
**Respiratory protective devices —
Human factors —**

**Part 8:
Ergonomic factors**

Appareils de protection respiratoire — Facteurs humains —

Partie 8: Facteurs ergonomiques

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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 — Personal protective Equipment*, Subcommittee SC 15, *Respiratory protective devices*.

This first edition of ISO 16976-8 cancels and replaces the first edition of ISO/TS 16976-8:2013, which has been technically revised.

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

— Requirements more specified.

A list of all parts in the ISO 16976 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 provides guidance for the writers of respiratory protective devices (RPD) performance standards on the specification of ergonomic factors.

Ergonomics involves the application of scientific methods and appropriate data to the design and specification of machines, equipment, environments, systems and the interface with the people using it. The successful use of ergonomics in designing RPD will enhance the acceptability of the RPD and through this will improve the safety, health, performance and effectiveness of the wearer.

RPD is used in situations where a risk to health or safety has been identified. The preferred solution is to reduce the risk to zero and thereby to remove the need for RPD. If this is not possible, the threat should be reduced so that practical RPD can minimize the risk to wearer exposed to that hazard. In some working conditions some RPD can be more comfortable than none and not to be considered as an additional discomfort. Side effects of using RPD can range from discomfort to severe constraint and physical load. The application of ergonomic principles to RPD allows optimization of the balance between protection and usability.

Some aspects of the design and specification of RPD require specialist knowledge of the particular job the RPD is used for and of the particular hazard against which the RPD is to be effective or particular ergonomics issues. Although this document covers many aspects, it cannot be expected to identify all the existing and possible future problem points for which ergonomic factors and test methods will be required in performance standards. It will remain the responsibility of the relevant experts to identify and quantify the hazards in the work place and to foresee the potential ergonomic problems, and thus to ensure that the RPD specified and manufactured is fit for the purposes intended in all respects.

For practical reasons, this document presents ergonomics factors separately. However, it should be recognized that the overall acceptability of a RPD will be determined by a combination of these and other factors by the individual wearer.

Together with ISO 16976-1 to ISO 16976-7, this document provides basic human factor data.

Respiratory protective devices — Human factors —

Part 8: Ergonomic factors

1 Scope

This document describes requirements on factors related to human physiology, ergonomics and performance for the preparation of standards for performance requirements, testing and use of respiratory protective devices (RPD).

This document gives guidance on the generic ergonomic factors related to RPD.

It specifies principles relating to

- the biomechanical interaction between RPD and the human body, and
- the interaction between RPD and the human senses: vision, hearing, smell, taste and skin contact.

This document does not cover requirements related to specific hazards for which RPD are designed.

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 — Vocabulary and graphical symbols*

3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 Ergonomic factors

4.1 General

Performance standards for RPD should contain ergonomic requirements and test methods, or should make normative reference to other standards to be applied.

Usually, ergonomic assessments of RPD have to be made while people are wearing them or are connected to the external component of the system. Wherever possible, the assessments should be objective, although some aspects can only be assessed subjectively.

Examples of how to make assessments are given in [Annex A](#).

4.2 Integration of performance and ergonomic requirements

The primary purpose of RPD is to provide protection against specific inhalation hazards that cannot be eliminated or adequately reduced by other means. Performance standards should therefore contain performance requirements and test methods to ensure that the products fulfilling the performance provide the appropriate protection against the identified hazards, and that they are ergonomically suitable for the users.

The tasks being performed, the equipment being used, the duration of the usage of the RPD, and the environments likely to be encountered should be considered. It should be ensured as far as possible that the RPD does not create hazards for the users. This can be by incorporating in performance standards requirements and test methods based on this document.

Where the presence of more than one risk or the need to cover more parts of the body makes it necessary for a wearer to use simultaneously besides an RPD another item of personal protective equipment (PPE), such equipment shall be mutually compatible and continue to be effective against the risk or risks in question.

In addition to interactive effects on technical performance, interaction between different forms of PPE including RPD can influence ergonomic aspects. Thus, although the effect of individual items of PPE tested in isolation might not be significant, it will be the combined effect that will determine the overall load and consequent acceptability. For example, both a half-mask respirator and a safety helmet can intrude upon the visual field (glasses). Either in isolation can be acceptable but, when worn together the combined impact might not be. At its most extreme, extensive body coverage by RPD, or wearing several forms of protection can result in sensory and physical isolation.

Ergonomics requirements can be taken into account by determination of performance levels on the basis of a risk assessment.

4.3 Factors to be considered in the determination of the best ergonomic solution

4.3.1 General

RPD is to be worn by an individual for protection against one or more health and safety hazards. This protection is the intended effect of the RPD, but wearing RPD can also result in unintended negative effects, which can interfere with the wearer's normal performance of the risk-related tasks.

It should be considered how to specify the best compromises between protection, practicality, and any potentially adverse impact of wearing the RPD. If different solutions apply, equivalent compromises may be possible.

4.3.2 Factors to be considered in specifying the optimum level of protection to be provided

The following variable aspects of the use of RPD should be considered:

- the duration of use of the RPD (some RPD such as escape RPD may be worn for only a few minutes when it is perceived that a hazard is present, but other RPD may be worn for several hours or throughout a working day/shift);
- whether there are different situations in which the RPD is used, that require different amounts of the body to be covered and for various other PPE to be used in addition;
- the reasonable balance between the severity of the hazard, protection, burden and duration.

4.3.3 Factors to be considered in specifying the optimal practicability

The designs of RPD that result from conformity with performance standards should allow, as far as possible, normal pursuit of all activity within the occupational environment. To ensure this is achieved, performance standards should include test procedures and requirements based on the performance of prescribed movements, or should make normative reference to such procedures and requirements.

Where relevant, a reference to the fact that where RPD suppliers claim mutually compatible components of PPE should be included that the resulting combination should be tested together. Tests should be selected to represent a range of the normal movements made by wearers of the RPD while using it.

In any event the following should be included:

- understanding instructions and warnings given by the manufacturers;
- putting on, adjusting, and taking off the RPD and/or PPE;
- general activities, such as moving and communicating;
- activities specific to situations where the RPD is to be used;
- safety of the subjects.

Practical performance tests can impose physiological strains on the test subjects thus requiring stringent controls. To ensure the safety of test subjects:

- a) the test subjects should be medically examined and fit in accordance with ISO 12894;
- b) ethical clearance should be obtained in accordance with Reference [21];
- c) the experimentation should be performed in accordance with Reference [21];
- d) there should be physiological monitoring of test subjects;
- e) normal safety procedures should be applied, including close supervision by trained, experienced staff, and voluntary withdrawal should be permitted at any time.

Interpretation of the results should take into account the levels of hazard against which the RPD is intended to provide protection, the inevitable burdens such RPD will impose, and the environmental conditions under which it will be used.

Guidance on the choice of movements and the overall conduct of ergonomic assessment of RPD using human subjects is given in [Annex A](#).

For more information, see ISO 16976-1, ISO 16976-3 and ISO 16976-5.

4.3.4 Factors to be considered in the physiological impact of RPD

The following indicators should be considered to determine the physiological impact in relation to the use of RPD:

- heart rate;
- oxygen consumption;
- alveolar gas composition;
- breathing rate;
- body temperature change;
- sweat rate;
- fatigue or strain of muscles.

Examples where indicators might be used include where the mass of the RPD can result in an excessive burden or where the exothermic processes providing breathable air or other factors of RPD can give rise to thermal strain.

More information can be obtained in ISO 16976-1 and ISO 16976-3.

4.4 Factors to be considered in specifying requirements for the adjustability of RPD and its appropriate fixation to the body

It should be considered whether requirements and test methods need to be included to test the adjustments and restraint of RPD. In deciding that need, the seriousness of the consequences of displacement of the RPD, and the maximum tolerable displacement should be considered. The following are examples of aspects that should be considered:

- the information and instructions for fitting and adjusting;
- the information and instructions for doffing of the RPD;
- the adjustability and the stability of adjustments;
- determining that the RPD has been correctly fitted.

When writing a test, consideration should be given to the static and dynamic forces that might be exerted on the RPD in normal wear, and during the circumstances in which it is intended to provide protection and how these can be represented in test methods.

4.5 Factors to be considered in specifying requirements to ensure that RPD does not irritate or cause discomfort

RPD shall not irritate or cause discomfort which can later lead to injuries for the users who can come into contact with it. Factors to be taken into account include:

- whether the RPD will be in contact with the skin and how sensitive this particular area of skin is to the effects of rubbing and pressure;
- for how long the RPD will normally be in contact with the skin;
- whether the type of RPD may have sharp or hard edges or points;
- whether the bulk, hardness and position of adjustment and closure mechanisms may have a negative impact on the user;
- whether chemical composition of the material used and its by-products may affect the body;
- whether any materials likely to be used in contact with the skin are known to produce allergic reactions in a proportion of the population;
- whether any closure mechanism, or other feature, may become caught up with scalp, facial or body hair;
- whether the outer surface of the RPD could harm other people;
- whether simple visual and manual examination of the RPD is adequate for an assessment, or whether specific test methods need to be developed for assessing the hardness, roughness or other features of the RPD.

4.6 Factors to be considered in specifying requirements to take into account the anthropometric factors of RPD

In determining appropriate anthropometric factors of the intended RPD wearer group to be specified in the RPD performance standards, the following shall be considered:

- the body part(s) it will be in contact with or cover;
- the physical activities expected to be performed during its use.

The body part(s) the RPD will be in contact with will serve to identify those parts for which anthropometric data are needed. If the RPD crosses or covers a body joint, then more anthropometric dimensions should be specified based on different joint positions.

The physical activity expected to be performed during the use of RPD can alter body dimensions. This should be taken into account in specifying anthropometric dimensions in a RPD performance standard. Excessively close fitting or otherwise poorly dimensioned RPD can prevent or hinder the performance of necessary activities.

Loose fitting or bulky RPD can restrict access to working areas or can present a potential safety hazard by snagging on projections or other features of the environment.

The intended user group will need to be defined to ensure that appropriate dimensions are specified to encompass that population. Variations in size may be accommodated by means of adequate adjustment systems or the provision of size ranges as appropriate.

Because different body dimensions are not necessarily closely correlated, the need to specify more than one essential anthropometric dimension in order to ensure satisfactory fit for the intended user group should be considered.

The topics related to anthropometric factors detailed in ISO 16976-2 and in ISO 15537 should at least be considered.

4.7 Factors to be considered in specifying requirements to take into account the biomechanical factors of RPD

4.7.1 General

In determining appropriate biomechanical effects to be specified in the RPD performance standards, the following should be considered:

- the static distribution of mass, the dynamic or inertial forces and consequent load on the human body when using different types of RPD and/or combinations of RPD and PPE;
- optimization of the influence of biomechanical effects of RPD on work load and/or task performance.

RPD can have adverse effects on the body by increasing muscle strain or energy consumption through increased passive loading or by altering the dynamic loading. For example, additional mass on the head produces forces in the neck that have to be countered by the neck muscles.

The mass of RPD and its distribution have to be considered in relation to the specific body part or parts likely to be affected.

Heavy masses on the body or body parts increase energy consumption, especially when walking or running.

Care should be taken when applying the principles in this section of this document to RPD intended to be worn under water or in situations involving unusual accelerative forces.

4.7.2 Mass distribution

Peripheral parts of the body are more susceptible to added mass than the trunk, because of the increased moment. Hence, an additional weight is best worn on the trunk and as close as possible to the body centre of gravity and as symmetrical as possible. This means that the waist is the body location where such a weight is best carried. However, this is often not practical because RPD is normally made to be worn on specific body parts in order to protect against a specific risk.