STANDARDS NEW ZEALAND
TE MANA TAUTIKANGA O AOTEAROA

STANDARDS Australia

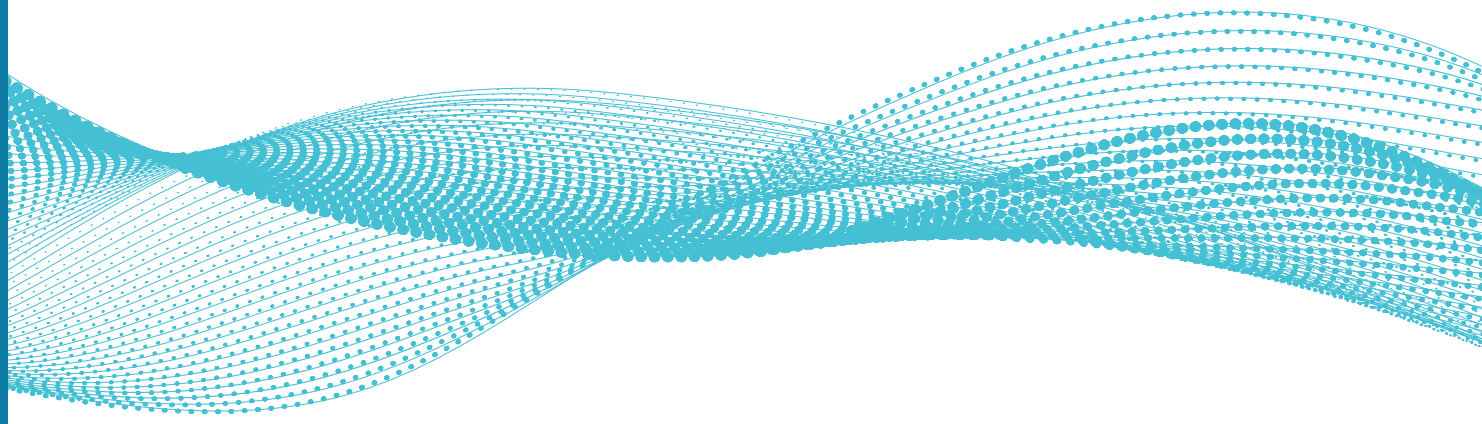
AS/NZS ISO 16900.13:2021

(ISO 16900-13:2015, IDT)

AUSTRALIAN/NEW ZEALAND STANDARD

Respiratory protective devices – Methods of test and test equipment

Method 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



ISO

AS/NZS ISO 16900.13:2021

This joint Australian/New Zealand standard was prepared by Joint Technical Committee SF-010, Occupational Respiratory Protection. It was approved on behalf of the Council of Standards Australia on 31 May 2021 and by the New Zealand Standards Approval Board on 2 June 2021.

This standard was published on 18 June 2021.

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Method 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

First published as AS/NZS ISO 16900.13:2021.

Jointly published by SAI Global Limited under licence from Standards Australia Limited, GPO Box 476, Sydney, NSW 2001 and by Standards New Zealand, PO Box 1473, Wellington 6140.

ISBN (Print) 978-1-77686-806-3
ISBN (PDF) 978-1-77686-807-0

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 tests which are specific to RPDs using regenerated breathable gas, compressed breathable gas with class L respiratory interfaces, and special application mining escape RPD.

This document is identical with, and has been reproduced from, ISO 16900-13:2015, *Respiratory protective devices — Methods of test and test equipment — 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*.

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Contents

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).

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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 standards. Test methods are specified for complete devices or parts of devices that are intended to comply with 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."

Australian/New Zealand Standard

Respiratory protective devices — Methods of test and test equipment

Method 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

1 Scope

This part of ISO 16900 specifies tests which are specific to RPDs using regenerated breathable gas, compressed breathable gas with class L respiratory interfaces, and special application mining escape RPD.

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 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 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 and the following apply.

3.1
class Sxxxx RPD
supplied breathable gas RPD, where Sxxxx equals the amount of breathable gas available for respiration in litres

3.2
body temperature pressure saturated
BTPS
standard condition for the expression of ventilation parameters

Note 1 to entry: Body temperature (37 °C), atmospheric pressure 101,3 kPa (760 mmHg), and water vapour pressure (6,27 kPa) in saturated air.

3.3
standard temperature pressure dry
STPD
standard conditions for expression of oxygen consumption

Note 1 to entry: Standard temperature (0 °C) and pressure (101,3 kPa, 760 mmHg), dry air (0 % relative humidity).

3.4
capacity
volume of available breathable gas of an RPD

4 Prerequisites

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

— number of specimens;

— operating conditions of the RPD;

— the types of support such as RPD headform/fixation;

— any prior conditioning or testing;

— work rate class;

— temperature(s) at which tests are to be performed;

— 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 conditions for testing shall be between 16 °C and 32 °C and (50 ± 30) % relative humidity. 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.

The startup process for the RPD shall follow the information supplied by the manufacturer.

6 Test of RPD performance at work rate

6.1 General

RPD cylinders shall be charged to working pressure before testing (if applicable).

RPD shall be equilibrated and tested at each specified test temperature.

The following parameters shall be determined:

— work of breathing/breathing resistance, see 6.4.1;

— elastance, see 6.4.2;

— CO_2 concentration limits, see 6.5.2;

— oxygen content of RPD using regenerated breathable gas, see 6.5.3.1;

— oxygen content of RPD using oxygen enriched breathable gas, see 6.5.3.2;

— temperature and humidity of inspired breathable gas for regenerated breathable gas RPD and oxygen enriched breathable gas RPD, see 6.6;

— capacity.

For RPD that protect against carbon monoxide, the carbon monoxide content of the inspired gas shall be determined in accordance with 6.7.

The test termination point for class Sxxxx RPD shall be when any one of the above criteria for the RPD's class is no longer met.

The settings for the metabolic simulator for each flow rate are given in Table 1.

Table 1 — Settings for metabolic simulator for each flow rate

Flow rate (dynamic sinusoidal)	**Breathing frequency**	**Tidal volume**	**O_2 consumption rate**	**CO_2 injection rate**
l/min (BTPS)[a]	cycles/min	l (BTPS)	l/min (STPD)[a]	l/min (STPD)
10 (±3 %)	10,0	1,0	0,31	0,26
35 (±2 %)	23,3	1,5	1,09	0,91
65 (±2 %)	32,5	2,0	2,03	1,82
105 (±2 %)	42,0	2,5	3,28	3,57
135 (±1 %)	45,0	3,0	4,22	4,59

[a] The values in Table 1 are given at BTPS and STPD, because values at BTPS reflect the conditions of the human, while STPD is used for settings of laboratory equipment.

6.2 Test regimes

6.2.1 General

RPD shall be tested to the test regime which is in accordance with the designated work rate class.

The transition period between one work rate and the next work rate shall be no more than one minute while the RPD is still functioning.

During the transition between the settings of the different flow rates, stopping of the breathing machine for more than 5 s is not allowed for those types of RPD using enriched or generated oxygen.

For all RPD using control means, the test shall be performed both with the operating setting of the RPD adjusted to the maximum and the minimum flow conditions as specified by the manufacturer.

Testing shall be performed on the appropriate required headform.

Humidity and temperature of the exhaled gas shall be as required by the performance requirements.

6.2.2 Regime for RPD of class W1

a) 35 l/min for 10 min

b) 10 l/min for 5 min

Repeat steps a and b above until the test termination point is reached.

The RPD shall have enough capacity to complete step a at least once. It is not required to complete all of step b if the test termination point is reached.

6.2.3 Regime for RPD of class W2

a) 35 l/min for 5 min

b) 65 l/min for 5 min

c) 10 l/min for 5 min

Repeat steps a through c above until the test termination point is reached.

The RPD shall have enough capacity to complete steps a and b at least once. It is not required to complete all of step c if the test termination point is reached.

6.2.4 Regime for RPD of class 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

Repeat steps a through d above until the test termination point is reached.

The RPD shall have enough capacity to complete steps a, b, and c at least once. It is not required to complete all of step d if the test termination point is reached.

6.2.5 Regime for RPD of class 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

Repeat steps a through e above until the test termination point is reached

The RPD shall have enough capacity to complete steps a, b, c, and d at least once. It is not required to complete all of step e if the test termination point is reached.

6.3 Determination of capacity of class Sxxxx RPD

6.3.1 Class Sxxxx RPD — having class L respiratory interfaces using compressed breathable gas

RPD shall be equilibrated at each specified test temperature and tested at ambient temperature, according to the work rate specified by the manufacturer. The determination of the capacity shall be performed at settings specified in Table 2.

Table 2 — Breathing machine settings for capacity tests

Work rate class	**Flow rate** (dynamic sinusoidal) l/min (BTPS)	**Tidal volume** l (BTPS)	**Frequency** cycles/min
W1	30 ± 2 %	1,5	20,0
W2	40 ± 2 %	2,0	20,0
W3	50 ± 2 %	2,0	25,0
W4	65 ± 2 %	2,0	32,5

Capacity for RPD is the usable breathable gas volume down to 2,0 MPa.

The capacity shall be determined by the lowest result.

Capacity is designated in litres rounded down to increments of 150 l up to 900 l and increments of 300 l above 900 l.

6.3.2 Class Sxxxx RPD — not using compressed breathable gas

RPD shall be evaluated as listed below when tested according to the table below. At least one RPD shall be equilibrated at each specified test temperature and tested at ambient temperature, according to the work rate specified by the manufacturer. The determination of the capacity shall be performed at settings described in Table 3.

Table 3 — Metabolic simulator settings for capacity

Work rate class	Flow rate (dynamic sinusoidal) l/min (BTPS)	Tidal volume l (BTPS)	Frequency cycles/min	O_2 consumption rate l/min (STPD)	CO_2 injection rate l/min (STPD)
W1	30 (±2 %)	1,5	20,0	0,93	0,78
W2	40 (±2 %)	2,0	20,0	1,24	1,05
W3	50 (±2 %)	2,0	25,0	1,55	1,35
W4	65 (±2 %)	2,0	32,5	2,03	1,82

Capacity is the usable breathable gas supplied by the RPD until the performance limits in performance standard are no longer met.

The capacity shall be determined by the lowest result.

Capacity is designated in litres rounded down to increments of 150 l up to 900 l and increments of 300 l above 900 l.

6.4 Volume averaged work of breathing, pressures and elastance

6.4.1 Work of breathing/breathing resistance (peak pressures)

RPD work of breathing and breathing resistance (peak pressures) shall be determined in each cycle of each step of the test regime for the designated work rate class, specified in 6.2.

The measurements shall begin after the stabilization of each step.

The average of any 10 consecutive determinations shall be reported.

Testing shall be performed in accordance with ISO 16900-12 and the relevant regimes specified in 6.2.2 to 6.2.5.

6.4.2 Elastance

RPD elastance shall be determined in each cycle of each step of the test regime for the designated work rate class, specified in 6.2. The measurements shall start after the stabilization of each step.

The average of any 10 consecutive determinations shall be reported.

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

6.5 Gas concentrations

6.5.1 General

A peak resulting from the switch of the testing equipment from one work rate level to the next shall not be considered as a failure and shall not be assessed during the gas measurement.

The test and measurement equipment shall be appropriate for the gas concentrations and humidity levels and have sufficient response times to record changes occurring during tests.

Gas concentration shall be reported as the percentage of the dry gas.

6.5.2 CO_2 concentration limits

The average of 10 consecutive breaths shall be used to determine the termination point.

Testing shall be performed in accordance with ISO 16900-9 using the relevant regimes specified in 6.2.2 to 6.2.5.

6.5.3 Oxygen content

6.5.3.1 Oxygen content of RPD using regenerated breathable gas

Test using the relevant regimes specified in 6.2.2 to 6.2.5.

Determine the lowest level of inspired oxygen in the initial three minutes.

Determine the lowest level of inspired oxygen between minute three and a half and the termination point.

6.5.3.2 Oxygen content of RPD using oxygen enriched breathable gas

Test using the relevant regimes specified in 6.2.2 to 6.2.5.

Determine the lowest level of inspired oxygen between the start of the test and the termination point.

6.6 Temperature and humidity

A peak resulting from the switch of the testing equipment from one work rate level to the next shall not be considered as a failure.

Test using the relevant regimes specified in 6.2.2 to 6.2.5.

Record the highest inspired temperature for each range of inspired relative humidity.

6.7 CO content of inspired gas

Schematic arrangement of equipment required for this test is shown in Figure 3. The temperature of the inspired gas shall be measured by a fast responding sensor. The wet bulb temperature of the inspired gas shall be measured at key 4 in Figure 3. Work of breathing, wet and dry bulb temperatures of inspired gas, and carbon monoxide concentration shall be measured and recorded continuously.

A continuous flow of test atmosphere shall be fed into the test chamber. The test atmosphere consists of air with a temperature and humidity and a CO concentration as specified in the performance standard. The carbon monoxide concentration in the test chamber shall be measured and monitored continuously close to the gas inlet of the filtering device. Temperature and humidity of the inspired gas shall be measured at the sampling point in the airway opening (see key 4 in Figure 3)

The temperature of the exhaled gas shall be checked at the temperature measuring point of the connector and adjusted before starting the test. The humidity of the test gas in the test chamber shall be monitored and controlled continuously close to the gas inlet of the RPD. Measurements of CO

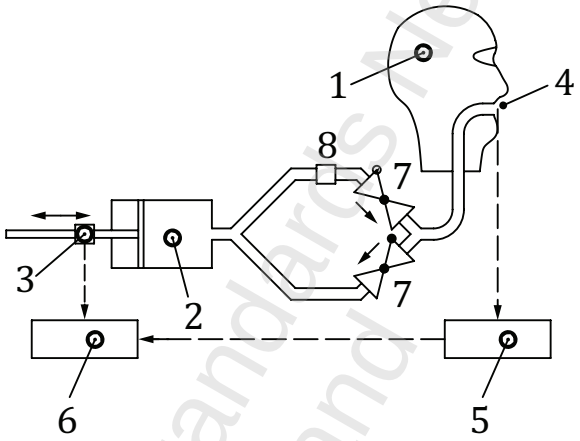
concentration and humidity may be performed at a point in the inspiratory flow path between check valves and the conditioning unit for exhaled gas (see key 7 and key 8 in Figure 3).

NOTE The test atmosphere in the test chamber can be affected by the RPD under test.

7 Apparatus

Figure 1 shows a simplified setup for recordings of temperature, O_2, CO_2, and humidity. Measurements are taken at the sampling point in the airway opening (see key 4). The displacement sensor on the breathing machine identifies whether the breathing machine is inhaling or exhaling.

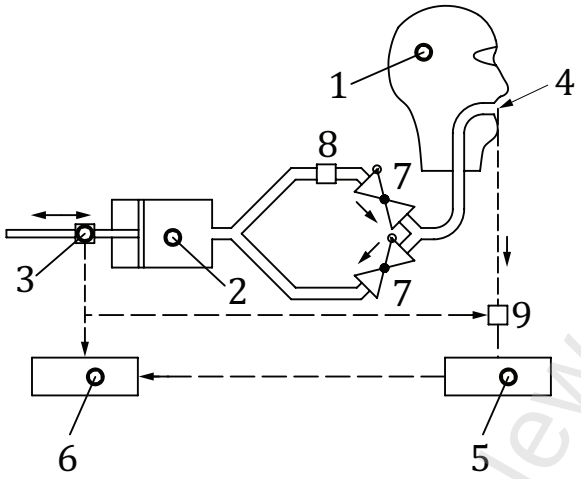
The inhaled gas can be analysed by drawing a sample only during inspiration (see Figure 2), by selecting only inspirations in the recorded data or other equivalent methods.



Key

1 headform or other suitable mechanism to hold RPD under test
2 breathing machine
3 displacement sensor
4 sampling point in the airway opening
5 transducer or signal conditioner, if separate from key 4
6 data acquisition device
7 check valve
8 conditioning unit (e.g. temperature and humidity control, O_2 and CO_2 control) for exhaled gas

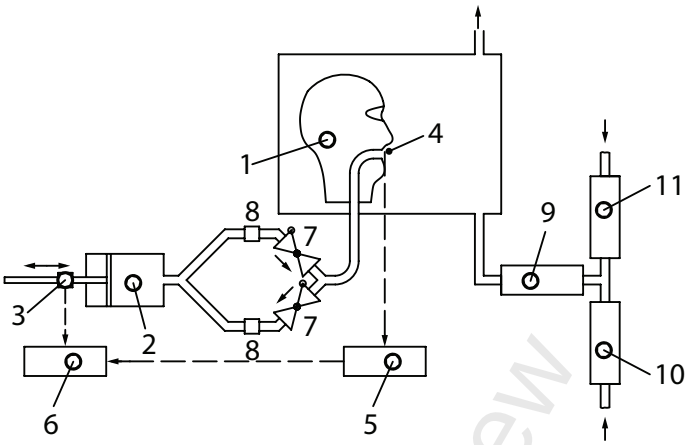
Figure 1 — Simplified schematic of a typical test set up



Key

1 headform or other suitable mechanism to hold RPD under test
2 breathing machine
3 displacement sensor
4 sampling point in the airway opening
5 transducer or signal conditioner, if separate from key 4
6 data acquisition device
7 check valves
8 conditioning unit (e.g. temperature and humidity control, O_2 and CO_2 control) for exhaled gas
9 sampling control device operated from the displacement sensor to ensure sampling only during inhalation

Figure 2 — Simplified schematic of a typical test set up where the sampling gas is drawn only during inhalations



Key

1 headform or other suitable mechanism to hold RPD under test
2 breathing machine
3 displacement sensor
4 sampling point in the airway opening
5 transducer or signal conditioner, if separate from 4.
6 data acquisition device
7 check valves
8 conditioning unit (e.g. temperature and humidity control, O_2 and CO_2 control) for exhaled gas
9 humidifier
10 flow controller for air
11 flow controller for carbon monoxide

Figure 3 — Simplified schematic of a typical test set up for carbon monoxide test

8 Test report

The test report shall include at least the following information:

a) information identifying the RPD (model, sizes);

b) operating parameters specific to RPD;

c) number of specimens tested;

d) any prior conditioning or testing;

e) the selection of RPD headforms/torso;

f) combination of tidal volume and breathing frequency and resulting minute ventilation;

g) for each test specimen:

   1) minimum oxygen content,

   2) carbon dioxide levels,

   3) temperatures and humidity,

   4) carbon monoxide levels;

h) any deviations from the method(s) and justification(s);

i) uncertainty of measurement (see Annex A).

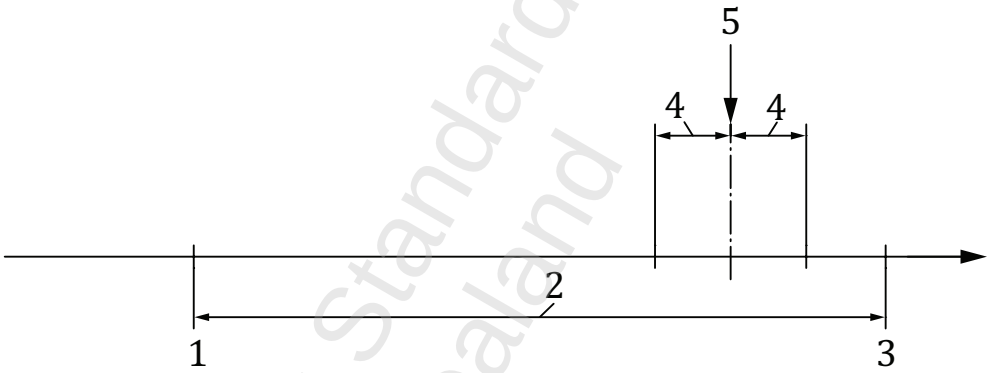
Annex A
(normative)

Application of uncertainty of measurement

A.1 Determination of compliance

In order to determine compliance or otherwise of the measurement made in accordance with this test method, when compared to the specification limits given in the performance standard, the following protocol shall be applied.

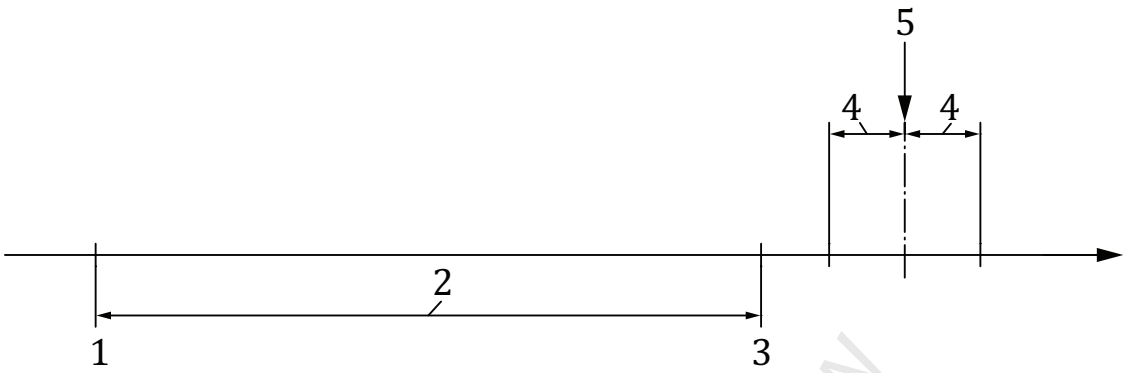
If the test result ± the uncertainty of measurement, *U*, falls completely inside or outside of the specification zone for the particular test given in the performance standard, then the result shall be deemed to be a straightforward pass or fail (see Figures A.1 and A.2).



Key

1 lower specification limit
2 specification zone
3 upper specification limit
4 uncertainty of measurement, *U*
5 measured value

Figure A.1 — Result pass

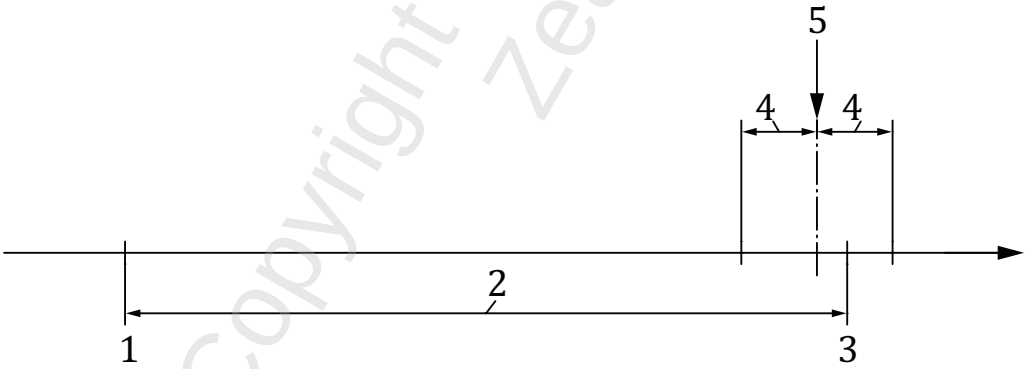


Key

1 lower specification limit
2 specification zone
3 upper specification limit
4 uncertainty of measurement, *U*
5 measured value

Figure A.2 — Result fail

If the test result ± the uncertainty of measurement, *U*, overlaps a specification limit value (upper or lower) for the particular test given in the performance standard, then the assessment of pass or fail shall be determined on the basis of safety for the wearer of the device; that is, the result shall be deemed to be a fail (see Figure A.3).



Key

1 lower specification limit
2 specification zone
3 upper specification limit
4 uncertainty of measurement, *U*
5 measured value

Figure A.3 — Result fail

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Australian/New Zealand Standards

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