INTERNATIONAL STANDARD

ISO 16900-1

First edition
2014-10-15

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

Reference number
ISO 16900-1:2014(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword ..... **iv**
Introduction ..... **vi**
1 Scope **1**
2 Normative references **1**
3 Terms and definitions **1**
4 Prerequisites **2**
5 General test requirements **2**
6 Principle **2**
7 Human test panel **4**
7.1 General 4
7.2 Selection of test subjects 5
8 Test agents **5**
9 Apparatus **5**
10 RPD preparation **6**
10.1 General 6
10.2 Sample tubes and probe 6
10.3 Sample flow rates 10
10.4 Filtering RPD preparation 10
10.5 Supplied breathable gas devices 12
10.6 Supplied breathable gas devices incorporating additional filtration capacity (combined RPD) 12
11 Method(s) **12**
11.1 Test method — General 12
11.2 Test method 1: Sulfur hexafluoride (SF_6) 13
11.3 Test method 2: Sodium chloride (NaCl) 16
11.4 Test method 3: Corn oil aerosol 23
12 Test report **25**
13 Uncertainty of measurement **25**
Annex A (normative) **Application of uncertainty of measurement** **26**
Annex B (normative) **Test exercise regime** **28**
Annex C (normative) **Material porosity test** **32**
Annex D (normative) **Human test panel** **34**

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 6: Mechanical resistance/strength of components*

— *Part 7: Practical performance test methods*

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

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

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

— *Part 11: Determination of field of vision*

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

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

— *Part 14: Measurement of sound level*

The following parts are under preparation:

— *Part 5: Breathing machine/metabolic simulator/RPD headforms/torso, tools and transfer standards*

Introduction

This part of ISO 16900 is intended as a supplement to the respiratory protective devices (RPD) performance standard ISO 17420 (all parts). Test methods are specified for complete devices or parts of devices that are intended to comply with ISO 17420. If deviations from the test method given in this part of ISO 16900 are necessary, these deviations will be specified in ISO 17420.

Respiratory protective devices — Methods of test and test equipment —

Part 1: Determination of inward leakage

1 Scope

This part of ISO 16900 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, 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*

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

ISO 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 estimation*

ISO/TS 16976-2:2010, *Respiratory protective devices — Human factors — Part 2: Anthropometrics*

3 Terms and definitions

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

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

1) To be published.

4 Prerequisites

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

a) minimum number of test specimens;

b) number of test subjects and selection criteria;

c) operating conditions of the RPD;

d) if appropriate, test method (including test agent and sampling methods) to be used;

e) the exercise regime to be used;

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

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

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

i) any optional features of the RPD to be included in the assessment;

j) characteristics to be assessed subjectively (if appropriate).

5 General test requirements

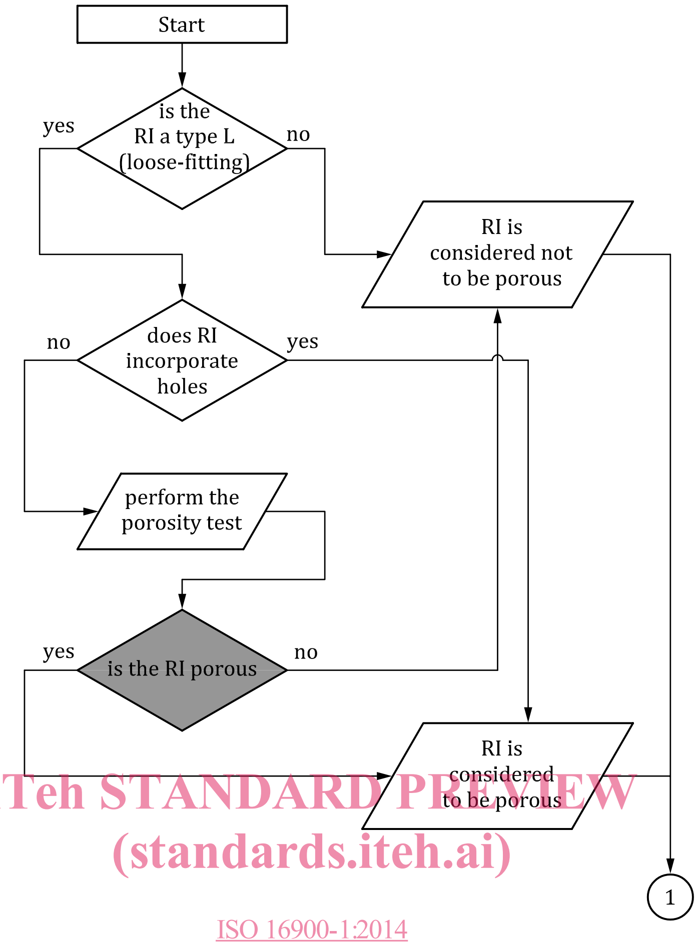
Unless otherwise specified, the values stated in this part of ISO 16900 are expressed as nominal values. Except for temperature limits, values which are not stated as maxima or minima shall be subject to a tolerance of ±5 %. Unless otherwise specified, the ambient conditions for testing shall be between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

6 Principle

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.

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.

NOTE Where a choice of gas or aerosol is permitted according to Figure 1, the aerosol test methods are preferred since 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)

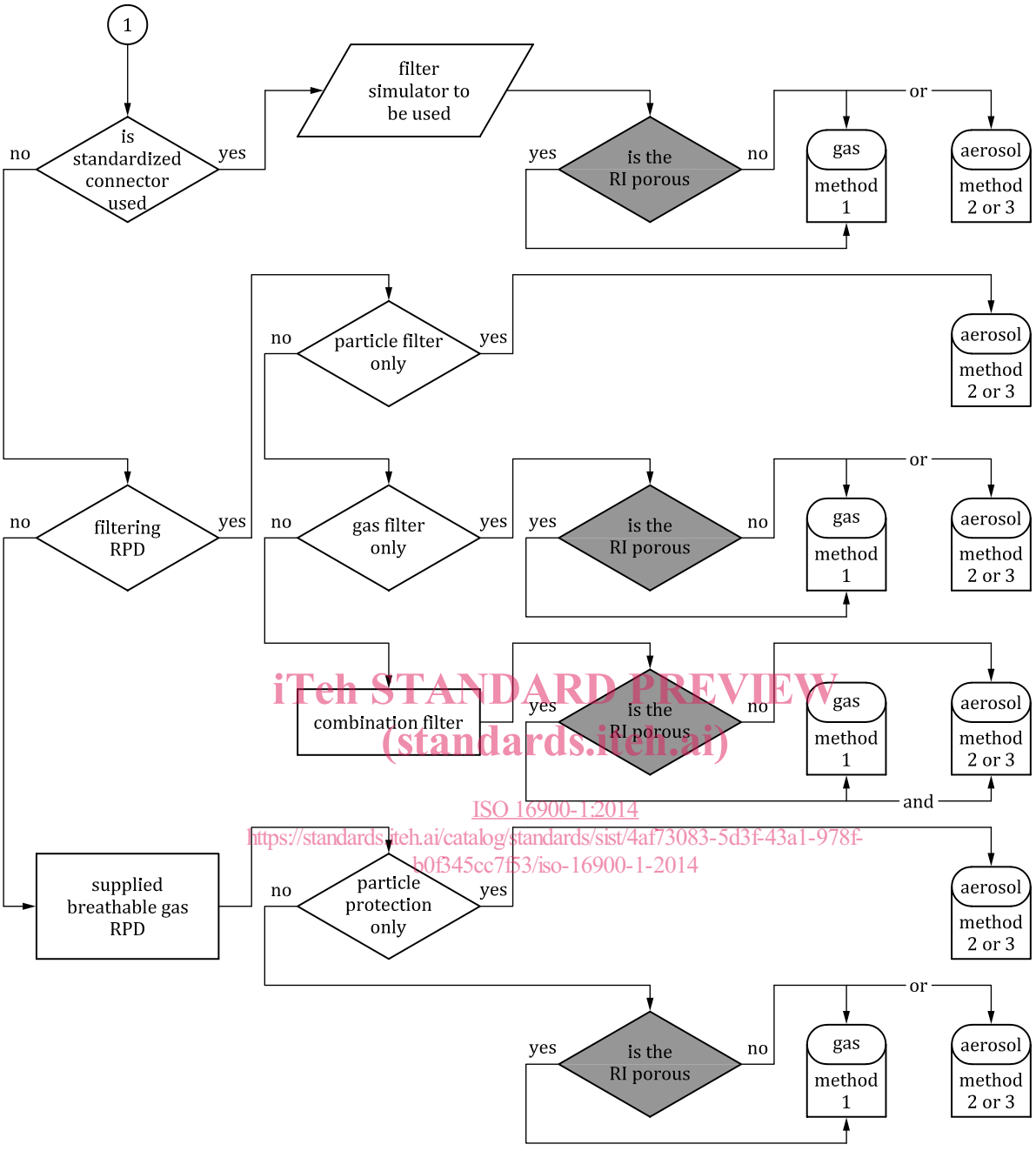


Figure 2 — Determination of test methods for RI (Respiratory Interface)

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 know allergies, examination, or supervision of the test subjects.

7.1.2 Test subjects shall be trained by a competent person in wearing the type of RPD being tested.

7.1.2.1 Unless the RPD manufacturer's user instructions specify that the device can be worn by persons with facial hair, then male 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 Persons nominated as test subjects shall follow the manufacturer's donning instructions, which can include a wearer seal check. If the person cannot achieve an adequate seal, following the manufacturer's instructions, the person shall not be used for the inward leakage test.

7.1.2.4 Where a manufacturer specifies a size range for wearers of the device, only subjects who fall within the specified range shall be used for the test.

7.1.2.5 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.

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

7.2 Selection of test subjects

The human test panel shall be as defined in ISO/TS 16976-2:2010, 8.3, [principal component analysis (PCA) panel]. Further information is given in Annex D. The selection of the test subject shall be as specified by the RPD manufacturer according to the requirements of ISO 17420.

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 aerosol.

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 (Annex C), then it 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 supervisor(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 might need to be adjustable in height to generate the crosswind at the appropriate position for all test subjects.

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 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 manufacturer's instructions to ensure that it is in good working condition and can be used without hazard to the test subject.

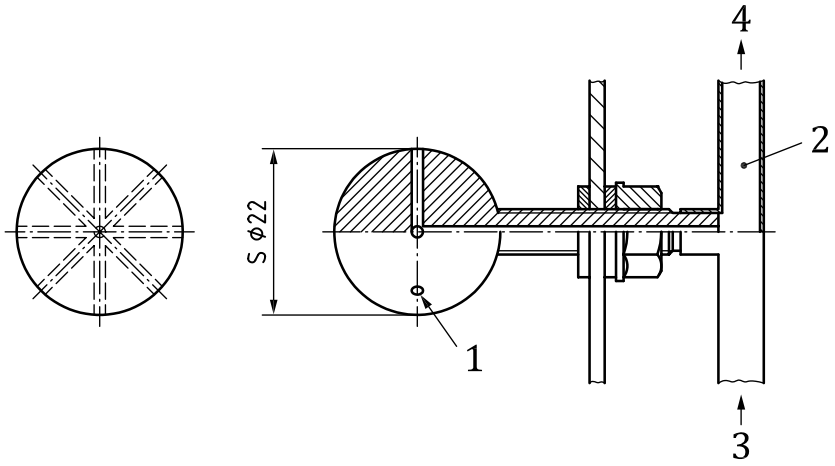
Prepare the RPD to be tested in accordance with their design, the test agent to be used, and whether the inward leakage of a respiratory interface or the total inward leakage of a complete device is to be determined. Further details are given in 10.4, 10.5, and 10.6.

10.2 Sample tubes and probe

In order to sample and analyse the air inside the respiratory interface, use an adapter normally provided by the manufacturer; or where this is not possible, punch a hole in the respiratory interface and insert a probe through which the sample is drawn by a suitable sample pump.

Multiple-hole sampling probe (Figure 3 and Figure 4) should be used to minimize sampling bias within the respiratory interface. Single-hole probes with chamfered entry (Figure 5) have been shown to be acceptable. Figures 6 to 9 show probe methods of fixation.

Dimensions in millimetres

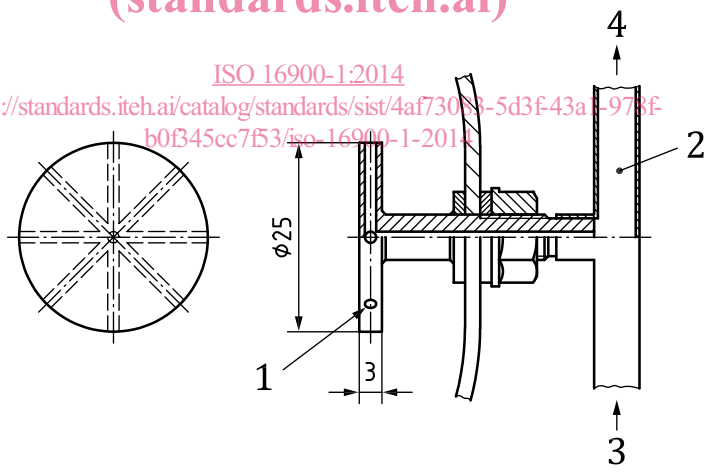


Key

1 eight holes, diameter 1,5 mm, equally spaced
2 suitable flexible tube
3 direction of drying air (for sodium chloride only)
4 connection to sample pump

Figure 3 — Example of ball probe

Dimension in millimetres



Key

1 eight holes, diameter 1,5 mm, equally spaced
2 suitable flexible tube
3 direction of drying air (for sodium chloride only)
4 connection to sample pump

Figure 4 — Example of disc probe