

AS/NZS 17420.2:2021



Australian/New Zealand Standard™

# Respiratory protective devices — Performance requirements

Part 2: Requirements for filtering RPD (ISO 17420-2:2021 (ED.1.0) MOD)



AS/NZS 17420.2:2021

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- Australian Institute of Occupational Hygienists
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Australian/New Zealand Standard™

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**Part 2: Requirements for filtering RPD (ISO  
17420-2:2021 (ED.1.0) MOD)**

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## Preface

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee SF-010, Occupational Respiratory Protection.

The objective of this document is to specify requirements for the performance and testing of filtering respiratory protective devices (RPD) in accordance with their classification and for use in the workplace to protect the wearer from hazardous atmospheres and/or environments.

Requirements for RPD elements and components are also specified in this document.

This document is an adoption with national modifications, and has been reproduced from, ISO 17420-2:2021, *Respiratory protective devices — Performance requirements — Part 2: Requirements for filtering RPD*.

The modifications are additional requirements and are set out in [Appendix ZZ](#), which has been added at the end of the source text.

[Appendix ZZ](#) lists the variations to ISO 17420-2:2021 for the application of this document in Australia and New Zealand.

As this document has been reproduced from an International Standard, the following applies:

- (a) In the source text “this part of 17420” should read “this Australian/New Zealand document”.
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## Foreword

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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](http://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](http://www.iso.org/patents)).

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For an explanation on 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 the following URL: [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 94, *Personal safety - Personal protective equipment*, Subcommittee SC 15, *Respiratory protective devices*.

A list of all parts in the ISO 17420 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](http://www.iso.org/members.html).

## Introduction

This document describes basic requirements for filtering respiratory protective devices (RPD) and its elements and components.

Requirements for RPD used in environments for special applications are given in the relevant parts of the ISO 17420 series.

Some test methods are described. For other test methods references are given to the ISO 16900 series "Methods of test and test equipment" or other test methods not developed by ISO/TC 94/SC 15.

[Annex A](#) gives information about reliability.

[Annex B](#) features an example of a FMEA (Failure Mode and Effects Analysis).

[Annex C](#) gives the test schedules including any pre-conditioning and number of samples.

[Annex D](#) provides information for normalisation of test results.

The sequence of testing follows the principle to minimize the necessary number of samples by carrying out destructive tests at the end. It also includes for safety reason that tests with test subjects are only carried out after the test samples have shown their safe performance in other tests.

# Australian/New Zealand Standard

## Respiratory protective devices — Performance requirements

### Part 2: Requirements for filtering RPD (ISO 17420-2:2021 (ED.1.0) MOD)

#### 1 Scope

This document specifies requirements for the performance and testing of filtering respiratory protective devices (RPD) in accordance with their classification and for use in the workplace to protect the wearer from hazardous atmospheres and/or environments.

Requirements for RPD elements and components are also specified in this document.

#### 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 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

ISO 16900-1:2019, *Respiratory protective devices — Methods of test and test equipment — Part 1: Determination of inward leakage*

ISO 16900-2, *Respiratory protective devices — Methods of test and test equipment — Part 2: Determination of breathing resistance*

ISO 16900-3, *Respiratory protective devices — Methods of test and test equipment — Part 3: Determination of particle filter penetration*

ISO 16900-4:2011, *Respiratory protective devices — Methods of test and test equipment — Part 4: Determination of gas filter capacity and migration, desorption and carbon monoxide dynamic testing*

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 16900-6:—<sup>1)</sup>, *Respiratory protective devices — Methods of test and test equipment — Part 6: Mechanical resistance/strength of components and connections*

ISO 16900-7:2020, *Respiratory protective devices — Methods of test and test equipment — Part 7: Practical performance test methods*

ISO 16900-8, *Respiratory protective devices — Methods of test and test equipment — Part 8: Measurement of RPD air flow rates of assisted filtering RPD*

ISO 16900-9, *Respiratory protective devices — Methods of test and test equipment — Part 9: Determination of carbon dioxide content of the inhaled gas*

ISO 16900-12, *Respiratory protective devices — Methods of test and test equipment — Part 12: Determination of volume-averaged work of breathing and peak respiratory pressures*

ISO 16900-14:2020, *Respiratory protective devices — Methods of test and test equipment — Part 14: Measurement of sound level*

ISO 16972, *Respiratory protective devices — Vocabulary and graphical symbols*

ISO/TS 16973, *Respiratory protective devices -- Classification for respiratory protective device (RPD), excluding RPD for underwater application*

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1) Under preparation, Stage at the time of publication ISO/DIS 16900-6:2020.

ISO 17420-1:2021, *Respiratory protective devices — Performance requirements — Part 1: General*

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

IEC 61000-6-2, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity standard for industrial environments*

### 3 Terms, definitions, abbreviations and symbols

#### 3.1 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/>

##### 3.1.1

##### **non pre-conditioned state**

without pre-conditioning but possibly modified to carry out tests or already used in non-destructive tests

Note 1 to entry: This includes e.g. cleaning and disinfection.

##### 3.1.2

##### **as worn state**

RPD where all components are connected and assembled in the way that it is intended to be used and worn (e.g. worn by the wearer, adapted to a RPD headform or RPD headform and torso or suitable holder)

Note 1 to entry: All of the various components [e.g. for an assisted filtering device: blower unit, battery, respiratory interface (RI), filters, etc.] have been completely assembled and then connected (RI connected to the hose of the blower unit) together in accordance with the information supplied by the manufacturer.

##### 3.1.3

##### **ready for assembly state**

RPD or components with seals, plugs or other environmental protective means, still in place ready to be assembled and/or donned

Note 1 to entry: RPD or components can remain sealed and plugged until donning if so stated in the information supplied by the manufacturer.

##### 3.1.4

##### **integrated RPD**

RPD designed so that components in the breathable gas supply chain are nonseparable

##### 3.1.5

##### **measured maximum flow rate**

volumetric flow rate of an assisted filtering RPD, determined in a laboratory test, when the RPD is in the condition which results in the highest air flow rate, where this condition takes into account the influences of temperatures, settings of RPD, pre-conditionings, use of accessories and any other related factors

[SOURCE: ISO 16900-8:2015, 3.6]

##### 3.1.6

##### **migration**

diffusion of the gas or vapour molecules within the sorbent after the filter is partially loaded

**3.1.7****standardized connector**

device that allows an optional connection between a filter and a respiratory interface

Note 1 to entry: Filter connector meeting the requirements of ISO 17420-3.

**3.1.8****replacement part**

identical to the one originally supplied with the RPD by the manufacturer, and declared interchangeable by the manufacturer

**3.1.9****normalised condition**

test condition adjusted to 1013 hPa and body temperature (37 °C or 310 K) saturated with water vapour, which is 63 hPa, used for the normalization of test results

Note 1 to entry: Further information is given in [Annex D](#).

**3.2 Abbreviated terms**

|       |                                     |
|-------|-------------------------------------|
| FMEA  | Failure Mode and Effects Analysis   |
| $V_T$ | Tidal volume                        |
| WoB   | Work of Breathing                   |
| BTPS  | body temperature pressure saturated |

**3.3 Symbols****3.3.1**

Product information; information point (ISO 7000-2760).

Indication for the RI that it is a part of a RPD system with multiple configurations.

**3.3.2**

Operator's manual; operating instructions (ISO 7000-1641).

Booklet: "See information supplied by the RPD manufacturer"

**3.3.3**

Do not re-use (ISO 7000-1051).

Crossed out 2: "For single shift use only"

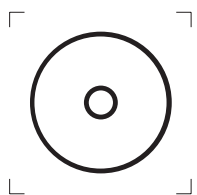
**3.3.4**

yyyy/mm

Use by date (ISO 7000-2607)

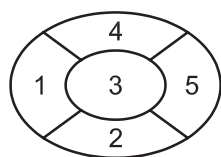
Hourglass: "End of shelf life"

Key: yyyy year, mm month

**3.3.5**

Roller; cylinder (ISO 7000-0566)

Target: "Standardized connector"

**3.3.6**

RPD headform number allocation for size designation

**4 Classification overview**

ISO 17420-1:2021, 4.1 applies with the following addition:

The classification of a filtering RPD is determined by the appropriate combination of the following classes: (protection class) (work rate class) (RI class) (particle filterclass and/or gas filter type and class).

Additionally filtering RPD may be classified for one or more special applications, as given in ISO 17420-5 to ISO 17420-9.

**Table 1 — Gas filter type and class**

| Type            | Class(es)                                               | Type description                                   |
|-----------------|---------------------------------------------------------|----------------------------------------------------|
| OV              | 1, 2, 3 or 4                                            | Organic vapours                                    |
| OG              | 1                                                       | Organic gases (low boiling, i.e. below 65 °C)      |
| AC              | 1, 2, 3 or 4                                            | Acidic compounds                                   |
| BC              | 1, 2, 3 or 4                                            | Basic compounds                                    |
| NO <sub>x</sub> | 1, 2 or 3                                               | Nitrogen oxides                                    |
| HG              | 1, 2 or 3                                               | Mercury (Hg)                                       |
| OZ              | 1                                                       | Ozone (O <sub>3</sub> )                            |
| HCN             | 1, 2, 3 or 4                                            | Hydrogen Cyanide (HCN)                             |
| AH              | 1                                                       | Arsine (AsH <sub>3</sub> )                         |
| HF              | 1, 2 or 3                                               | Hydrogen fluoride (HF)                             |
| CD              | 1                                                       | Chlorine dioxide (ClO <sub>2</sub> )               |
| ETO             | 1, 2 or 3                                               | Ethylene oxide ((CH <sub>2</sub> ) <sub>2</sub> O) |
| FM              | 1, 2 or 3                                               | Formaldehyde (CH <sub>2</sub> O)                   |
| MB              | 1, 2 or 3                                               | Methyl bromide (CH <sub>3</sub> Br)                |
| CO              | Three classes based on time (20 min, 60 min or 180 min) | Carbon monoxide (CO)                               |
| PH              | 1 or 2                                                  | Phosphine (PH <sub>3</sub> )                       |

The designation of a filtering RPD is determined by an appropriate combination of the classes given in ISO 17420-1:2021, Table 1 and [Table 1](#) of this document.

Example for a basic RPD with protection class (PC3), work rate class (W2), RI class (bT), particle filter class (F3) and gas filter type and class (OV2).

Marking for the given example      PC3 W2 bT F3 OV2

Multi-functional filtering RPD have separate classifications for each function, i.e. one classification for the unassisted mode and one classification for the assisted mode.

## 5 General requirements for RPD

### 5.1 General

ISO 17420-1:2021, 5.1, applies.

### 5.2 Field of vision

ISO 17420-1:2021, 5.2, applies.

### 5.3 Resistance to flame – Single burner dynamic

ISO 17420-1:2021, 5.3, applies.

### 5.4 Compatibility with additional equipment

ISO 17420-1:2021, 5.4, applies.

### 5.5 Monitor performance

ISO 17420-1:2021, 5.5, applies with the following addition:

The monitor system shall not interfere with the operation of the RPD.

## **5.6 Warning device(s), checking device(s) and control means**

### **5.6.1 Performance of warning device(s), if applicable**

RPD shall be checked after sequential pre-conditioning in accordance with [6.9.2](#).

RPD powered by an energy source shall be equipped with a low energy warning device to warn the wearer at least 5 min prior to the performance of the RPD falling below the manufacturer's minimum design conditions. From the activation of the warning the RPD shall be tested in accordance with [6.3.2](#) for a period of 5 min but with a fixed setting of 35 l/min, see [Table 2](#).

Check in accordance with [7.2](#) and [Clause 9](#).

For assisted filtering RPD a warning device shall warn the wearer when the performance of the RPD is outside of the manufacturer's design conditions.

Testing shall be performed in accordance with [6.3.2](#) and, if applicable, in accordance with ISO 16900-8.

During use, warning devices shall not switch off automatically and shall not be capable of being switched off by the wearer while the cause of the warning remains other than to correct the warning condition.

Check in accordance with [7.2](#).

Any warning shall be detectable without any intervention by the wearer. Any warning shall be detectable by the wearer within 15 s.

Testing shall be performed in accordance with ISO 16900-7:2020, Annex B, activity k).

Any warnings which require different reactions by the wearer shall be distinguishable from one another.

Check in accordance with [7.2](#).

### **5.6.2 Performance of checking device**

ISO 17420-1:2021, 5.6.2, applies.

### **5.6.3 Control means (if applicable)**

Manual control means installed on a RPD shall be clearly identifiable and, if more than one, distinguishable from one another by the wearer during use.

If there is a control means for setting different PC classes it shall not be possible to change the PC class during use without indication to the wearer.

Adjustable control means shall be tested in accordance with [6.3](#).

Testing shall be performed in accordance with ISO 16900-7.

## **5.7 Protection class determination**

### **5.7.1 General**

ISO 17420-1:2021, 5.7.1, applies.

### **5.7.2 Total inward leakage (TIL)**

ISO 17420-1:2021, 5.7.2, applies.

The following applies in addition to ISO 17420-1:2021, 5.7.

### **5.7.3 Total inward leakage requirement for RPD not using a standardized connector**

RPD, except those with RIs class aT, shall be tested for total inward leakage in accordance with ISO 17420-1:2021, 5.7.2.

NOTE 1 For RI using standardized connector see [6.11.3.3](#).

NOTE 2 For RI class a see ISO 17420-1:2021, 5.7.2.

## **5.8 Validation by practical performance**

### **5.8.1 General**

ISO 17420-1:2021, 5.8.1, and the following applies:

Two RPD sequentially pre-conditioned in accordance with [6.9.2](#) shall undergo practical performance tests.

Prior to the practical performance testing the RPD performance shall have passed the tests according to at least the following clauses:

- [6.3](#) [work of breathing, breathing resistance (peak pressure) and elastance];
- [6.4](#) (CO<sub>2</sub> concentration);
- ISO 17420-1:2021, 5.9.1 (RI);
- [6.5](#) (noise limit for assisted RPD),
- [6.7](#) (connections);
- [5.6](#) [warning and checking device(s)].

### **5.8.2 Donning/doffing**

ISO 17420-1:2021, 5.8.2 applies.

### **5.8.3 Communication performance - hearing and speech**

ISO 17420-1:2021, 5.8.3 applies.

### **5.8.4 Eye irritation caused by the RPD**

ISO 17420-1:2021, 5.8.4 applies.

### **5.8.5 Fogging of visor**

ISO 17420-1:2021, 5.8.5 applies.

### **5.8.6 Ergonomic requirements**

ISO 17420-1:2021, 5.8.6 applies.

## **5.9 Requirements for elements/components**

ISO 17420-1:2021, 5.9 applies.

## 6 Requirements for filtering RPD

### 6.1 Determination of air flow rate of assisted RPD

For assisted RPD the air flow rate shall be determined at conditions which result in the minimum flow rate and the maximum flow rate of the RPD.

Depending on the design of the RPD these air flow rates can be influenced by

- possible flow settings of the RPD,
- service life,
- the charging status of the battery,
- different filter types,
- alarm settings,
- the temperature of the RPD, including the temperature range for use,
- use of accessories,
- hose length, and
- other factors, if applicable.
- Testing shall be performed in accordance with ISO 16900-8.

### 6.2 Determination of the effect of temperature on flow rates for assisted RPD

To determine the influence of temperature the RPD shall be tested for flow after each of the following:

- a) equilibrated for a minimum of 4 h at  $\begin{pmatrix} 35 & 0 \\ & -2 \end{pmatrix}^{\circ}\text{C}$  and at a relative humidity of  $(50 \pm 20) \%$
- b) and equilibrated for a minimum of 4 h at  $\begin{pmatrix} -5 & +2 \\ & 0 \end{pmatrix}^{\circ}\text{C}$ .

Testing shall be started within 3 min after each equilibration at ambient laboratory conditions.

Taking into account the influencing parameters as listed in [6.1](#) the measured minimum and the measured maximum flow rate shall be determined in accordance with ISO 16900-8.

### 6.3 Work of breathing, breathing resistance (peak pressure) and elastance

#### 6.3.1 Work of breathing, breathing resistance (peak pressure) and elastance for unassisted RPD

For filters with standardized connectors see [6.11.2.1](#).

For RI with standardized connectors see [6.11.3.2](#).

The RPD shall be tested with one of each size of the RI.

The RPD headform number(s) allocated to the RI used for the tests is/are specified by the manufacturer.

Integrated RPD or components in ready for assembly state shall be exposed to the sequential preconditioning in accordance with [6.9.2](#).

In addition to the sequential pre-conditioning in accordance with [6.9.2](#) one integrated RPD in its ready to worn state containing electronics or component(s) in its ready for assembly state containing

electronics shall be exposed to the non-sequential preconditioning in accordance with [6.9.3.2](#). RPD shall meet the requirements set forth in [Table 3](#) for work of breathing/breathing resistance, when tested in accordance with the settings for the breathing machine for each work rate as given in [Table 2](#).

The temperature of operation of unassisted RPD is covered by the pre-conditioning according to [6.9.2.2](#) because for those types of RPD testing at the extremes gives no further information.

The work of breathing, breathing resistance (peak pressure), and elastance shall be calculated from the average pressure volume loop based on 10 consecutive breathing cycles and shall not exceed the limits given in [Table 3](#).

The settings for the breathing machine for each work rate are given in [Table 2](#).

**Table 2 — Setting of breathing machine at work rates for assisted and unassisted RPD**

| Work rate | Flow rate<br>(dynamic sinusoidal)<br>l/min at BTPS | Frequency<br>cycles/min | Tidal volume<br>l at BTPS |
|-----------|----------------------------------------------------|-------------------------|---------------------------|
| Resting   | 10 with a tolerance of $\pm 3$ %                   | 10,0                    | 1,0                       |
| W1        | 35 with a tolerance of $\pm 2$ %                   | 23,3                    | 1,5                       |
| W2        | 65 with a tolerance of $\pm 2$ %                   | 32,5                    | 2,0                       |
| W3        | 105 with a tolerance of $\pm 2$ %                  | 42,0                    | 2,5                       |
| W4        | 135 with a tolerance of $\pm 1$ %                  | 45,0                    | 3,0                       |

Testing shall be performed in accordance with ISO 16900-5 and ISO 16900-12.

Tidal volumes are expressed at BTPS. In order to be able to compare the performance of different RPD the results achieved at any laboratory conditions shall be normalized to body temperature (37 °C) and normalized pressure (1 013 hPa) in accordance with [Annex D](#).

An example for normalisation calculation for work of breathing results is given in [D.2.1](#).

### 6.3.2 Work of breathing, breathing resistance (peak pressure) and elastance for assisted RPD

Integrated RPD or components in ready for assembly state shall be pre-conditioned in accordance with [6.9.2](#).

In addition to the sequential pre-conditioning in accordance with [6.9.2](#) one integrated RPD or component(s) in ready for assembly state shall be pre-conditioned in accordance with [6.9.3.2](#) (salt spray) as applicable, prior to validation testing.

RPD shall be set to the minimum and maximum measured flow rates determined in accordance with [6.2](#).

RPD shall be tested in accordance with the test regime for its work rate class as stated by the manufacturer and meet the requirements for work of breathing, breathing resistance and elastance for each flow rate as given in [Table 3](#).

RPD work of breathing and breathing resistance (peak pressures) shall be measured in each step of the performance regime for the designated work rate class, given in [Table 3](#). The measurements shall start after the stabilization of each step in the test regimes W1 to W4.

The transition period between one work rate and the next work rate shall be no more than one minute, which includes the stabilization, whilst the RPD remains in operational mode.

The work of breathing, breathing resistance and elastance shall be computed from the average pressure volume loop based on ten consecutive breaths and shall not exceed the limits given in [Table 3](#).

Test regime to achieve W1:

- a) 35 l/min for 5 min;

b) 10 l/min for 5 min;

c) 35 l/min for 5 min.

Test regime to achieve W2:

a) 35 l/min for 5 min;

b) 65 l/min for 5 min;

c) 10 l/min for 5 min;

d) 35 l/min for 5 min.

Test regime to achieve W3:

a) 35 l/min for 4 min;

b) 65 l/min for 3 min;

c) 105 l/min for 3 min;

d) 10 l/min for 5 min;

e) 35 l/min for 5 min.

Test regime to achieve W4:

a) 35 l/min for 2 min;

b) 105 l/min for 3 min;

c) 65 l/min for 2 min;

d) 135 l/min for 3 min;

e) 10 l/min for 5 min;

f) 35 l/min for 5 min.

The test termination point shall be after one complete cycle of the applicable test regime. Each test regime shall be performed with the operation of the RPD adjusted to both the maximum and the minimum measured flow rates as determined by ISO 16900-8.

**Table 3 — Limits of work of breathing, breathing resistance (peak pressure) and elastance for assisted and unassisted RPD**

| Flow rate<br>(dynamic sinusoidal)<br>l/min at BTPS | Work of breathing limit<br>measured as<br>WoB/V <sub>T</sub> |            | Breathing resistance limit<br>(peak pressures) |            | Elastance<br>limit<br>measured as<br>Δp/V <sub>T</sub><br>kPa/l |
|----------------------------------------------------|--------------------------------------------------------------|------------|------------------------------------------------|------------|-----------------------------------------------------------------|
|                                                    | inhalation                                                   | exhalation | inhalation                                     | exhalation |                                                                 |
|                                                    | kPa                                                          |            | kPa                                            |            |                                                                 |
| 10 with a tolerance of ± 3 % <sup>a</sup>          | 0,9                                                          | 0,9        | -1,2                                           | 1,2        | 1,0                                                             |
| 35 with a tolerance of ± 2%                        |                                                              |            |                                                |            |                                                                 |
| 65 with a tolerance of ± 2%                        |                                                              |            |                                                |            |                                                                 |
| 105 with a tolerance of ± 2%                       |                                                              |            |                                                |            |                                                                 |
| 135 with a tolerance of ± 1%                       | 1,6                                                          | 1,6        | -2,0                                           | 2,0        |                                                                 |

Δp is the difference in pressure between the beginning of inhalation and beginning of exhalation.

NOTE Flow rates and tidal volumes are expressed at BTPS (body temperature, ambient pressure, saturated gas).

RPD work of breathing and breathing resistance (peak pressures) shall be measured in each step of the regime for the designated work rate class above. The measurements shall begin after the stabilization of each step.

The transition period between one work rate and the next work rate shall be no more than one minute, which includes the stabilization, whilst the RPD remains in operational mode.

During the transition between different flow rates, stopping of the breathing machine is allowable as long as the 1 min time period is not exceeded.

The settings for the breathing machine for each work rate are given in [Table 2](#).

Testing shall be performed in accordance with ISO 17420-1 and ISO 16900-12.

## 6.4 CO<sub>2</sub> concentration limits

### 6.4.1 CO<sub>2</sub> concentration limits for assisted RPD

One RPD in non pre-conditioned state, for each size RI shall be tested on the RPD headform based on the size as designated by the manufacturer.

RPD shall meet the requirements when tested at ambient temperature when adjusted to the measured minimum flow as tested in ISO 16900-8.

The carbon dioxide content of the inhalation air shall not exceed an average volume fraction as given in [Table 4](#) tested at its work rate class and at resting to determine the average.

**Table 4 — Maximum average volume fraction of CO<sub>2</sub> concentration in the inhalation air in relation to flow rate**

| Flow rate<br>(dynamic sinusoidal)<br>l/min at BTPS | CO <sub>2</sub> concentration<br>% |
|----------------------------------------------------|------------------------------------|
| 10 with a tolerance of $\pm 3\%$                   | 2,50                               |
| 35 with a tolerance of $\pm 2\%$                   | 2,00                               |
| 65 with a tolerance of $\pm 2\%$                   |                                    |
| 105 with a tolerance of $\pm 2\%$                  | 1,40                               |
| 135 with a tolerance of $\pm 1\%$                  |                                    |

After stabilization, the measurement of at least 10 cycles shall be taken to determine the average. Within at least 10 cycles the average value of CO<sub>2</sub> at the end of each exhalation cycle shall contain  $(5,3 \pm 0,1) \% \text{ CO}_2$ .

The setting of the breathing machine is as given in [Table 2](#).

Testing shall be performed in accordance with ISO 16900-9.

### 6.4.2 CO<sub>2</sub> concentration limits of unassisted RPD

One RPD in non pre-conditioned state, for each RI size shall be tested on the RPD headform based on the size as designated by the manufacturer.

The carbon dioxide content of the inhalation air shall not exceed an average volume fraction as given in [Table 4](#) with the setting of the breathing machine as given in [Table 2](#). After stabilization, the measurement of at least 10 cycles shall be taken to determine the average.

Within at least 10 cycles the average value of CO<sub>2</sub> at the end of each exhalation cycle shall contain  $(5,3 \pm 0,1) \% \text{ CO}_2$ .

Testing shall be performed in accordance with ISO 16900-9.

#### **6.4.3 CO<sub>2</sub> concentration limits for RI with standardized connector**

One RI with standardized connector in non pre-conditioned state, for each size shall be tested on the RPD headform based on the size as designated by the manufacturer.

The carbon dioxide content of the inhalation air shall not exceed an average volume fraction as given in [Table 4](#) for the flow rates of 10 l/min, 35 l/min and 65 l/min with the setting of the breathing machine as given in [Table 2](#). After stabilization, the measurement of at least 10 cycles shall be taken to determine the average.

Within at least 10 cycles the average value of CO<sub>2</sub> at the end of each exhalation cycle shall contain  $(5,3 \pm 0,1) \% \text{ CO}_2$ .

Testing shall be performed in accordance with ISO 16900-9.

#### **6.5 Noise limit for assisted RPD**

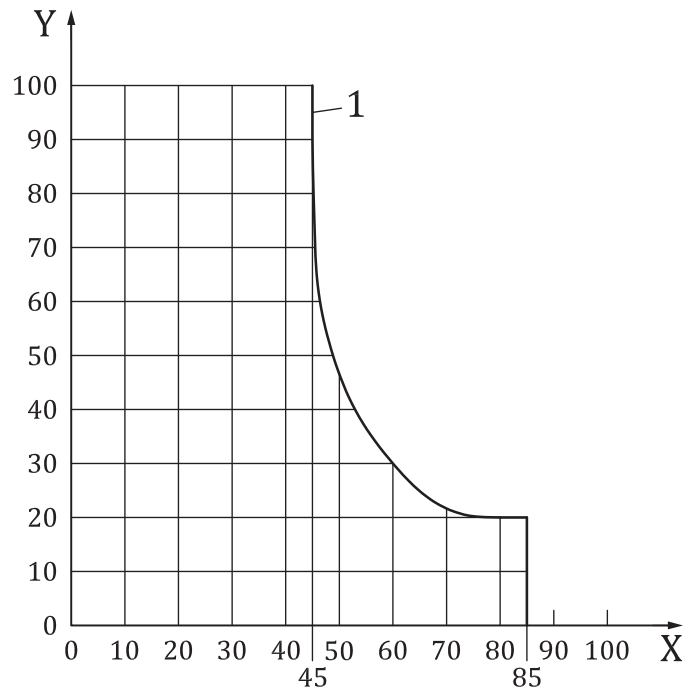
Only one RI size in non pre-conditioned state shall be tested.

RI Type d and e, when operated at the manufacturer's maximum flow conditions on a breathing machine set according to [Table 2](#) for its work rate, and without activated warning device, the noise of the RPD shall be less than or equal to 80 dB(A) at both ears on the RPD headform. The measurement shall start 5 min after the activation of the RPD for a period of 5 min.

Testing shall be performed in accordance with ISO 16900-14:2020, method A.

#### **6.6 Temperature and humidity of inhaled air for RPD which protect against CO**

When tested in accordance with [6.10.1.3.2](#), [Table 9](#), with the test gas concentration of 3 000 ml/m<sup>3</sup> CO, the temperature and relative humidity of the air supplied by the filtering RPD to the wearer shall not exceed the limits given in [Figure 1](#), item 1, measured at the filter outlet. Preconditioning is required for filters only.



**key**

- X temperature in °C
- Y relative humidity in %
- 1 temperature limit for inhaled air

**Figure 1 — Temperature and humidity curve for inhaled air**

Testing shall be performed in accordance with ISO 16900-4.

## 6.7 Connections

### 6.7.1 General

If more than one connection is present on an RPD incorrect combinations shall be prevented by design. If for certain RPD systems such design solutions are not possible (for example for multiple-filter configuration), this shall be covered by information on the correct selection of combinations contained in the information supplied by the RPD manufacturer.

Check in accordance with [7.2](#).

### 6.7.2 Strength of connections – Connections to RI

RPD in non pre-conditioned state shall be tested.

Connections to a RI shall withstand the axial force perpendicular to the plane of affixation as defined in [Table 5](#) and [6](#) and identified in [Figure 2](#) and [Figure 3](#). During the test it is acceptable that the direction of the force shift from the plane of affixation. The force shall be applied for  $\left(10^{+2}_0\right)$  s when the RI is mounted on a headform, in accordance with the information supplied by the RPD manufacturer for proper donning by a wearer. The force shall be applied progressively avoiding an initial shock or jerking motion to the connection.

No further fixation means of the RI to the headform is allowed.

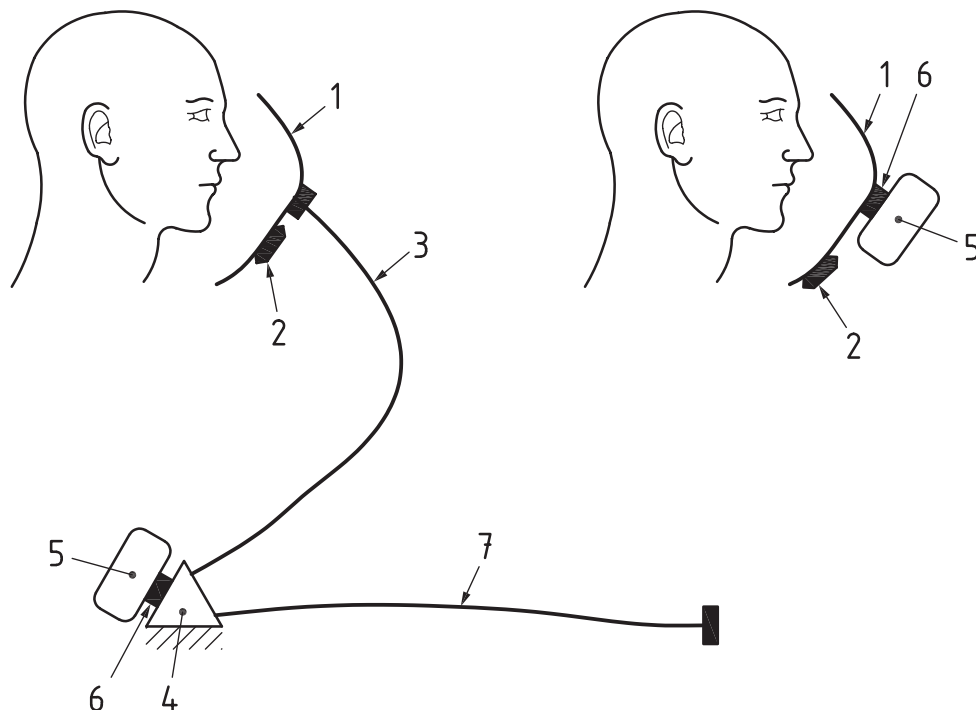
The RI is allowed to slip off the headform provided that the RI can be readily re-donned.

The  $F_{2a}$  and  $F_3$  requirements apply to filters, exhalation valves and/or accessories attached to the RI only which have the potential of being snagged. These are identified by using the exposed surface identification probe defined in ISO 16900-5. The procedure for using the probe is given in ISO 16900-6.

As a result of the applied force, no connection or other component, including the components that attach the RI to the wearer, shall separate, break or permanently deform to such an extent that a further donning in accordance with the information supplied by the RPD manufacturer is no longer possible.

A separation or break of a component that does not affect the respiratory function of the RPD shall not be deemed a failure (e.g. heads-up display on the outside of the visor).

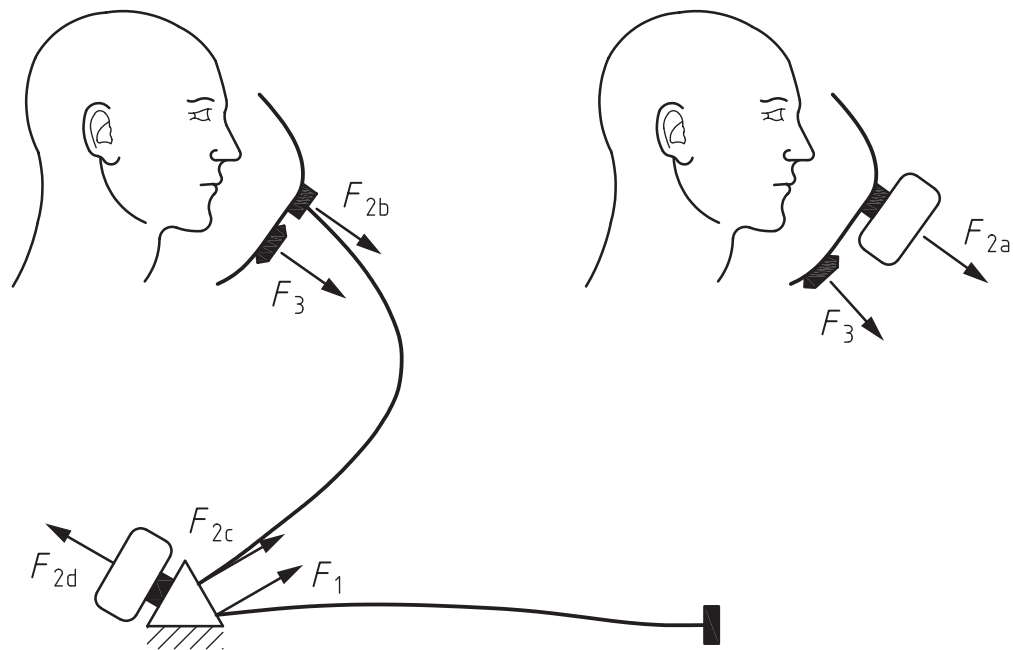
Testing shall be performed in accordance with ISO 16900-6 and checked in accordance with [7.2](#).



**key**

- 1 RI
- 2 accessory/exhalation valve
- 3 breathing hose
- 4 fixation to wearer
- 5 filter
- 6 filter connection
- 7 low pressure hose

**Figure 2 — Typical arrangements of RPD for pull force test**

**key**

- $F_1$  pull force direction for connection between manifold and supply hose  
 $F_{2a}$  pull force direction for connection between RI and filter  
 $F_{2b}$  pull force direction for connection between RI and breathing hose  
 $F_{2c}$  pull force direction for connection between manifold and breathing hose  
 $F_{2d}$  pull force direction for connection between manifold and filter  
 $F_3$  pull force direction for connection between RI and accessories

**Figure 3 — Pull force arrangement****Table 5 — Pull forces on RPD classes without standardized connector**

| Pull Force<br>Area/Direction<br>(Vectors) | $F_1$        | $F_{2a}$   | $F_{2b}, F_{2c}, F_{2d}$ | $F_3$      |
|-------------------------------------------|--------------|------------|--------------------------|------------|
|                                           | N            |            |                          |            |
| PC 4 and greater                          | (1 000 ± 50) | (50 ± 2,5) | (250 ± 10)               | (50 ± 2,5) |
| PC 3                                      | (500 ± 25)   | (25 ± 1)   | (100 ± 5)                | (10 ± 0,5) |
| PC 1 and PC 2                             | (500 ± 25)   | (25 ± 1)   | (50 ± 5)                 | (10 ± 0,5) |

**Table 6 — Pull forces on RPD class PC 2, PC 3 and PC 4 with standardized connector**

| Pull Force<br>Area/Direction<br>(Vectors) | $F_1$ | $F_{2a}$  | $F_{2b}, F_{2c}, F_{2d}$ | $F_3$      |
|-------------------------------------------|-------|-----------|--------------------------|------------|
|                                           | N     |           |                          |            |
| PC 2, PC 3 and PC 4                       | NA    | (100 ± 5) | (250 ± 10)               | (50 ± 2,5) |

**6.7.3 Low pressure connections other than to the RI**

RPD in non pre-conditioned state shall be tested.

Any low pressure connection of RPD other than those directly to the RI, such as filter(s) or hoses connected to a RPD, shall withstand a progressively applied axial force in accordance with [Table 5](#) and [6](#)

and identified in [Figure 2](#) and [Figure 4](#) for 10 s without separating, breaking or permanently deforming to the extent a leak path is created. The force shall be applied progressively avoiding an initial shock or jerking motion to the connection.

After being exposed to the applied force, the hose connection shall be pressurized to  $(2 \pm 0,2)$  kPa and submerged in water for 1 min unless separating, breaking or permanently deforming is observed on the hose connection. The connector shall not leak at a rate of more than one bubble per second.

For this test the components or sub-assemblies, such as filter housing or hose connector, may be used instead of a complete RPD.

One of each connection shall be tested.

Testing shall be performed in accordance with ISO 16900-6.

Check in accordance with [7.2](#), followed by testing in accordance with [7.3](#).

## 6.8 Assessment of reliability

Since many types of failure are possible, FMEA (failure mode and effects analysis) is a recommended way to examine failure situations and suggest safety design and procedures.

Manufacturers shall state, by providing a written declaration, that the reliability of the RPD or component was adequately considered in the design.

Special attention shall be given to the effects of

- temperature and humidity of inhaled air during use for filtering RPD which protects against contaminants other than CO,
- abrasion resistance,
- chemical resistance of materials,
- dusty environment,
- compatibility of materials with the wearer's body, and
- cleaning, disinfection and decontamination procedures and cycles on the function of the RPD.

In [Annex A](#) some aspects that should be considered by manufacturers to ensure reliability are indicated.

NOTE FMEA is a suitable tool to comply with this requirement.

## 6.9 Pre-conditioning (Sequential/Non-sequential)

### 6.9.1 General

The pre-conditioning shall follow the pre-conditioning test sequence as given [Figure 4](#).

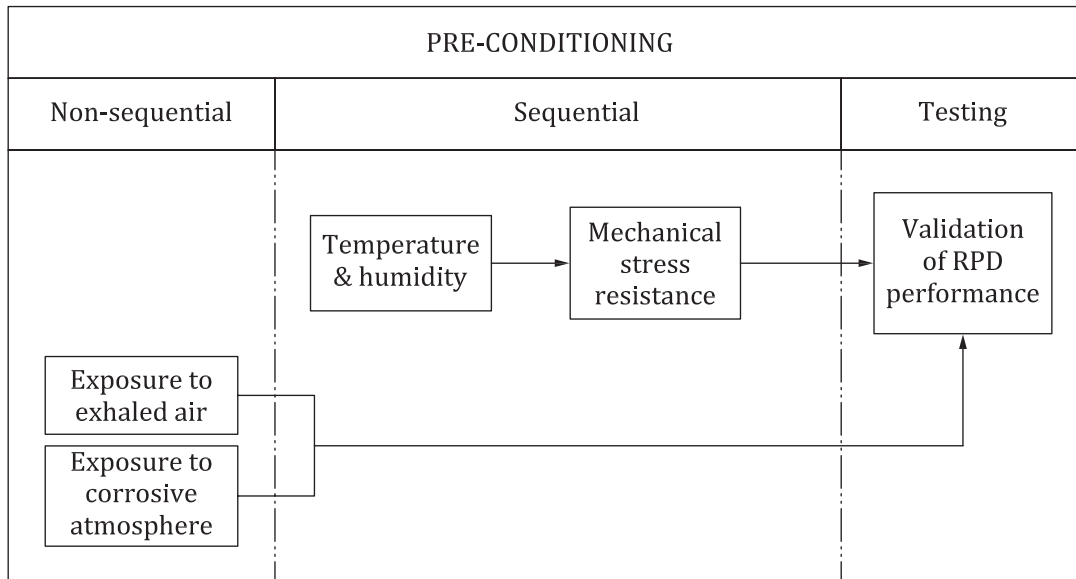


**Figure 4 — Pre-conditioning test sequence**

## 6.9.2 Sequential pre-conditioning

### 6.9.2.1 General

Integrated RPD and components shall be pre-conditioned in the following sequence:

- exposure to temperature and humidity conditioning, see [6.9.2.2](#);
- exposure to mechanical stress resistance, see [6.9.2.3](#).

### 6.9.2.2 Exposure to temperature and humidity

Integrated RPD and components shall be pre-conditioned in accordance with the following thermal cycle, without interruption:

- ambient temperature and humidity;
- $(40 \pm 3) ^\circ\text{C}$  and  $<20\%$  RH for  $(24 \pm 1)$  h;
- $(-10 \pm 3) ^\circ\text{C}$  for  $(24 \pm 1)$  h;
- $(40 \pm 3) ^\circ\text{C}$  and  $(90 \pm 5)\%$  RH for  $(24 \pm 1)$  h; and
- ambient temperature between  $16 ^\circ\text{C}$  and  $32 ^\circ\text{C}$  and  $(50 \pm 30)\%$  RH until temperature is equilibrated.

In order to ensure that there is no temperature shock during the conditioning of the samples, the temperature gradient shall be less than  $2 ^\circ\text{C}/\text{min}$  between phases at different temperatures, and between the beginning and the end of a thermal cycle.

The number of samples is given in the relevant requirement clauses.

### 6.9.2.3 Mechanical stress resistance

Integrated RPD, replaceable filter(s) and components containing electronics and/or electro-mechanics in their ready for assembly state shall be positioned in accordance with ISO 16900-6:—, 6.8, in the steel case in such a way that the samples do not touch each other during the test and allows horizontal movement and free vertical movement.

Other PPE and accessory components containing electronics are excluded.

Integrated RPD and components in ready for assembly state shall be subjected to mechanical pre-conditioning in three different orientations (x, y, z) with 650 rotations each.

In the case of replaceable filter(s), they shall be positioned in the steel case in such a way, that the axis of air flow through the filter is horizontal and such that the filters do not touch each other during the test, allowing horizontal movement and free vertical movement for a total of 1 950 rotations.

The exposure shall be conducted at the rate of  $(100 \pm 5)$  r/min.

After the exposure any loose materials that have been released from the filter shall be removed from the filter prior to the performance testing.

Testing shall be performed in accordance with ISO 16900-6:—, 6.8.

### 6.9.3 Non-sequential pre-conditioning

#### 6.9.3.1 Exposure to exhaled air

RPD whose air management allows the wearer's exhaled air to pass through the filter shall be tested for filter efficiency and/or gas capacity as appropriate within 30 min after the following pre-conditioning.

A test setup consisting of a RPD headform of appropriate size, complying with ISO 16900-5, connected to a breathing machine complying with ISO 16900-5 with the additional function to warm and humidify exhaled air shall be used. Temperatures and humidity shall comply with ISO 16900-5:2016, 4.4 c) and d).

The ambient laboratory condition for intake of air shall comply with  $(22 \pm 3)$  °C and  $(50 \pm 25)$  % RH.

The appropriate work rate for the RPD class shall be used.

In order to prevent excess water spilling out of the mouth and contaminating the filter the head shall be tilted back so that the water runs away from the mouth and is collected in a trap.

The test setup shall be allowed to stabilise and the RPD shall be mounted on the RPD headform and exposed for  $\left(180^{+20}_0\right)$  min.

Numbers of samples to be exposed are given in [Table 14](#).

#### 6.9.3.2 Exposure to corrosive atmosphere

Integrated RPD and components in ready for assembly state containing electronics shall be subjected to the salt spray test specified in ISO 9227 (neutral salt spray test NSS) for an exposure time of  $(24 \pm 1)$  h.

The RPD shall be tested with the open connection(s) blocked and with the RI mounted on an appropriate form in the as worn state to prevent the salt spray from getting on its inside.

Check in accordance with [7.2](#) and record any observation.

### 6.10 Requirements for elements/components

#### 6.10.1 Filters

##### 6.10.1.1 General

If RPDs are equipped with non-separable filters all filter requirements shall be met when using the integrated RPD for testing.

When testing one filter of a multiple filter RPD the appropriate filter performance requirements of this standard shall be met with the defined proportioned air flow.