

Human Subject Testing of Leakage in a Loose-Fitting PAPR

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Leakage from loose-fitting PAPRs (powered air-purifying respirators) can compromise the safety of wearers. The Martindale Centurion MAX multifunction PAPR is a loose-fitting PAPR that also incorporates head, eye, and ear protection. This respirator is used in mines where coal dust usually is controlled by ventilation systems. Should the respirator be depended on for significant respiratory protection? Ten human volunteers were asked to wear the Centurion MAX inside a fog-filled chamber. Their inhalation flow rates were measured with small pitot-tube flowmeters held inside their mouths. They were video imaged while they breathed deeply, and the points at which the fog reached their mouths were determined. Results showed that an average of 1.1 L could be inhaled before contaminated air reached the mouth. As long as the blower purges contamination from inside the face piece during exhalation, the 1.1 L acts as a buffer against contaminants leaked due to overbreathing of blower flow rate.

Keywords dead volume, protection, protection factor, respirator

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INTRODUCTION

Loose-fitting powered air-purifying respirators (PAPRs) have the advantages that they never restrict breathing of the wearer, and they can accommodate items, such as normal eyeglasses, worn on the face. Air drawn by a blower through a filter is blown across the face and intersects the normal path for breathed air to enter the mouth. Thus, under quiet circumstances, the air that is inhaled should be filtered air. When exertion increases and breaths become deeper, however, there is little to impede contaminated air from mixing with the filtered air. Most loose-fitting PAPRs incorporate a face shield, and some have a cloth scarf spanning the gap between the face shield and face or neck to impede contaminated air from entering the vicinity of the mouth.

Mackey et al.⁽¹⁾ published a report about overbreathing a multifunction, loose-fitting PAPR, the Centurion MAX (Martindale Protection, Thetford, Norfolk, U.K.). They

reported that all 16 subjects inhaled more air than was supplied by the PAPR blower. In the same paper they also reported a measured volume inside the face shield of 1.4 L. They contended that if the whole 1.4 L was protective, then the problem of overbreathing would be minimal. This condition would have required diffuse, nonpreferential flow of outside air into the facepiece.

Experiments have been conducted on a loose-fitting PAPR mounted on a head form and challenged with generated fog. (Unpublished observations) The breathing machine was adjusted such that inhaled flow rate exceeded blower flow rate. It was found that the volume of air inhaled before fog reached the mouth averaged 1.4 L. The present experiment was conducted to determine whether the same results can be anticipated for human wearers. If so, then the volume inside the facepiece could be considered to be protective dead volume that buffers against inhalation of airborne contaminants while overbreathing the PAPR blower.

METHODS

Ten young, healthy (determined by questionnaire) participants volunteered from the University of Maryland student body, and each signed a consent form before participating. This protocol was approved by the University of Maryland Institutional Review Board.

Subjects sat in a full body chamber constructed of plywood and could be observed through Lexan plastic windows. Overall dimensions of the chamber were 137 cm long by 76 cm wide by 180 cm high. The rigid plastic window at the front of the chamber was replaced by a transparent, thin plastic film normally used to reduce home window drafts. Each subject wore a Centurion MAX multifunctional PAPR and leaned into the transparent film with the PAPR visor in contact with the film. Thus, it could be seen when fog that filled the chamber entered the space between the visor and the face.

Glycerol fog was produced outside the chamber with a Fog Storm (American DJ, Los Angeles, Calif.) 1200HD generator and introduced into the chamber through a hose inserted into a port in the chamber wall. The fog generator was capable of