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Respiratory protective devices — Human factors —

Part 4: Work of breathing and breathing resistance: physiologically based limits

Appareils de protection respiratoire — Facteurs humains —

Partie 4: Travail de respiration et résistance respiratoire : limites physiologiques

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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).

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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, P*ersonal safety — Personal protective equipment*, Subcommittee SC 15, *Respiratory protective devices*.

This first edition of ISO 16976-4 cancels and replaces the second edition of the Technical Specification ISO/TS 16976-4:2019, which has been technically revised.

The main changes are as follows:

— the document has been editorially revised.

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.

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Introduction

A respiratory protective device (RPD) is designed to offer protection from the inhalation of hazardous substances. However, this protection requires extra effort by the respiratory muscles as they need to generate higher pressures to overcome the associated respiratory loads imposed by the RPD.

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Respiratory protective devices — Human factors —

Part 4: Work of breathing and breathing resistance: physiologically based limits

1 Scope

This document describes how to calculate the work performed by a person's respiratory muscles with and without the external respiratory impediments that are imposed by RPD of all kinds, except diving equipment. This document describes how much additional impediment people can tolerate and contains values that can be used to judge the acceptability of an RPD.

NOTE These calculations are explained in some textbooks on respiratory physiology (in the absence of an RPD), but most omit them or are incomplete in their explanations.

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 and the following 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/

3.1
body temperature pressure saturated
BTPS
standard condition for the expression of ventilation parameters

EXAMPLE Body temperature (37 °C), atmospheric pressure (1 013,25 hPa) and water vapour pressure (6,27 kPa) in saturated air.

Note 1 to entry: It is the atmospheric pressure at the test location that should be used whenever BTPS conditions are specified.

3.2
compliance
change in volume of the human lung that results from a change in pressure

Note 1 to entry: The compliance is measured in l/kPa.

Note 2 to entry: This term is the typical term for the elastic behaviour of the lungs and chest. Compliance is the inverse of elastance.

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3.3
elastance
change in pressure that results from a given volume change of the human lung

Note 1 to entry: The elastance is measured in kPa/l.

Note 2 to entry: This term is the typical term for the elastic behaviour of an RPD. Elastance is the inverse of compliance.

3.4
relaxation volume
lung volume when respiratory muscles are relaxed, i.e. the volume at the beginning of an inspiration, also known as functional residual capacity (FRC) and expiratory reserve volume (ERV)

3.5
tidal volume
V_T
volume of a breath

Note 1 to entry: The tidal volume is measured in litres BTPS.

3.6
vital capacity
VC
volume of the largest breath a person can take, i.e. the volume difference between a maximum inspiration and a maximum expiration

Note 1 to entry: The vital capacity is measured in litres BTPS.

3.7
work of breathing
WoB
work required for an entire breathing cycle

Note 1 to entry: The work in breathing is measured in Joules.

3.8
work of breathing per tidal volume
WoB/V_T
normalized *WoB* (3.7) (equivalent to volume-averaged pressure)

Note 1 to entry: The work in breathing per tidal volume is measured in Joules per litre = kPa.

4 Symbols and abbreviated terms

BTPS	body temperature pressure saturated
ERV	expiratory reserve volume
FRC	functional residual capacity
RPD	respiratory protective device
VC	vital capacity
WoB	work of breathing
p_{el}	pressure required to overcome the elastance
p_{aw}	pressure required to overcome the flow resistance of the airways

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