

Second edition
2019-03

Respiratory protective devices — Human factors —

Part 3: Physiological responses and limitations of oxygen and limitations of carbon dioxide in the breathing environment

Appareils de protection respiratoire — Facteurs humains —

Partie 3: Réponses physiologiques et limitations en oxygène et en gaz carbonique dans l'environnement respiratoire



Reference number
ISO/TS 16976-3:2019(E)

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

This is a preview of "ISO/TS 16976-3:2019". [Click here to purchase the full version from the ANSI store.](#)

Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Symbols and abbreviated terms	5
5 Oxygen and carbon dioxide in the breathing environment: Physiological responses and limitations	5
5.1 General.....	5
5.2 Oxygen and carbon dioxide gas exchange in the human lung.....	6
5.3 Oxygen and carbon dioxide transport in the blood.....	6
5.4 Oxygen and carbon dioxide and the control of respiration.....	8
5.5 Hyperoxia: physiological effects.....	9
5.6 Hypoxia: physiological effects.....	10
5.7 Hypercarbia: Physiological effects.....	13
5.8 Relevance to the use of respiratory protective devices (RPD).....	16
5.9 Interpretation of results.....	20
5.10 Significance of results.....	21
Bibliography	22

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 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 second edition cancels and replaces the first edition (ISO/TS 16976-3:2011), which has been technically revised. The main changes compared to the previous edition are as follows:

- adding a new [Table 3](#) to give limits for CO₂ when breathing against imposed breathing resistance;
- explanation of the new limits for CO₂ derived from a study.

A list of all parts in the ISO/TS 16976 series can be found on the ISO website.

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Introduction

Due to the nature of their occupations, millions of workers worldwide should wear respiratory protective devices (RPD). RPD vary considerably, from filtering devices, supplied breathable gas devices, and underwater breathing apparatus (UBA), to escape respirators used in emergency situations (self-contained self-rescuer or SCSR). Many of these devices protect against airborne contaminants without supplying air or other breathing gas mixtures to the user. Therefore, the user might be protected from particulates or other airborne toxins but still be exposed to an ambient gas mixture that differs significantly from that which is normally found at sea level. RPD that supply breathing air to the user, such as an SCBA or UBA, can malfunction or not adequately remove carbon dioxide from the breathing space, thus exposing the user to an altered breathing gas environment. In special cases, RPD intentionally expose the wearer to breathing gas mixtures that significantly differ from the normal atmospheric gas mixture of approximately 79 % nitrogen and 21 % oxygen with additional trace gases. These special circumstances occur in aviation, commercial and military diving, and in clinical settings.

Breathing gas mixtures that differ from normal atmospheric can have significant effects on most physiological systems. Many of the physiological responses to exposure to high or low levels of either oxygen or carbon dioxide can have a profound effect on the ability to work safely, to escape from a dangerous situation, and to make clear judgements about the environmental dangers. In addition, alteration of the breathing gas environment can, if severe enough, be dangerous or even fatal. Therefore, monitoring and controlling the breathing gas, and limiting user exposure to variations in the concentration or partial pressure of oxygen and carbon dioxide, is crucial to the safety and health of the worker.

This document discusses the gas composition of the Earth's atmosphere; the basic physiology of metabolism as the origin of carbon dioxide in the body, respiratory physiology and the transport of oxygen to the cells and tissues of the body; and the subsequent transport of carbon dioxide from the tissues to the lungs for removal from the body. Following the basic physiology of respiration, this document addresses the physiological responses to altered breathing environments (hyperoxia, hypoxia) and to the effects of excess carbon dioxide in the blood (hypercarbia). Examples are given from the relevant biomedical literature.

Finally, it deals with the impact of altered partial pressures/concentrations of oxygen and carbon dioxide on respirator use. The content of this Document is intended to serve as the basis for advancing research and development of RPD with the aim of minimizing the changes in the breathing environment, thus minimizing the physiological impact of RPD use on the wearer. If this can be accomplished, the health and safety of all workers recommended by their occupation to wear RPD will be enhanced.