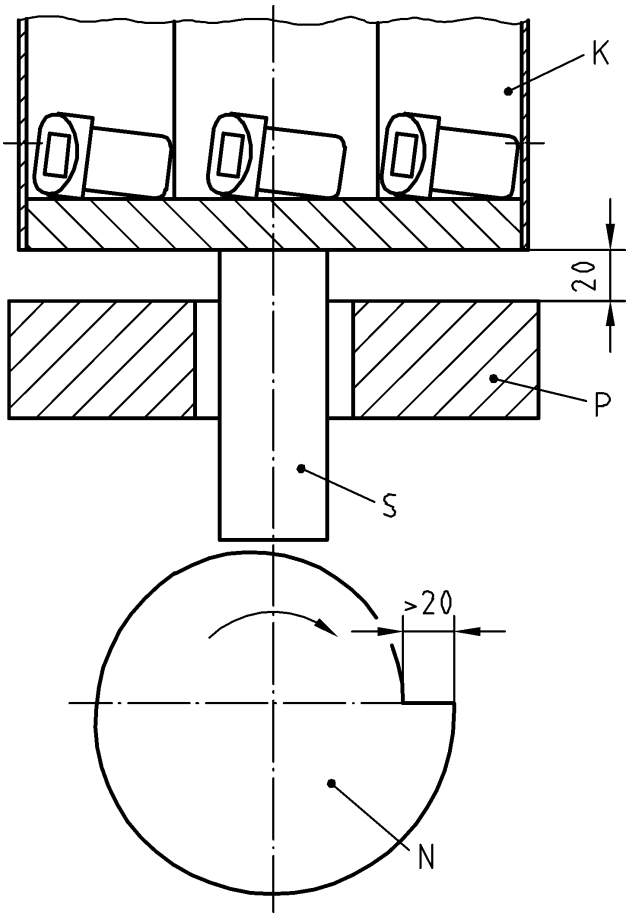
Key

1 Pressure measuring port

2 Thermocouple measuring port

Figure 6 — Schematic of an alternative connector

Dimensions in millimetres



Key

K Steel case
P Steel plate
S Piston
N Cam

Figure 7 — Schematic of a test equipment for mechanical strength test

Dimensions in millimetres

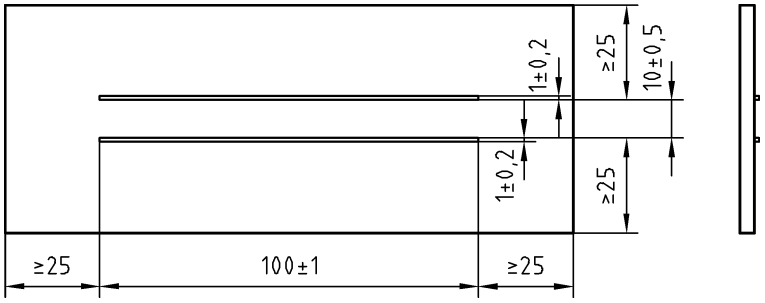


Figure 8 — Schematic of the test piece with electrodes for insulation resistance test

Dimensions in millimetres

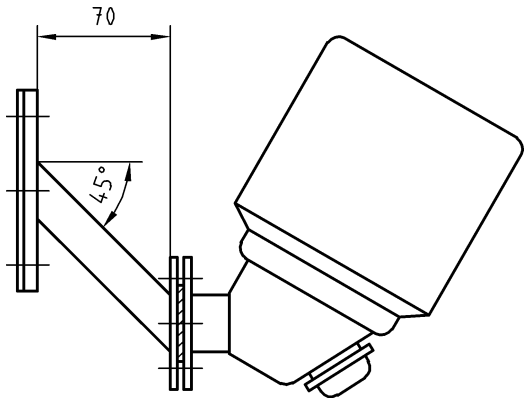
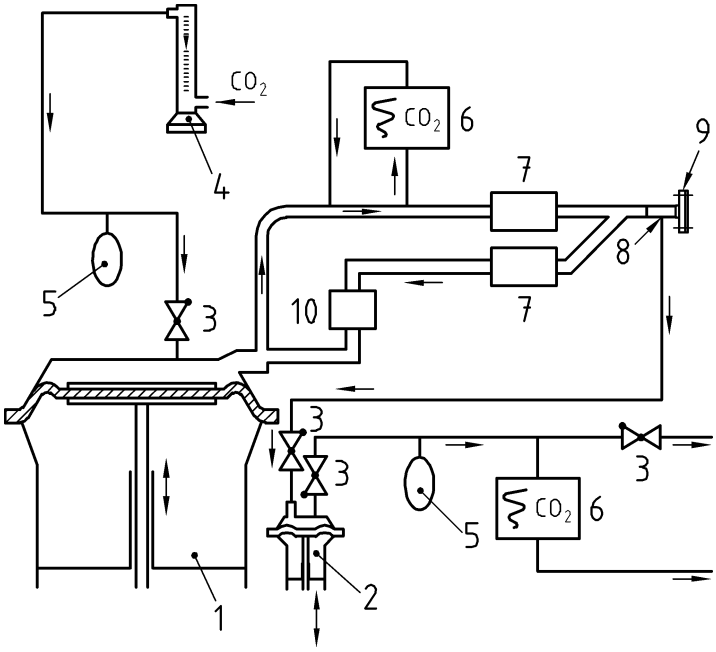


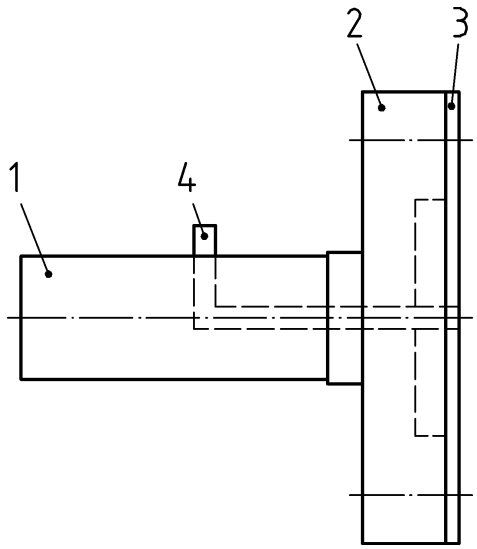
Figure 9 — Schematic of a typical connector for inhalation and exhalation valve testing at the test rig for filter self-rescuers



Key

1 Breathing machine
2 Auxiliary lung
3 Non-return valve
4 Flow meter
5 Compensator
6 Carbon dioxide analyser
7 Solenoid valve
8 Sampling port for inhalation air
9 Connecting piece and counter part (see Figures 11 to 13)
10 Carbon dioxide absorber

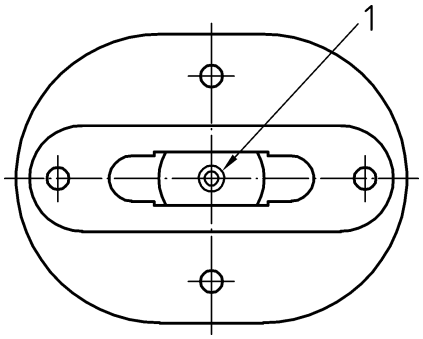
Figure 10 — Schematic of a typical test rig for carbon dioxide content of the inhalation air



Key

1 Tube
2 Connecting piece (part of connector)
3 Counter part (part of connector)
4 Sampling port for inhalation air

Figure 11 — Schematic of a typical connector for carbon dioxide content of inhalation air

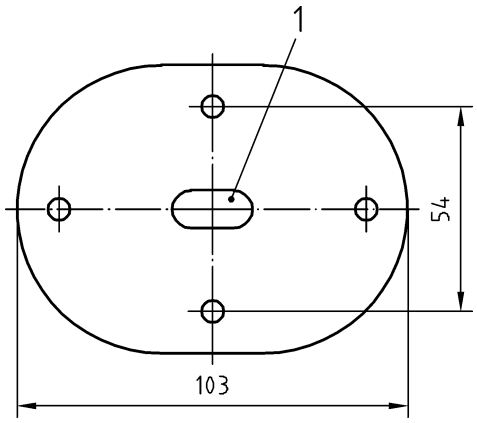


Key

1 Sampling port

Figure 12 — Schematic of a typical connecting piece for carbon dioxide content of inhalation air

Dimensions in millimetres



Key

1 Cross section according to mouthpiece contours

Figure 13 — Schematic of a typical counter part of connecting piece for carbon dioxide content of inhalation air

Annex A
(normative)

Methods of measurement of the insulation resistance of non-metallic carrying containers

A.1 Voltmeter ammeter method

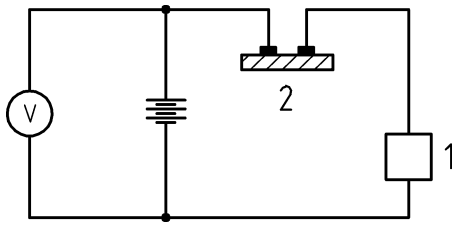
The current is measured directly by means of a micro-ammeter, or a galvanometer (Figure A.1), or indirectly by a d.c. amplifier which indicates the current by measuring the voltage drop which it determines in a known resistance (Figure A.2). The voltage shall be measured by a voltmeter. In certain cases the voltage-current ratio is measured by an instrument indicating the resistance directly (Figure A.3).

A.2 Comparative method

The unknown resistance is compared to a known resistance by determining the ratio of the currents when the same voltage is applied in succession to two resistances (Figure A.4) or by balancing the two resistances in a Wheatstone bridge (Figure A.5).

For all these methods, the unknown resistance shall be large in relation to any calibrated resistance connected in series with it such as to be submitted to practically all the voltage.

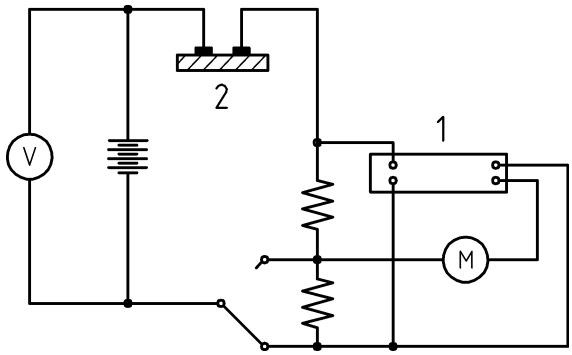
Voltmeter ammeter method



Key

1 Micro-ammeter or galvanometer with shunt
2 Sample
V Voltmeter

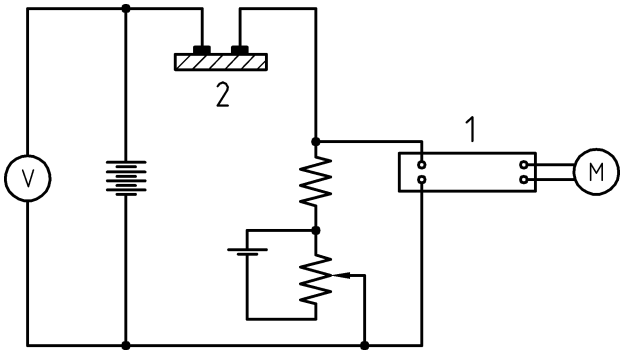
Figure A.1 — Current measurement by micro-ammeter or galvanometer



Key

1 D.C. amplifier
2 Sample
V D.C. Voltmeter
M Indicating Voltmeter

Figure A.2 — Current measurement by means of a D.C. amplifier

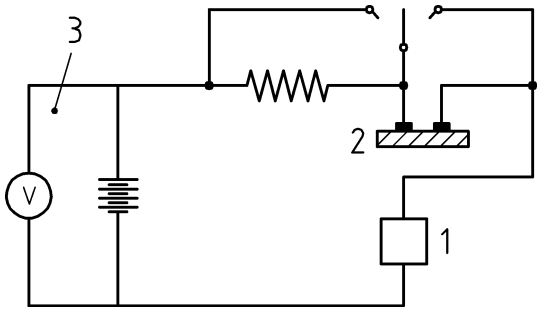


Key

1 D.C. amplifier
2 Sample
V D.C. Voltmeter
M Indicating Voltmeter

Figure A.3 — Current measurement by means of a D.C. amplifier

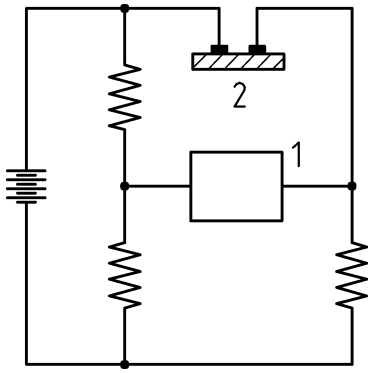
Comparative method



Key

1 Micro-ammeter or galvanometer with shunt
2 Sample
V D.C. Voltmeter (optional)

Figure A.4 — Determination of the ratio of currents when the same voltage is applied successively to the two resistances



Key

1 Detector
2 Sample

Figure A.5 — Wheatstone bridge method

Annex B
(informative)

Method for the determination of wet bulb temperature of the inhaled air

A schematic arrangement of a suitable apparatus is shown in Figure B.1.

A continuous sample of air shall be drawn from the inhalation breathing path at a continuous flow rate of 0,1 l/min and passed through the sensor head block. All sample lines and the sensor head block shall be heated to at least 10 °C above the anticipated dew point temperature. The dew point temperature shall be recorded throughout the test. The dry bulb temperature shall be measured in accordance with 7.6.1.

The wet bulb temperature then shall be determined using the following calculation.

At the dew point temperature, the gas is fully saturated. Hence, the relative humidity (RH) is given by:

$$RH(\%) = \frac{\text{Saturation vapour pressure at dew point temperature}}{\text{Saturation vapour pressure at dry bulb temperature}} x\,100 \qquad \text{(B.1)}$$

Saturation vapour pressure at temperature t shall be obtained from the following equation:

$$\log_{10}(e'') = \frac{\mathrm{G}t}{\mathrm{H}+t} + \mathrm{I} \qquad \text{(B.2)}$$

where

e" is the saturation vapour pressure (mbar)

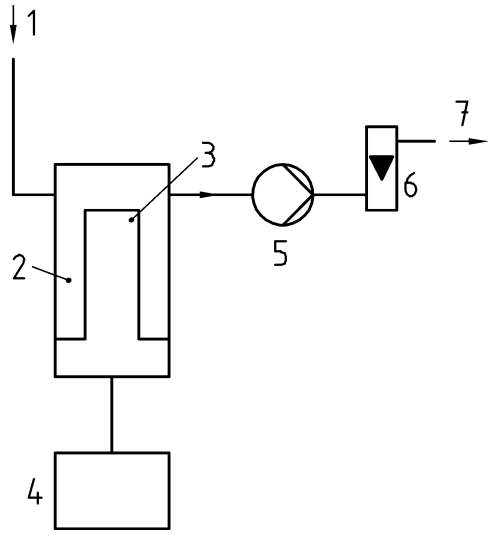
t is the dry bulb temperature (°C)

G is the constant = 7,5

H is the constant = 237,3

I is the constant = 0,785 71

Since the dry bulb temperature has been measured, and the relative humidity determined from Equations (B.1) and (B.2), then the wet bulb depression, and hence the wet bulb temperature can be obtained from standard psychrometric tables.



Key

1 Sample in
2 Stainless steel sensor head block
3 Detector head
4 Control and display unit
5 Sample pump
6 Flow meter (0,1 l/min)
7 Exhaust

Figure B.1 — Schematic arrangement for the determination of wet bulb temperature of the inhaled air

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 89/686/EEC Personal Protective Equipment

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 89/686/EEC Personal Protective Equipment.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Directive 89/686EEC Personal Protective Equipment

Clause(s)/ sub-clause(s) of this EN	Essential Requirements (ERs) of Directive		Qualifying remarks/ Notes
5	1.1.2.2	Classes of protection appropriate to different levels of risk	
6.2	1.1.1	Ergonomics	
6.2	1.1.2.1	Highest level of protection possible	
6.2	1.2.1.3	Maximum permissible user impediment	
6.2	1.3.1	Adaptation of PPE to user morphology	
6.3	1.2.1	Absence of risks and other inherent nuisance factors	
6.3	1.2.1.2	Satisfactory surface condition of all PPE parts in contact with the user	
6.3	1.3.2	Lightness and design strength	
6.4	1.2.1.1	Suitable constituent materials	
6.4	1.3.2	Lightness and design strength	
6.4	2.6	PPE for use in explosive atmosphere	
6.5	2.4.	PPE subject to ageing	
6.6	1.2.1.3	Maximum permissible user impediment	
6.6	1.3.2	Lightness and design strength	
6.7	1.3.2	Lightness and design strength	
6.8	1.3.2	Lightness and design strength	
6.8	2.1	PPE incorporating adjustment systems	
6.9	1.3.1	Adaptation of PPE to user morphology	
6.9	1.3.2	Lightness and design strength	
6.9	2.1	PPE incorporating adjustment systems	
6.10	1.2.1	Absence of risks and other inherent nuisance factors	

6.10	1.3.2	Lightness and design strength	
6.10	2.7	PPE intended for emergency use or rapid installation and/or removal	
6.11	1.2.1	Absence of risks and other inherent nuisance factors	
6.12.1	3.10.1	Respiratory protection	
6.12.2	1.2.1	Absence of risks and other inherent nuisance factors	
6.13	3.10.1	Respiratory protection	
6.14	1.2.1	Absence of risks and other inherent nuisance factors	
6.15	1.3.2	Lightness and design strength	
6.16	1.3.2	Lightness and design strength	
6.17	1.2.1	Absence of risks and other inherent nuisance factors	
6.17	3.10.1	Respiratory protection	
6.18.1	3.10.1	Respiratory protection	
6.18.2	3.10.1	Respiratory protection	
6.18.3	1.2.1	Absence of risks and other inherent nuisance factors	
6.18.4	3.10.1	Respiratory protection	
6.19	1.1.1	Ergonomics	
6.19	1.1.2.1	Highest level of protection possible	
6.19	1.2.1.2	Satisfactory surface condition of all PPE parts in contact with the user	
6.19	1.2.1.3	Maximum permissible user impediment	
6.19	1.3.1	Adaptation of PPE to user morphology	
6.19	2.1	PPE incorporating adjustment systems	
6.19	2.7	PPE intended for emergency use or rapid installation and/or removal	
8	2.4	PPE subject to ageing	
8	2.12	PPE bearing one or more identification or recognition marks directly or indirectly relating to health and safety	
8	3.10.1	Respiratory protection	
9	1.4	Information supplied by the manufacturer	
9	2.4	PPE subject to ageing	
9	2.8	PPE for use in very dangerous situations	
9	3.10.1	Respiratory protection	

WARNING: Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

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