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The Workplace Performance of a Continuous Flow Supplied Air Respirator during Aircraft Sanding

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This article presents and discusses the results of a WPF study on the 3M™ Helmet L-901 Supplied Air Respirator.

In April 2000, this workplace protection factor (WPF) study was conducted to determine the workplace performance of a continuous flow supplied air respirator. At that time, the current assigned protection factor (APF) for this class of respirators was 1000 according to the American National Standards Institute (ANSI) committee for respiratory protection[1] while an APF of 25 was recommended by the National Institute for Occupational Safety and Health (NIOSH).[2] As of August 2006, OSHA ruled this type of respirator system to have an APF of 25 unless data suports an APF of 1000. This study provides data supporting an APF of 1000 for 3M™ Helmets L-Series.

Definitions

- Workplace protection factor (WPF) measurements provide an estimate of the protection provided in a workplace, under the conditions of that workplace, by a properly selected, fit tested and functioning respirator while it is correctly worn and used.[3]

  WPF may be expressed mathematically as follows,
  WPF = C_o/C_i where:
  C_o represents inhalation exposure outside the respirator (ambient sample);
  C_i represents inhalation exposure inside the respirator (in-facepiece sample); and
  C_o and C_i are determined simultaneously only while the respirator is worn and used during normal work activities.[3]

- The assigned protection factor (APF) means the workplace level of respiratory protection that a respirator or class of respirators is expected to provide to employees when the employer implements a continuing, effective respiratory protection program.[4]

Since WPFs are direct measurements of respirator performance capabilities in a specific work environment, they provide data to help support, refute or establish an APF. When WPF data are used to set an APF, typically the fifth percentile WPF value is used. More clearly, 95% of WPFs would exceed the recommended value that would be used to set an APF.

On August 24, 2006 the Occupational Safety and Health Administration (OSHA) amended

continued on page 2 >

The Workplace Performance of a Continuous Flow Supplied Air Respirator during Aircraft Sanding (*continued from page 1*)

its regulation for respiratory protection (29 CFR 1910.134) by adding definitions and requirements for APFs and Maximum Use Concentrations (MUCs). The revisions also supersede many of the APF requirements established in substance specific standards. This final rule became effective November 22, 2006.

With regard to hoods and helmets (respirator inlet coverings), when used in their NIOSH approved configurations (both powered and supplied air), the final rule states "The employer must have evidence provided by the respirator manufacturer that testing of these respirators demonstrates performance at a level of protection of 1000 or greater to receive an APF of 1000. This level of performance can best be demonstrated by performing a WPF or simulated workplace protection factor (SWPF) study or equivalent testing. Absent such testing, all other powered air purifying respirators (PAPRs) and supplied air respirators (SARs) with helmets/hoods are to be treated as loose-fitting facepiece respirators, and receive an APF of 25."[4]

The results of this WPF study help demonstrate the level of protection of 1000 for the 3M™ Helmets L-Series.

Workplace Testing

The 3M™ Helmet L-901, 3M™ Breathing Tube L-122, 3M™ Vortex Air Regulating Valve V-100 and 3M™ Supplied Air Hose W-9435-50 was tested against particulate contaminants in an aircraft manufacturing plant. This workplace was chosen because the respirator was in use in the workplace prior to the study and the exposure levels were high enough to challenge the respirator. A preliminary visit to the site confirmed these key criteria for conducting a WPF study were met.

WPF measurements were made while workers performed their normal work duties that included sanding of a primer on aircraft. Four workers participated in the study over a four-day period. They had been medically evaluated and trained in proper use of the respirator by their employer.

$WPF = C_O/C_i$

C_O = inhalation exposure outside the respirator (ambient sample);

C_i = inhalation exposure inside the respirator (in-facepiece sample);

In-respirator samples (C_i) were collected via a sampling probe patterned after a design by Liu et al. to minimize entry losses of particles ≥5 µm.[5] Because of the characteristics of the helmet tested, a hole was drilled into the lens of the helmet at a position opposite the nose and mouth. A sample cassette was fitted directly to the probe for collection of the in-respirator sample.

The ambient sample cassette (C_O) was placed in the worker's breathing zone (outside the respirator), clipped to the shroud of the helmet L-901. The cassettes and sample tubing were attached to personal sampling pumps. Each worker wore two pumps as samples were taken simultaneously.

The workers were sampled for entire 10-hour shifts. It was anticipated that the supplied air helmet would perform consistently with a high protection factor, resulting in very little contaminant on the Ci samples. Therefore, samples were changed only at lunch time.

Pumps were calibrated in-line at the start and end of each day of sampling. The samples were collected at two liters per minute. Field blanks were collected and handled in the same manner as the C_O and C_i samples, except no air was drawn through them. Manufacturers' blanks (unused sample cassettes) were also sent to the analytical laboratory with the field blanks and samples to check for background levels of contaminants.

All samples and blanks were analyzed for strontium (Sr), zinc (Zn), and chromium (Cr) as these were the elements contained in the primer. The C_i samples and blanks were analyzed with proton induced x-ray emission spectroscopy (PIXE). C_O samples were subjected to inductively coupled plasma (ICP) analysis using NIOSH method 7300.[6]

Results

Of the 33 sample sets collected, six were eliminated due to equipment failure or the worker raised the faceshield during sampling or the sample dislodged from its probe. The remaining 27 sample sets were analyzed and the results used to calculate workplace protection factors.

continued on page 3 >

The Workplace Performance of a Continuous Flow Supplied Air Respirator during Aircraft Sanding (*continued from page 2*)

The outside zinc concentrations ranged from 81 to 415 µg/m^3. Outside concentrations of Sr ranged from 56 to 244 µg/m^3 and those of Cr ranged from 48 to 215 µg/m^3. For the inside concentrations, no Sr was detected, and Cr ranged from <0.08 to 0.37 µg/m^3. The inside concentrations of zinc ranged from <0.054 to 0.28 µg/m^3, well below the permissible exposure limit (PEL), 2000 µg/m^3. Because zinc was the predominant material found on the C_O samples, it was used in the WPF calculations and statistical analysis.

No zinc was detected on 13 of the 27 C_i samples, so an estimate of the WPF could not be directly calculated. Instead, a conservative estimate of respirator performance was made by assuming zinc at the detection limit was present in the non-detectable C_i samples. By using the detection limit as the mass value for the C_i samples, subsequent calculations of the C_i and C_O concentrations lead to a minimum WPF result for each sample pair. This resulted in a geometric mean WPF of approximately 4000 and a 5th percentile WPF estimate of 830.

Conclusion

As indicated by the inside sampling results, no worker was overexposed during the study. Therefore, the respirator provided adequate protection. This level of performance is consistent with other WPF studies on this type of respirator.[7] It is clear that the APF for this type of respirator is greater than 25 and is consistent with an APF of 1000. ■

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