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Respiratory protective devices — Methods of test and test equipment —

Part 9: Determination of carbon dioxide content of the inhaled gas

Appareils de protection respiratoire — Méthodes d'essai et équipement d'essai —
Partie 9: Dosage de la teneur en dioxyde de carbone du gaz inhalé

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Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

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

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

— *Part 1: Determination of inward leakage*

— *Part 2: Determination of breathing resistance*

— *Part 3: Determination of particle filter penetration*

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

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

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

— *Part 7: Practical performance tests methods*

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

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

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

— *Part 11: Determination of field of vision*

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

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

— *Part 14: Measurement of sound level*

Introduction

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

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

— "shall" indicates a requirement;

— "should" indicates a recommendation;

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

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

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

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

Respiratory protective devices — Methods of test and test equipment —

Part 9: Determination of carbon dioxide content of the inhaled gas

1 Scope

This part of ISO 16900 specifies the test methods for determining the increased carbon dioxide content of the inhaled gas caused by wearing the RPD.

Closed circuit supplied breathable gas RPD are excluded from this part of ISO 16900.

NOTE See test method in ISO 16900-13.

2 Normative references

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

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

3 Terms and definitions

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

4 Prerequisites

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

a) the number of test specimens;

b) operating conditions of the RPD;

c) types of RPD head form;

d) any prior conditioning or testing;

e) breathing minute volumes (frequency and tidal volume);

f) carbon dioxide exhalation concentrations (average and peak);

g) any deviations from the test method(s).

5 General test requirements

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

Where the assessment of the pass/fail criterion depends on a measurement, an uncertainty of measurement as specified in Annex A shall be reported.

6 Principle

The respiratory interface is fitted to a RPD head form/torso. Any air or breathable gas supply is operated in the manufacturer's minimum condition, unless prescribed otherwise in the performance standards. Breathing gas containing a defined concentration of carbon dioxide is supplied at a specified rate from a breathing machine to the RPD head form/torso. The inhaled gas is analysed for carbon dioxide concentration. The test is also conducted without the RPD fitted to the RPD head form to determine the baseline carbon dioxide concentration for the test apparatus. This value is then subtracted from the value determined when the RPD is fitted, to determine the increase in inhaled carbon dioxide concentration caused by the RPD.

7 Apparatus

7.1 General

Details of the RPD head forms, airway openings, and sampling ports shall be given.

The breathing machine shall exhale carbon dioxide with peak and average carbon dioxide concentrations as defined by the performance standards. This ensures that the dead space of the respiratory interface is flushed with carbon dioxide rich gas in the same way as would occur when the RPD is worn by a person.

The inhaled gas shall be analysed for carbon dioxide content. The results can be presented as average inhaled carbon dioxide concentration and/or equivalent dead space.

Three alternative test methods are specified in 7.2, 7.3, and 7.4 and shown in Figures 1, 2, and 3. They employ different practical ways of exhaling carbon dioxide enriched gas and different ways to determine the inhaled carbon dioxide concentration. All three methods have been shown to be suitable for the determination of the carbon dioxide concentration of the inhaled breathable gas. Combinations of these methods or other methods may be used if shown to be equivalent, but shall use an appropriate RPD head form/torso.

The accuracy of the inhaled carbon dioxide concentration measurement is determined using the verification volumes (working standards) which are either (250 ± 50) ml or (500 ± 50) ml.

The carbon dioxide exhalation concentration shall be adjustable to be within the limits given in the performance standards.

In order to ensure that the RPD inhales laboratory air containing a minimum concentration of carbon dioxide, an auxiliary fan (not shown in Figures 1 to 3) is arranged so that it blows the exhaled air emerging from the RPD away from the RPD inlet.

NOTE The auxiliary fan method is not required when carrying out tests on devices which have their own independent breathable gas supply (e.g. compressed airline devices).

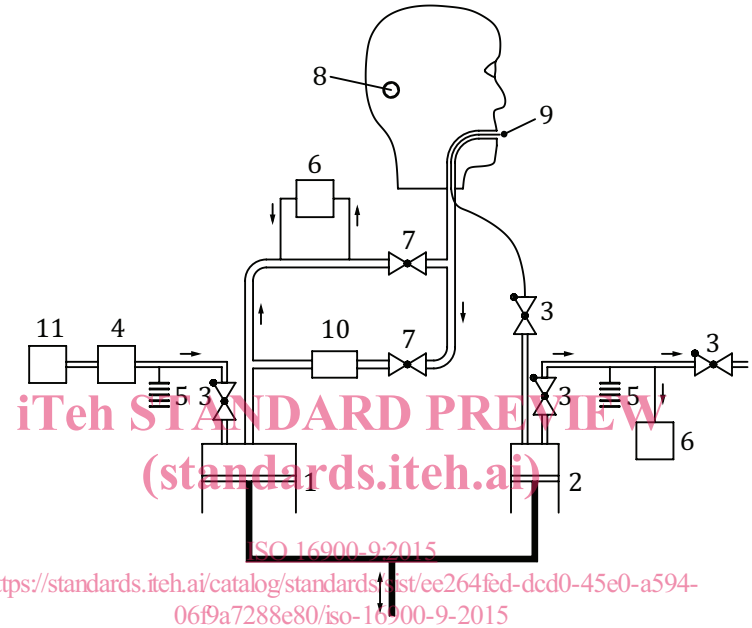
Good laboratory ventilation is required to maintain the ambient laboratory carbon dioxide concentration below 0,1 % during testing.

For RPD with an independent breathable gas supply, the carbon dioxide concentration in the supply shall be less than 0,1 %.

7.2 Test method 1

7.2.1 Breathing machine

A single cylinder breathing machine meeting shall be used. In order to avoid errors in the measurement of carbon dioxide in the inhaled gas, it is important that the solenoid valves (see Figure 1) make a good seal on closing and are actuated at precisely the same time. In order to avoid upsetting the pressure balance within the system, the solenoid valve actuation should always occur at a time when the piston's movement is at a minimum. Valves shall have a response time of not more than 5 ms from triggering to fully open/closed. The effective tubing volume between the output of the breathing machine to the mouth of the RPD head form shall not exceed 4 l.



Key

1	breathing machine	7	solenoid valve
2	auxiliary piston	8	RPD head form
3	non-return valve	9	sampling tube for inhalation gas
4	carbon dioxide flow controller	10	carbon dioxide absorber
5	volume compensator	11	carbon dioxide supply
6	carbon dioxide analyser		

Figure 1 — Schematic of a typical single cylinder arrangement for testing carbon dioxide content of the inhalation gas

7.2.2 Carbon dioxide analyser

A carbon dioxide analyser with a resolution of 0,01 % is recommended. For the exhaled and inhaled carbon dioxide measurements, separate analysers may be used.

7.2.3 Carbon dioxide sampling

A sample of the inhaled gas is taken from the mouth (see Figure 1, key 9) by an auxiliary lung driven by the breathing machine and in phase with it. It is set to inhale a known sample volume (a chosen percentage of the inhalation volume of the breathing machine) during the inhalation stroke of the breathing machine. This apparent "loss" in inhalation volume of the breathing machine is compensated for by the volume of carbon dioxide fed via the flow meter into the breathing machine on its inhalation stroke. It is therefore important that these two volumes are equal.