

Respirator Testing Standards and Physiology

A review of 42 CFR pt. 84 Respirator Test Standards and the Physiological Responses to Oxygen and Carbon Dioxide in the Breathing Environment

W. Jon Williams

National Institute of Occupational Safety and Health, Pittsburgh, Pennsylvania, USA

Background: NIOSH evaluates and certifies respiratory protective devices (RPDs) as described in the Code of Federal Regulations (42 CFR 84). RPDs are tested and certified using bench tests however there are some circumstances where human volunteers are used during testing. In most cases, RPD performance is the focus of the testing – not the physiological response to wearing an RPD. However, wearing an RPD may result in a significant physiological response. The physiological (and psychological) responses to RPD wear may affect human job performance and impact the safety of the wearer. Changes in concentrations of O₂ and CO₂ in the breathing environment, perception of heat, breathing resistance, and a sense of claustrophobia could have a severe impact on the physiology and psychology of the wearer that could result in the removal of the RPD while still exposed to a dangerous atmosphere. This presentation will discuss the testing requirements of the 42 CFR 84 compared to the physiological responses to changes in gas concentrations in the breathing space.

Methods: The literature surveyed in this review were obtained through internet searches (PubMed®), electronic database search by a NIOSH professional librarian (Index Medicus, OVID), and from textbooks on physiology and medicine. A list of key words included the following: carbon dioxide, oxygen, physiological exposure limits, high altitude, hypoxia, medical oxygen, hyperoxia, hypercapnia, underwater diving, submarine and other confined spaces atmospheres. The search was conducted in order to review the literature published in this topic over the last 25 years.

Results: Of the 1231 articles identified in the literature search, 350 articles were obtained that proved relevant to the present topic. Of the 350 articles on the general topic, those cited in a review article (Williams 2010), as well as the guidance in 42 CFR 84 and a recently published ISO Technical Specification (ISO/TS 16976-3:2011(E)), were the most relevant to this presentation.

Discussion: Breathing O₂ and CO₂ concentrations that differ from the normal atmosphere can significantly influence human respiration and limit the ability to perform work. Changes in the concentrations of these gases in the breathing atmosphere can strongly influence ventilation, potentially affecting RPD function and the performance of individuals during RPD wear. Increased ventilation will place demands on respirators that could result in increased breathing resistance or impact filter performance. Increased concentration of CO₂ in the breathing space of an RPD may result in a sensation of dyspnea to the degree that the wearer may remove the RPD. Hypoxia may occur unnoticed by the wearer, resulting in loss of consciousness without warning; resulting in injury or fatality if it occurs in a dangerous situation. Therefore, understanding the physiological response to RPDs is as critical to wearer safety as is selection of the proper RPD for the protection of the user.

Reference: Williams, WJ [2010] Physiological response to alterations in [O₂] and [CO₂]: relevance to respiratory protective devices. J Intl Soc Resp Protect. 27(1):27-51.