Hindawi Publishing Corporation
Journal of Environmental and Public Health
Volume 2011, Article ID 473143, 8 pages
doi:10.1155/2011/473143

Research Article

Inward Leakage in Tight-Fitting PAPRs

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Received 16 September 2010; Revised 16 February 2011; Accepted 16 March 2011

Academic Editor: Issam Al-Khatib

A combination of local flow measurement techniques and fog flow visualization was used to determine the inward leakage for two tight-fitting powered air-purifying respirators (PAPRs), the 3M Breathe-Easy PAPR and the SE 400 breathing demand PAPR. The PAPRs were mounted on a breathing machine head form, and flows were measured from the blower and into the breathing machine. Both respirators leaked a little at the beginning of inhalation, probably through their exhalation valves. In both cases, the leakage was not enough for fog to appear at the mouth of the head form.

1. Introduction

Tight-fitting powered air-purifying respirators (PAPRs) can be used in situations where contaminated air must be filtered, with the additional work of drawing air through the filter supplied by a battery-powered blower rather than the wearer's respiratory muscles. Tight-fitting PAPRs form a tight seal with the face, which should minimize exposure to contaminated air. Maintenance of a positive pressure within the facepiece portends that any face seal leakage that does occur should flow outward rather than inward. Performance of work while wearing PAPRs in the heat is influenced also by the cooling flow of air across the face [1].

Despite these advantages, some doubts remain. Is the protection afforded by tight-fitting PAPR wear as good as it would seem? Is there opportunity for contamination to enter the facepiece and be inhaled by the wearer? Is inward leakage, if it exists, likely to lead to inhaled contaminant?

In this study, we have been motivated to explore these issues. Of importance to the wearer is contaminant-laden air that reaches the mouth [2]. This study was conducted to determine if (1) there is possible leakage of ambient air into the PAPR facepieces and (2) whether contaminant leakage actually reaches the mouth where it can be inhaled. The second objective has been considered to be the more important of the two because it relates directly to the safety and health of the wearer. The first objective can be achieved by measuring blower flows and comparing them to inhaled flows. The second objective could be accomplished by visual detection inside the PAPR facepiece, especially at the mouth. The major hurdle to overcome is the fact that tight-fitting PAPRs almost always include visually opaque facepieces, unlike loose-fitting PAPRs. Thus, leakage flow pathways were not able to be visualized in this study.

2. Methods

Two commercially available tight-fitting PAPRs (SE 400; SEA, Meadowlands, PA; 3M Breathe Easy; St. Paul, MN) were tested on a breathing machine head form (Krug Life Sciences, Houston, TX). The SE 400 PAPR is a breathing-demand device with a blower that adjusts to the breathing flow rates of the wearer. The 3M Breathe-Easy PAPR has a blower that is supposed to supply a constant 114 L/min flow rate to the facepiece (this figure was obtained from the manufacturer's literature). The SE 400 blower was operated with a fully charged battery; the 3M Breathe-Easy blower had accessible electrical connections and was attached to a dc power supply at 4.8 volts in order to assure a constant rate of flow. For each of these tests, the Krug breathing machine was operated at 40 breaths/min and with a tidal volume of about 2.25 L.