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Respiratory protective devices — Human factors —

Part 1: Metabolic rates and respiratory flow rates

Appareils de protection respiratoire — Facteurs humains —

Partie 1: Métabolismes énergétiques et régimes des débits respiratoires

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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 ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 15, *Respiratory protective devices*.

This first edition of ISO 16976-1 cancels and replaces ISO/TS 16976-1:2015, 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

For an appropriate design, selection, and use of respiratory protective devices, it is important to consider the basic physiological demands of the user. The type and intensity of work affect the metabolic rate (energy expenditure) of the wearer. The mass and mass distribution of the device on the human body also may influence metabolic rate. Metabolic rate is directly correlated with oxygen consumption, which determines the respiratory demands and flow rates. The work of breathing is influenced by the air flow resistances of the device and the lung airways. The work (or energy cost) of a breath is related to the pressure gradient created by the breathing muscles and the volume that is moved in and out of the lung during the breath. Anthropometric and biomechanical data are required for the appropriate design of various components of a respiratory protective device, as well as for the design of relevant test methods.

This document is the first part of a series of documents providing basic physiological and anthropometric data on humans. It contains information about metabolic rates and respiratory flow rates for various types of physical activity.

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Respiratory protective devices — Human factors —

Part 1: Metabolic rates and respiratory flow rates

1 Scope

This document provides information on factors related to human anthropometry, physiology, ergonomics, and performance for the preparation of standards for performance requirements, testing, and use of respiratory protective devices.

This document contains information related to respiratory and metabolic responses to rest and work at various intensities. Information is provided for the following:

— metabolic rates associated with various intensities of work;

— oxygen consumption as a function of metabolic rate and minute ventilation for persons representing three body sizes;

— peak inspiratory flow rates during conditions of speech and no speech for persons representing three body sizes as a function of metabolic rates.

The information contained within this document represents data for healthy adult men and women of approximately 30 years of age, but is considered to be applicable for the age range of the worker population.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
aerobic energy production
biochemical process in the human cells that delivers energy by combustion of fat, carbohydrates and, to a lesser extent, protein in the presence of oxygen, with water and carbon dioxide as end products

3.2
ambient temperature pressure saturated
ATPS
standard condition for the expression of ventilation parameters related to expired air

Note 1 to entry: Actual ambient temperature and atmospheric pressure; saturated water vapour pressure.

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3.3
ambient temperature pressure humidity
ATPH
standard condition for the expression of ventilation parameters related to inspired air

Note 1 to entry: Actual ambient temperature, atmospheric pressure and water vapour pressure.

3.4
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.

3.5
peak inspiratory flow rate
PIFR
highest instantaneous flow rate during the inhalation phase of a respiratory period comprising an inhalation and an exhalation phase

Note 1 to entry: It is expressed in l/s BTPS.

Note 2 to entry: l/s is the preferred unit as the flow takes place during only a short fraction of the respiratory period comprising an inhalation and an exhalation phase.

3.6
minute ventilation
$\dot{V}_E$
total volume of air inspired (or expired) in the lungs during 1 min

Note 1 to entry: It is expressed in l/s BTPS.

3.7
oxygen consumption
$\dot{V}(O_2)$
amount of oxygen consumed by the human tissues for *aerobic energy production* (3.1)

Note 1 to entry: It is expressed in l/min STPD.

3.8
physical work capacity
ability of a person to engage in muscular work

3.9
standard temperature pressure dry
STPD
standard conditions for expression of *oxygen consumption* (3.7)

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

4 Activity and metabolic rate

Users of respiratory protective devices (RPD) perform physical work at various intensities. Physical work, in particular when associated with large muscle groups as is the case with firefighting, requires high levels of metabolic energy production (metabolic rate). The energy is produced in human cells by aerobic or anaerobic processes.

Aerobic energy production is by far the most common form of energy yield for all types of human cells. It is also the normal form of energy production for the muscles. Depending on physical fitness and other

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