PD ISO/TS 16976-6:2014

BSI Standards Publication

Respiratory protective devices — Human factors

Part 6: Psycho-physiological effects

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee PH/4, Respiratory protection.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2014

ISBN 978 0 580 82285 8
ICS 13.340.30

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 July 2014.

Amendments/corrigenda issued since publication

Date	Text affected

PD ISO/TS 16976-6:2014

TECHNICAL SPECIFICATION

ISO/TS 16976-6

First edition
2014-06-01

Respiratory protective devices — Human factors —

Part 6: Psycho-physiological effects

Appareils de protection respiratoire — Facteurs humains — Partie 6: Effets psycho-physiologiques

Reference number
ISO/TS 16976-6:2014(E)

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
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Published in Switzerland

Contents

Page

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 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/TS 16976 consists of the following parts, under the general title *Respiratory protective devices — Human factors*:

— *Part 1: Metabolic rates and respiratory flow rates*

— *Part 2: Anthropometrics*

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

— *Part 4: Work of breathing and breathing resistance: Physiologically based limits*

— *Part 5: Thermal effects*

— *Part 6: Psycho-physiological effects*

— *Part 7: Hearing and speech*

— *Part 8: Ergonomic factors*

Introduction

This part of ISO/TS 16976 addresses the psychological factors that can trigger physiological effects (psycho-physiology effects) that contribute to user acceptance, or the ability to tolerate wearing respiratory protective devices (RPD) for the duration needed. This part of ISO/TS 16976 takes the position that the psychological state has a physiological correlate (e.g. anxiety is accompanied by an increase in heart rate) and that the physiological responses to wearing an RPD have an impact on the psychology of the wearer (e.g. difficulty in breathing will result in anxiety). The following sections focuses on a separate psycho-physiological situation that can impact user acceptance or contribute to the likelihood of the wearer removing the RPD prematurely and, thus, being exposed to a respiratory hazard. The physiological responses to wearing an RPD is addressed first followed by a discussion on the psychological responses to wearing RPD. The discussion then turns to the methodologies used to measure the psycho-physiological responses and how these measurements are used to predict whether an individual will have difficulty wearing an RPD. Finally, this part of ISO/TS 16976 addresses the selection criteria that can be used to determine who is best suited to engage in an occupation requiring the use of RPD.

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.”

TECHNICAL SPECIFICATION **ISO/TS 16976-6:2014(E)**

Respiratory protective devices — Human factors —

Part 6: Psycho-physiological effects

1 Scope

This part of ISO/TS 16976 provides information on the psycho-physiological effects related to the wearing of respiratory protective devices (RPD) and it is intended for the preparation of standards for selection and use of RPD.

It specifies for the writers of RPD standards, principles relating to

— the interaction between RPD and the human physiological and psychological perception,

— the acceptance by the wearer, and

— the need for training to improve acceptance of the RPD by the wearer.

This part of ISO/TS 16976 does not cover requirements related to the specific hazard for which the RPD is designed.

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 16972, *Respiratory protective devices — Terms, definitions, graphical symbols and units of measurement*

3 Terms and definitions, symbols and abbreviated terms

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

3.1
aetiopathology
cause of the pathological state or disorder, pathogenesis

3.2
anxiety
state of being uneasy, apprehensive, or worried about what might happen, misgiving

3.3
BP
arterial blood pressure (mmHg)

3.4
cardiac arrhythmia
variation from the normal rhythm of the heart beat

3.5
claustrophobia
abnormal fear or dread of being in an enclosed or confined space

3.6
dysphoria
sensation of disquiet, restlessness, or malaise

3.7
dyspnoea
sense of air hunger, difficult or laboured breathing, or a sense of breathlessness

3.8
HR
heart rate (beats·min^{-1})

3.9
hypercapnia
excess amount of CO_2 in the blood

3.10
hyperventilation
increase in overall respiration resulting from an increase in both the depth and frequency of breathing

Note 1 to entry: This can be voluntary or result from an increase in activity, fear, or breathing excess carbon dioxide (CO_2).

3.11
hypoxia
volume fraction or partial pressure of oxygen in the breathing atmosphere below that found in the atmosphere at sea level

3.12
metabolism/metabolic rate
energy produced in human cells by aerobic or anaerobic processes

3.13
minute ventilation
$\dot{V}_E$
total volume of air inspired (or expired) in the lungs during 1 min, in L·min^{-1} (BTPS)

3.14
paresthesia
abnormal sensation without objective cause such as numbness, prickling, and tingling; heightened sensitivity

3.15
psycho-physical effect
pertains to the mind and its relation to physical manifestations

3.16
psycho-physiological effect
psychological trait(s) and responses to a given situation which can provoke a physiological response and the physiological responses to a given situation which can provoke a psychological reaction

3.17
RR
respiratory rate (breaths·min^{-1})

3.18
SaO_2
degree of saturation of haemoglobin with oxygen in arterial blood (expressed as a % of total saturation)

3.19
stereoacuity
visual clarity in three dimensions

3.20
tachycardia
increased heart rate due to exercise, pain, anxiety, or pathophysiological state

3.21
$tcCO_2$
measured transcutaneous carbon dioxide

Note 1 to entry: The level of carbon dioxide in tissue vasculature, as measured by a transcutaneous CO_2 detector attached to the earlobe.

3.22
phobia
any persistent and irrational fear of a specific object, activity, or situation that results in a compelling desire to avoid the feared stimulus

3.23
State-Trait Anxiety Inventory
psychological assessment tool used to determine the presence and type of anxiety in an individual and is used to differentiate between situational anxiety (state anxiety) and chronic feelings of anxiety as part of the overall personality structure (trait anxiety)

4 Symbols and abbreviated terms

RPD	respiratory protective device
$\dot{V}_E$	minute ventilation
BP	blood pressure
STAI	State-Trait Anxiety Inventory
FFR	filtering facepiece respirator
HR	heart rate
RR	respiratory rate
SaO_2	arterial oxyhaemoglobin saturation
SARS	severe acute respiratory syndrome
WoB	work of breathing
Pa	pascal
SCBA	self-contained breathing apparatus
T_{sk}	skin temperature
SA	state anxiety
TA	trait anxiety
IDLH	immediately dangerous to life and health

$\dot{V}\,O_2$ rate of oxygen consumption during breathing

$\dot{V}\,CO_2$ rate of carbon dioxide production during breathing

5 Psycho-physiological effects influencing user acceptance of RPD

5.1 General

Many occupations require workers to wear RPD to protect them from hazardous atmospheres. However, a small but significant fraction of the workers find it difficult or even impossible to wear RPD for longer than a few minutes. This might be due to the physical discomfort of a poorly fitting RPD or due to dangerous situations under extreme circumstances or might be due to the particular psychological traits of the wearer's personality. Wearing an RPD provokes physiological responses in essentially all wearers and it appears to be the psychological response to the physiological sensations (air hunger, heat, narrowing of the visual field) that might provoke a psychological reaction that renders the individual incapable of wearing the RPD. The following sections address first the physiological responses to wearing RPD and the potential psychological reactions to those physiological responses.

5.2 Physiological responses to wearing RPD and impact on performance of work

The simple act of donning an RPD can elicit a number of psychological responses that can be independent of the environment in which the RPD is used. Wearing an RPD can alter the concentration of oxygen (O_2) and carbon dioxide (CO_2) in the breathing space that, if of sufficient magnitude, significantly affect gross respiratory function (e.g. increase or decrease in minute ventilation). In addition, wearing an RPD is associated with changes in cardiovascular function in response to sympathetic nervous system stimulation, reduction in physical performance, work of breathing, changes in $\dot{V}_E$ (e.g. dyspnoea) as a result of increased resistance to airflow, and sensation of heat. In most, if not all people, there will be a psychological response to the physiological sensations that are experienced by the wearer of the RPD. The psychological responses will determine the degree of wearer acceptance of the RPD and compliance with the requirements of RPD necessary in providing an appropriate level of protection. Each of the physiological responses is discussed in the following paragraphs.

5.2.1 Oxygen (O_2) and carbon dioxide (CO_2) in the breathing space

The physiological responses to O_2 and CO_2 in the breathing space have already been addressed in detail in ISO 16976-3 and in a recent review article.[62] Briefly, changes in the concentration of either O_2 or CO_2 in the breathing space might significantly alter the cardiorespiratory system as evidenced by changes in heart rate (HR), blood pressure (BP), $\dot{V}_E$, blood pH, and other physiological parameters. Reduced atmospheric O_2 (hypoxia) results in an increased ventilatory response[10] and increased cardiac output due to stimulation of the central nervous system[13] in order to ensure adequate oxygenation of the blood and elimination of metabolically produced CO_2. Severe hypoxia results in a constellation of signs and symptoms including a decrease in exercise tolerance, a decrease in cold tolerance, dizziness, euphoria, loss of consciousness, and if oxygen is not administered quickly, death from asphyxiation.[32] Mild hypoxia results in little change in the healthy person[11] and results in an initial mild respiratory depression followed by an increase in $\dot{V}_E$.[13] Breathing hyperoxic gas mixtures under higher atmospheric pressure (underwater diving, caisson work) can result in generalized seizures, hallucinations, involuntary movements, paresthesias, psychological changes (dysphoria, amnesia), and problems with some autonomic (involuntary) nervous system function.[55]

Breathing elevated CO_2 might result in changes in stereoacuity and perception of coherent motion[56] [64] reduced retinal blood flow[31] increased rate of body heat loss during snow burial[15] decreased performance on reasoning tasks, subjective increases in both irritability and discomfort,[45] and reduced ability to exercise during simulated emergency escape procedures[6], an increase in resting $\dot{V}_E$ of up to 75 L·min^{-1},[49] induction of anaesthesia, as well as inert gas narcosis[32]. Increased partial pressure of CO_2 (PCO_2) affects pulmonary $\dot{V}_E$ disproportionate to the level of exercise, thus, increasing the metabolic

cost of breathing as well as inducing a sense of "air hunger" (dyspnoea) that limits exercise tolerance[6] and can increase the potential to induce cardiac arrhythmias[32].

For some workers, the RPD does not seem to present a significant problem during relatively short-term use[43]. Roberge et al.[44] found that O_2 and CO_2 in the breathing space remained relatively unchanged but retention of CO_2 (increased $tcCO_2$) occurred after about one hour of wear. This level of $tcCO_2$ did not result in symptomatology but might be a cause for concern if the worker wore the RPD for longer than an hour. It is interesting to note that there were small but statistically significant differences in SaO_2 between filtering facepiece respirator (FFR) RPD with and without an exhalation valve.

5.2.2 Metabolic rate during RPD use

Wearing an RPD generally results in an increase in the metabolic rate of the wearer over and above the increase resulting from performing physical work alone. Clinically significant increases in metabolic rate as measured by increased HR, BP, RR, and elevated T_{sk} in the immediate proximity underneath the RPD have been noted at moderate and higher workloads and attributable to increased breathing resistance of the FFR[22]. In other studies in which ventilator resistance was varied, exercise tolerance to increased breathing resistance decreased[17]. These general physiological responses were also noted by Smith et al.[50] Raven et al.[40] noted a 17 % to 21 % decrement in function, a 37 % increase metabolic rate, a 24 % increase in BP, and a 27 % increase in submaximal HR. Increased breathing resistance in RPD also resulted in a decrease in O_2 uptake leading to increased O_2 deficiency during exercise, and a decrease in $\dot{V}_E$ [40]. In studies by White et al.,[62] subjects wearing protective clothing including RPD also experienced an increased physiological burden as manifested by increased HR and decreased work tolerance that worsened at higher work intensities. The increased HR and RR have also been measured in subjects wearing FFR[25]. These responses are a clear indicator of an increase in the physiological cost of wearing respirators and the greater resistance to air flow, the greater the workload and the greater the physiological effect.

5.3 Subjective feelings of discomfort

A commonly reported type of discomfort related to wearing RPD is headache. In a report by Lim et al.,[29] 37,3 % of respondents reported headache associated with wearing FFR during an epidemic of severe acute respiratory syndrome (SARS) in Asia and Canada that required analgesic medication and sick leave. Although some respondents reported that they had chronic headache that was exacerbated by RPD use, others reported that the use of the RPD alone caused headache. Lim et al.[29] suggested that the aetiopathology could be hypoxemia, hypercapnia, mechanical factors (e.g. poor-fitting respirator), or stress associated with the circumstances of use (dangerous epidemic). However, neither the gas concentrations in the breathing space of the RPD nor blood gases were measured. Therefore, it is difficult to determine the specific cause of RPD-associated headache in this study. Others have suggested that excessive pressure on superficial nerves in the head, poor RPD fit, or pulling FFR straps too tightly might be the root cause of the headaches[28].

Reports of headache during and after RPD use might also be due to exposure to an elevated level of CO_2 in the breathing environment. A report by NIOSH[2] summarized 19 studies on the effects of CO_2 on human subjects. Both the physiological responses to acute and longer term exposure were described. The results of these studies have been integrated into ISO 16976-3. In this summary, studies supported the notion that breathing CO_2 at sufficient concentrations usually resulted in a CO_2-induced headache. As mentioned in 5.2.1, breathing gas mixtures containing >6,5 % CO_2 decreased performance on reasoning tasks and subjectively increased both irritability and discomfort[45]. The discomfort experienced by breathing elevated levels of CO_2 can also influence RPD use in hazardous environments. Nevertheless, given the wide range of human tolerance to CO_2, it is likely that inhalation of even relatively low concentrations of CO_2 in the breathing space of an RPD might be responsible for headache and other discomforts in the sensitive individual[43].

Although nearly everyone who wears an RPD experiences some level of discomfort, and the tolerance to discomfort varies greatly among people,[12] there is no question that the correct fitting of an RPD is critical to wearer comfort and acceptance especially when the RPD is worn in an extreme environment[37]. An RPD that is too tight on the face, has straps or other features that create pressure on the skin might cause

such extreme discomfort or pain that the wearer might remove the RPD[14]. Other sources of discomfort might arise from an undiagnosed medical condition experienced by the wearer. Other wearers might feel discomfort due to a perceived sense of an increased difficulty in performing mentally stressing tasks[21].

5.3.1 Subjective feelings of dyspnoea (air hunger) due to increased breathing resistance and work of breathing

Sensations of dyspnoea might be due to physical or physiological stressors that do not have a psychological basis. Increased breathing resistance imposed by wearing an RPD might result in a feeling of not being able to inhale sufficient air during the breathing cycle. Resistance to either inhalation or exhalation that did not alter $\dot{V}_E$ have been reported to be acceptable to the wearer[47] [48]. In these studies, work of breathing (WoB) caused by resistance to breathing was acceptable over the long term if the inspiratory and expiratory work of breathing per tidal volume (WoB/V_T) each was ≤0,9 kPa and with a peak inspiratory and peak expiratory pressures of ≤1,2 kPa. Short-term tolerances were greater. Resistances that exceeded these values were deemed unacceptable and might create a sense of dyspnoea that could induce the wearer to remove the RPD while still in a hazardous environment. As mentioned previously, the tolerance to discomfort varies widely among individuals but might be related to psycho-physical (as distinct from psycho-physiological) effects with associated physiological responses that are not completely related to exercise limitations[17].

Breathing elevated PCO_2 or decreased PO_2 might also result in a sensation of dyspnoea and the resulting increased discomfort might reduce RPD tolerance. As mentioned previously, both hypoxia and hypercapnia are powerful stimulators of ventilation and, if the inhaled PO_2 is low enough or PCO_2 is high enough, the person might have a sense of dyspnoea. The sense of dyspnoea might even occur when there is sufficient O_2 in the presence of a high concentration CO_2 to prevent hypoxia[62]. This situation is exacerbated in the presence of an increased breathing resistance or load. Hypoxic or hypercapnic stimulation of $\dot{V}_E$ against an increased resistance to breathing might induce a sense of dyspnoea or a sense of discomfort even when workloads are minimal and more so with increasing workloads or increases in breathing resistance[16] [23]. In persons with high psycho-physical load, sensitivity might have an even lower tolerance than average even if the person is "physiologically normal"[17]. Increased breathing resistance also results in a decrease in submaximal $\dot{V}\,O_2$, $\dot{V}_E$ and respiratory exchange ratio (decreased exhaled CO_2 relative to O_2 consumed resulting in CO_2 retention) leading to an increase in energy being supplied through anaerobic metabolism[40]. If the resistance to breathing is increased beyond a certain level, an O_2 deficit might arise leading to attempts to increase ventilation against the resistance leading to dyspnoea[1] [8]. If the inspired CO_2 is above 3 % by volume (an alveolar PCO_2 > 40 mmHg) and breathing resistance is above 1 kPa (as measured at a constant air flow of 100 L min^{-1}),[30] subjects were unable to continue exercise due to dyspnoea and headache[48]. Therefore, increased resistance to breathing coupled with an inhaled CO_2 > 3 % reduced tolerance to the RPD with complaints of dyspnoea, headache, and reduced ability to work[22].

Previously, disordered breathing (e.g. rapid breathing in the absence of exercise), awareness of breathing sensations (e.g. sensation of increased effort of breathing), or hyperventilation syndrome was thought to be secondary to psychological conditions such as anxiety. However, it is now understood that anxiety might be a response to, and not the cause of, the awareness of breathing (e.g. dyspnoea from increased resistance to breathing) by the healthy wearer[37]. This implies that in the case of many (but not all) healthy wearers, the respiratory or other physiological responses to wearing an RPD are what provoke a psychological response that affects wearer tolerance of the RPD ("hyperventilation syndrome"). In other cases, pre-existing psychological conditions in the wearer which are exacerbated by the physiological responses to RPD wear are what influence RPD tolerance[37].

5.3.2 Subjective feelings of dry respiratory passages

5.3.2.1 Mouth breathing

Many wearers of RPD revert to mouth breathing after donning a respirator. The switch from nasal to mouth breathing depends on the individual but is generally related to the level of exercise[59] [60] or with

an increase in resistance to airflow (e.g. increased nasal congestion)[9]. However, the percent time spent in mouth breathing also increases with RPD wear time. The nasal passages offer the greatest resistance to air flow within the pulmonary system (~50 % of the total resistance). When this anatomical resistance to air flow is combined with resistances imposed by wearing an RPD, the total resistance to breathing increases and reversion to mouth breathing occurs sooner than it would without wearing the RPD. This is especially true as exercise begins to increase beyond a $\dot{V}_E$ of about 35 L·min^{-1}[18] [19] [33].

Breathing directly through the nose allows air to be heated, humidified, and filtered of particulates (>10 µm in size) prior to the air reaching the deeper respiratory passages[9]. However, the nasal passages offer a greater resistance to air flow compared to breathing through the oral passages. The resistance to air flow results in a slowing of the air velocity to allow for the "conditioning" of air as mentioned previously[18]. Although breathing through the mouth offers less resistance to air flow, air passing across the oral mucosa might dry out the oral passages causing discomfort to the wearer. The use of dry compressed breathable gas can aggravate the drying of oral mucosa during mouth breathing[19].

The drying of the oral and pulmonary mucosa through the breathing of cold, dry breathable gas or due to the rapid movement across the pulmonary airways is known to provoke asthma attacks in the susceptible individual[34]. Some types of RPD supply cold, dry breathable gas, to the wearer which could trigger an asthma attack. The anxiety produced by the possibility of using an RPD that might trigger an asthma attack would exacerbate the psychological stress of using an RPD in the first place.

5.3.2.2 Hot breathable gas produced by RPD

Certain types of closed-circuit RPD produce oxygen through chemical reactions (typically potassium superoxide reacting with H_2O to produce oxygen). This reaction is strongly exothermic and might result in the wearer breathing very hot gaseous oxygen[1]. Breathing large volumes of hot or cold dry gas might result in a drying of the oral cavity[58]. The breathing of extremely hot gas might result in actual damage to the pulmonary tissue if the temperature is too great, especially if the air is very humid (and above 100 °C with high relative humidity ≥70 %)[33]. On the other hand, the sensation of dry oral passages might cause significant discomfort in many people. With some escape RPD the wearer must place a mouth piece into the mouth and then inhale hot, breathable gas directly into the mouth, with the potential for the drying of the oral cavity[19] [57]. In addition, water loss from the exhaled breath increases when switching from nasal to oral breathing[57]. The loss of water from the oral cavity might contribute to the sense of dry mouth[26]. Certain medications, particularly atropine-like drugs[7] and certain anti-depressants,[4] might also result in drying of the oral cavity. An individual being treated with these types of medications (especially if being treated for anxiety) will likely experience an aggravation of the sensation of dry mouth while using an RPD that delivers either hot or cold dry gas. Therefore, a complete understanding of the wearer's medical history, including the use of any prescription medications that can impact the ability to tolerate wearing an RPD, is necessary.

5.3.3 Subjective feelings of heat stress

There is a potential for RPD to impose increased heat stress on the wearer regardless of the degree of acclimatization as indicated by increased sweating, HR, and T_{sk}, even during light workloads, and tolerance time was significantly reduced during maximal workloads. This effect seems to be exacerbated while wearing RPD (e.g. SCBA) with encapsulating protective clothing[61].

5.4 Psychological responses to RPD wear

As outlined previously, there are many physiological responses to wearing RPD that can have an impact on the wearer's psychological state. The donning of an RPD might provoke a psychological response (e.g. "anticipatory" response) in the wearer in the same manner that the RPD provokes a physiological response (e.g. increased sweating response). In a review of these issues, Morgan[37] observed that wearer "comfort" represents an important criterion for both the selection of RPD but also the wearer acceptance of the RPD which will determine user compliance with the requirement to wear the RPD. The physical limitations such as a narrowing of the visual field might lead to anxiety and hyperventilation because of subjective feelings of stress that is in excess of the actual external work or hazard exposure.

The following discussion addresses some of the psychological reactions to physiological sensations resulting from wearing an RPD[38].

5.4.1 Subjective feelings of claustrophobia

Many people experience some level of claustrophobia when donning an RPD. This might be derived from the stimulation of skin sensors that result in a sensation of heat, narrowing of the perceptual field, increased resistance to breathing that might, in some people, induce a feeling that there is insufficient breathable gas or requiring too much effort to access the gas, all leading to a general sense of claustrophobia[37]. These sensations evolve over time such that the sense of claustrophobia worsens the longer the person wears the RPD. In soldiers susceptible to claustrophobia, the tolerance to wearing these RPD prior to removal of the RPD is measured in minutes[41] [42]. Others who are tolerant of increased resistance to breathing and dead space loads were able to wear the RPD for the duration of the time necessary to complete the tasks[17]. Those more sensitive to CO_2 (in terms of the sensation of increased $\dot{V}_E$ and air hunger) were less tolerant of the RPD and were more likely to remove the RPD[6] [62]. Sensitivity to CO_2 stimulation of $\dot{V}_E$ varies with the individual and is influenced by personality. However, in a study examining the effects of personality on CO_2 sensitivity, Shershow et al.[46] reported that in subjects whose personality was evaluated using the Minnesota Multiphasic Personality Inventory (MMPI), those scoring more highly for abnormal psychological features were "low-responders" to a CO_2 challenge compared to a more CO_2-sensitive group. Therefore, the individual's psychological state might influence tolerance to RPD and would explain the wide range of tolerance among individuals.

5.4.2 RPD phobia

Military-type RPD have routinely been issued to military personnel as a result of the development of chemical (and, later, biological) warfare agents that were used extensively starting in 1915 near the beginning of the First World War through the Persian Gulf Wars to protect against hazards ranging from blistering agents to nerve gas[41] [42] [51]. As such, the US military (and many armed forces worldwide) currently issues RPD to all soldiers both during combat training and throughout deployment. Although the military use of RPD is outside the scope of this document, the extensive military experience with RPD has revealed that a small but significant number of RPD wearers (about 10 %) develop what has come to be termed RPD phobia and this experience can inform the civilian sector on ways to address this issue.

RPD phobia is a general term that encompasses a cluster of signs and symptoms including hyperventilation, tachycardia (rapid heart rate), sweating, fear, an overwhelming urge to remove the RPD (thereby risking exposure to the hazardous atmosphere), sensations of claustrophobia, and fainting[35] [41]. RPD phobia, therefore, might be exacerbated by a number of physiological factors including the increased resistance to breathing which ultimately hinders physical performance, fogging of lenses due to perspiration resulting in a reduction of vision, and difficulty in communication[27]. Increased CO_2 in the breathing space might stimulate pulmonary ventilation and aggravate the sensation imposed by the resistance to breathing[63]. Treatment strategies have been developed by the military for RPD phobia focus on desensitization techniquess[41] [42] [63].

5.5 Objective measures of psycho-physiological effects

Measuring the physiological responses to wearing RPD has been performed with increasingly sophisticated instrumentation for decades. However, there are measurement tools devised by psychologists that can be used to predict[20] [38] as well as monitor[37] the psychological responses to wearing RPD. The prediction can be based on a battery of personality tests,[46] screening using both physiological and psychological measurements,[20] or using a specific psychological inventory to determine the general level of anxiety either due to a personality type or a situation. The following section discusses a selection of these methods.

5.5.1 Use of screening tool to predict the psycho-physiological effect on the RPD wearer

As mentioned previously, claustrophobia is commonly experienced by many people when they wear an RPD for the first time. Therefore, successful desensitization techniques which remove or minimize symptoms of anxiety or phobia are required to allow the individual to work in the environment that requires the use of an RPD[41] [42]. Properly treated using proven techniques, these people eventually overcome or desensitize to the feelings of claustrophobia and are able to successfully wear the RPD occupationally[39]. Although effective desensitization techniques exist, it still seems important to be able to screen for those individuals who are likely to suffer from RPD phobia and to either preclude them from occupations that require RPD use or, if possible, offer those individuals training aimed at desensitizing them to the RPD.

5.5.2 Anxiety

Human physical performance depends not only on overall physiological fitness but on the psychological state of the individual and has been reviewed in detail[36]. Essentially, there are two forms of anxiety described by adherents to this system of psychology. A person who feels anxiety due to circumstances (facing an important exam, walking alone at night) is said to be experiencing state anxiety – that is, the state of anxiety is due less to a facet of the individual's personality than to circumstances that provoke the individual's anxiety. On the other hand, psychologists recognize a common form of anxiety that seems to be chronic, involving up to 18 % of the general population, and is linked to a facet of the individual's psychological make-up. These individuals might feel a sense of anxiety that is not linked to some external circumstance – that is, they might feel chronically anxious regardless of circumstance[63].

Anxiety, whether situational or chronic, might have a significant impact on the ability of an individual to wear RPD long enough to protect against an external respiratory hazard. The industrial psychologist has specific testing tools available to them to determine the presence of anxiety in a worker and to differentiate between workers with "state" or "trait" anxiety. An example of a psychological screening test for anxiety is the State-Trait Anxiety Inventory originally developed in 1970 and further refined by Reference [54]. The State-Trait Anxiety Inventory was designed to be generally applicable and its validity has been consistently supported in the literature[16] [24] [52] [54]. The State-Trait Anxiety Inventory has appeared in more than 3 000 studies[5] and has been translated into at least 48 languages[24].

Individuals who must wear RPD due to potential to exposure to occupational inhalation hazards can be evaluated using State-Trait Anxiety Inventory (STAI) that measures state anxiety (SA) before (screening) and during (monitoring) RPD use. The STAI can also measure trait anxiety (TA) which is a stable personality characteristic. Individuals who score high (>48) for TA probably experience some degree of chronic anxiety. These individuals would not be expected to be good candidates for occupational RPD. Individuals with scores of ~30 to 32 but experiencing SA would be good candidates for RPD use[63]. Even if RPD phobia were to occur in SA individuals, desensitization techniques have been developed which have successfully reduced or eliminated RPD phobia and have allowed the use of RPD without, or with minimal, symptoms of RPD phobia[41].

In addition, RPD design can contribute to SA in some individuals and RPD design can be an important means for reducing SA in the wearer[63]. Reducing resistance to breathing or other RPD feature to reduce the perceived effect might ultimately contribute to a reduction in SA in the RPD wearer[17].

5.6 Selection criteria for potential RPD wearer

As has been mentioned in previous sections, approximately 10 % of the potential wearers of RPD might be unable to do so for a variety of reasons including a cluster of psychological and physiological factors. Because of the negative consequences to the individual and any co-workers' safety in a hazardous atmosphere, the ability to screen for a potential inability to wear an RPD when the occupation demands it would seem invaluable. Several authors have offered possible objective tests to determine personality traits that can be used to screen for RPD acceptance and use[36] [37] [39] [63]. These authors have identified both personality traits (the so-called "trait anxiety") as well as physiological responses to CO_2 which can be used as criteria in determining whether a person is likely to be able to wear an RPD successfully in a hazardous atmosphere. Simple tests for personality traits as well as a test to measure the physiological response to CO_2 could be used to screen individuals for RPD acceptance for safety

reasons. In addition, proposed psychological desensitizing strategies for overcoming RPD phobia have been used successfully[41] [42]. The screening for psychological and physiological responses can also be used to identify workers who might have difficulty wearing an RPD but would be responsive to desensitizing techniques that would allow them to continue to work with an RPD.

5.7 Impact of the psychological and physiological responses

The impact of the psychological and physiological responses to wearing RPD cannot be overemphasized. Many occupations require workers to wear RPD to protect them from hazardous atmospheres. Some of these hazards result in chronic illness (asbestos, silica dust) and other atmospheres are immediately dangerous to life and health (IDLH) (superheated, low oxygen atmospheres found in structural fires). Regardless of whether the risk is long-term or immediate, RPD are a critical component to worker safety. The cost of pulmonary disease, lost work time, loss of income, and premature death are all consequences of ignoring psychological and physiological responses to wearing RPD. Part of the problem is training and the perception of risk, user acceptance, and the inability to wear an RPD due to psychological or physiological reasons.

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