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Second edition
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Respiratory protective devices — Methods of test and test equipment —

Part 1: Determination of inward leakage

Appareils de protection respiratoire — Méthodes d'essai et équipement d'essai —
Partie 1: Détermination des fuites vers l'intérieur

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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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 15, *Respiratory protective devices*

This second edition cancels and replaces the first edition (ISO 16900-1:2014), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the criteria for selection of test panels has been changed from the principal components analysis (PCA) method to the bivariate grid method. References to the PCA method in other clauses have been modified as necessary;

— a new clause has been added to address measurement of inward leakage in the ocular zone;

— a figure has been added to illustrate the pulsed sampling system;

— the conditions for use of a condensation particle counter have been modified;

— Annex D has been re-written to reflect changes to the criteria for selection of test panels.

NOTE The list above is not intended as a complete list of all changes.

A list of all parts in the ISO 16900 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

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

Respiratory protective devices — Methods of test and test equipment —

Part 1: Determination of inward leakage

1 Scope

This document specifies the test methods for determining inward leakage of respiratory interfaces (RI) and total inward leakage of complete respiratory protective devices (RPD) using specified test agents and incorporating specified body movements, at specified metabolic work rates.

These tests are conducted in laboratories using specific test agents under specified conditions and therefore do not indicate the performance of the device in actual use.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

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

ISO 16900-5, *Respiratory protective devices — Methods of test and test equipment — Part 5: Breathing machine, metabolic simulator, RPD headforms and torso, tools and verification tools*

ISO 17420-3, *Respiratory protective devices — Performance requirements — Part 3: Thread connection*

ISO 21748, *Guidance for the use of repeatability, reproducibility and trueness estimates in measurement uncertainty evaluation*

ISO/TS 16976-2:2015, *Respiratory protective devices — Human factors — Part 2: Anthropometrics*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
assisted filtering RPD
filtering RPD in which air is moved through the filter(s) by means of a blower in addition to the breathing of the wearer

3.2
porous device
RPD incorporating materials, excluding filters, that can be penetrated by gases and vapours during an inward leakage test, leading to an increase of the inward leakage

3.3
unassisted filtering RPD
filtering RPD in which air is drawn through the filter(s) solely by the breathing of the wearer

4 Prerequisites

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

a) minimum number of test samples;

b) operating conditions of the RPD;

c) the exercise regime to be used;

d) if appropriate, the use of crosswinds during particular test exercises;

e) any exclusions from the test exercise regimes of Annex B;

f) any prior conditioning, sequence of preconditioning, and/or testing required;

g) any accessory(ies) of the RPD to be included in the assessment;

h) Selection of test panel candidates.

5 General test requirements

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 conditions 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.

For each of the required measurements performed in accordance with this document, a corresponding estimate of the uncertainty of measurement shall be evaluated. This estimate of uncertainty shall be stated when reporting test results, in order to enable the user of the test report to assess the reliability of the result in accordance with Annex A.

NOTE Uncertainty of measurement can be calculated in accordance with JCGM 100[1].

6 Principle

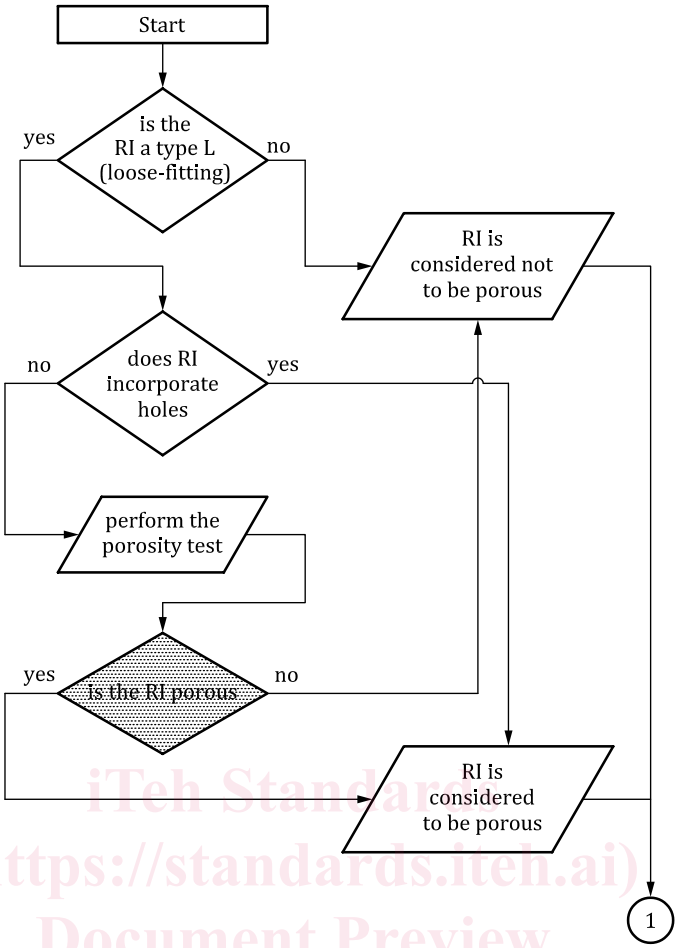
6.1 General

A test subject wearing the RPD being tested performs a series of exercises while surrounded by an atmosphere containing a known concentration of a test substance. During these exercises, the concentration of the test substance inside and outside the respiratory interface (RI) is measured and compared.

6.2 Choice of test agent

Three test agents are specified: one solid aerosol, one liquid aerosol, and a gas. The general principle of the test is the same for all substances. The test agent(s) used depend on the type of RPD being tested and are chosen according to Figure 1 and Figure 2. When using sodium chloride as the test agent for respiratory interfaces type T (tight fitting), Method 2A (pulsed sampling) shall be used.

Where a choice of gas or aerosol is permitted according to Figure 1 and Figure 2, the aerosol test methods are preferred. SF_6 is regarded to be a greenhouse gas and its use is deemed undesirable where it could be avoided.



NOTE Excluded are RPD which are obviously open to the atmosphere and which need not be tested using a challenge gas.

Figure 1 — Determination of porosity of RI (Respiratory Interface)

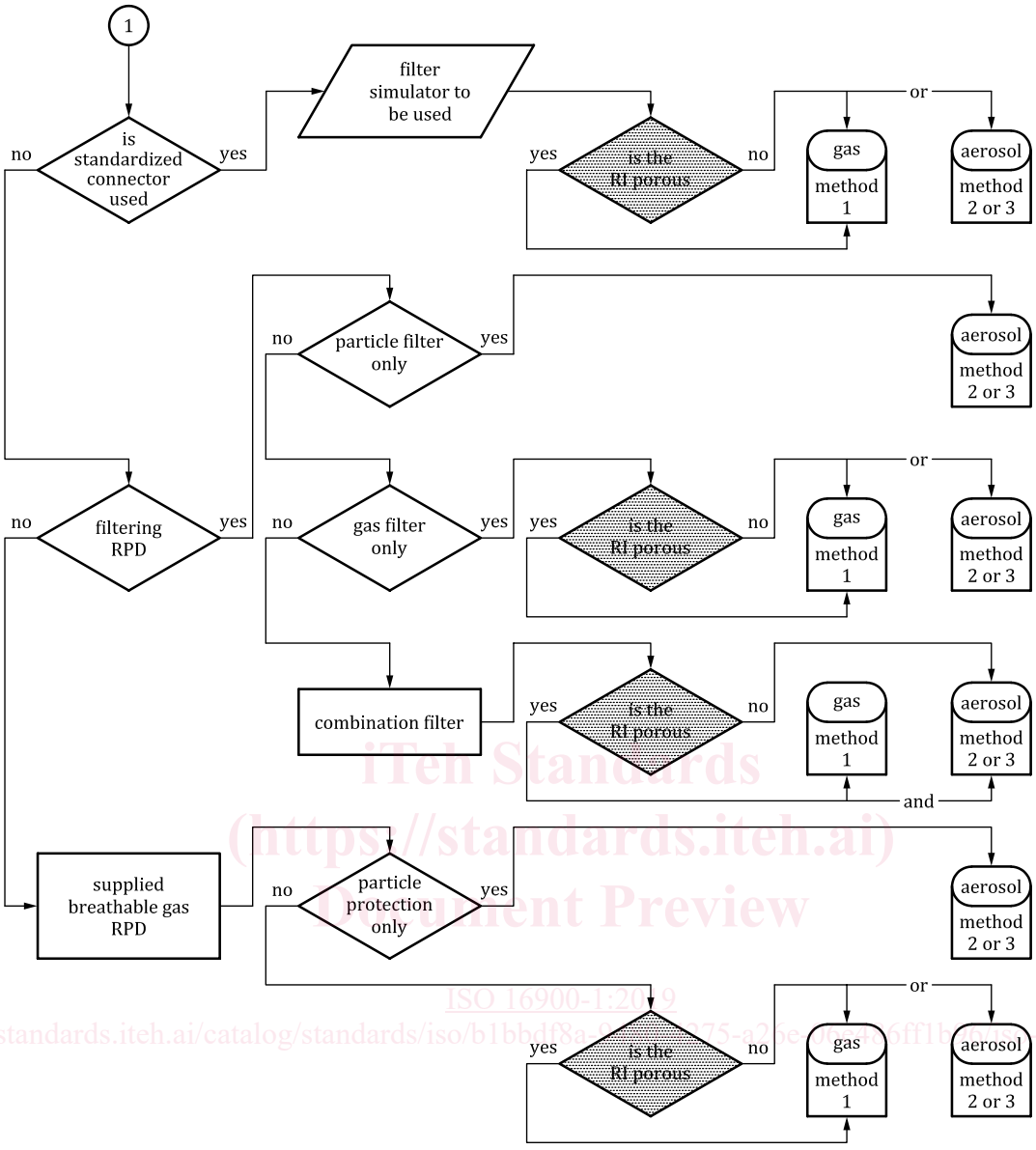


Figure 2 — Determination of test methods for RI (Respiratory Interface)

7 Human test panel

7.1 General

7.1.1 Before performing tests involving human test panels, account should be taken of any national or other regulations concerning, for example the medical history, any known allergies, examination, or supervision of the test subjects.

7.1.2 Test subjects shall be trained in wearing the type of RPD being tested.

7.1.2.1 Unless the information supplied by the RPD manufacturer specifies that the device can be worn by persons with facial hair, then panel members shall be clean shaven in the area of the face seal.

7.1.2.2 Persons with scars or other facial blemishes in the area of the face seal that might give rise to face seal leakage shall not be selected for the test panel.

7.1.2.3 If more than one size of respiratory interface is manufactured, the test subjects shall select the most appropriate size in accordance with the information supplied by the manufacturer.

7.1.3 The test subject shall be informed of all aspects of the test to be undertaken. In particular, where the total length of the test duration is as long as 40 min, it shall be ensured that the test subject is physically able to undertake a test of this duration.

When using particle counting detection methods, the test subject should refrain from smoking for at least 30 min before wearing the RPD.

7.2 Test panel

Unless otherwise specified in the performance standards, the test panel shall consist of 15 test subjects selected according to the following criteria:

a) Candidates for the test panel shall be measured for face length and face width in accordance with ISO/TS 16976-2:2015, Annex C;

b) The face length and face width measurements of the candidates shall be used to allocate the candidates to the cells of the bivariate panel according to ISO/TS 16976-2:2015, 8.2, (see Annex D);

c) Any candidate for whom the bivariate measurements for face width and length fall outside of the limits of the panel (see ISO/TS 16976-2:2015, Figure C.1) shall not be used as a test subject;

d) The selection of the subjects for a test panel shall take into consideration the size of the respiratory interface as defined by the manufacturer;

NOTE In certain circumstances (e.g. for class dT respiratory interfaces) it can be necessary to take into consideration neck circumference.

e) Where an RPD equipped with a tight fitting respiratory interface (Type T) is being tested, the fit of the respiratory interface shall be assessed on each subject in accordance with the method specified in the information supplied by the RPD manufacturer. If the respiratory interface does not fit the subject in accordance with the test required by the manufacturer, then that subject shall be excluded from the test panel and shall be replaced with an alternative test subject. The fit assessment described shall be performed in a separate test, prior to the inward leakage assessment

8 Test agents

Three test agents are specified for the inward leakage tests:

a) test agent 1 = sulfur hexafluoride gas (SF_6);

b) test agent 2 = sodium chloride aerosol (NaCl);

c) test agent 3 = corn oil

All three test agents are equally acceptable for determination of inward leakage or total inward leakage, subject to the selection requirements of Figure 2.

If porosity is indicated by the results from the materials porosity test (see Annex C), then the RPD shall be tested using sulfur hexafluoride gas.

9 Apparatus

9.1 Enclosure, large enough to permit each test subject to complete the test exercise regime without restriction. A uniform and continuous flow of the relevant test atmosphere shall be delivered into the test enclosure.

The enclosure design and air flow management system shall permit the test atmosphere concentration within the area occupied by the RPD and wearer during all exercises to be homogeneous and stable (within ±10 %) throughout the duration of any test.

The air velocity through the enclosure measured close (within 30 cm) to the test subject's head, with the test subject standing centrally (on the treadmill where appropriate) and without crosswind conditions, shall be sufficient to maintain the specified concentration but shall not exceed 0,2 m/s.

The enclosure shall be designed so that the test subject is visible from the outside of the enclosure at all times while in the enclosure. A means of providing communication between the test subject(s) and the test operator(s) shall be provided.

For RPD to be tested under crosswind conditions, provision shall be made to generate a crosswind of 2 m/s across the enclosure, from the front, rear or side (left or right), in the vicinity of the test subject's head.

NOTE Such provision could need to be adjustable in height to generate the crosswind at the position appropriate for each test subject.

The design of the enclosure shall be such that the device worn by the subject can be supplied with clean air (free of the test agent), where necessary.

The volume of the test chamber shall be large enough, and the replacement rate of the test atmosphere shall be such as to prevent dilution of the test atmosphere by clean air emanating from the device under test.

When SF_6 gas is employed as the test atmosphere, the test chamber should preferably permit re-circulation of the air/SF_6 volume to minimize exhaust of SF_6 into the ambient atmosphere.

9.2 Treadmill, capable of working up to the speed as required by the exercise regime defined in Annex B, shall be used.

9.3 Test agent generator - General, capable of generating the test agent in the required concentration, and, in case of an aerosol, of the required particle size distribution.

9.4 Detection system - General, either one detector or different detectors for measuring the test enclosure and the respiratory interface sample concentrations.

The detection system including sampling probes and connections shall have a response time of less than 20 s for a response of 10 % to 90 % of the full-scale deflection of the range used. Further details of the detections system required for each specified test agent are given in 11.2, 11.3, and 11.4.

10 RPD preparation

10.1 General

Prior to the inward leakage test, examine the RPD in accordance with the information supplied by the manufacturer to ensure that it is in good working condition and can be used without hazard to the test subject.