

The ISRP Forum— *Pertinent Discussions in Respiratory Protection*

This section of the ISRP Journal is intended to provide the reader with current and/or controversial topics in respiratory protection. It also provides a mechanism for interested parties to comment on the topics presented, or to introduce any new topic of concern for discussion.

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Workplace Protection Factor Studies—Unanswered Questions

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Two types of studies are commonly used in the development of assigned protection factors for respirators. These are the workplace protection factor (WPF) study and the controlled environmental chamber study. The Occupational Safety and Health Administration (OSHA) uses the term Maximum Use Limit (MUL) to define the protection provided by a respirator. If a half-mask negative-pressure respirator has an assigned MUL of 10, it means that the device could provide adequate protection up to ten times the permissible exposure limit (PEL) of the air contaminant. The WPF is a ratio between the ambient and in-mask concentrations of the contaminant as measured in a workplace. A respirator with a WPF of 10 means that the respirator would provide up to a ten times reduction of the ambient concentration inside the facepiece. By definition, these two terms are not necessarily the same.

Factors such as ambient concentration, particle size, and sensitivity of the analytical method could change the outcome of a WPF study. Many studies on half-mask respirators were performed at concentrations far below ten times the PEL. Since the ambient concentration is so low, the reported protection factors are based on

the detection limit of the analytical method. If a study reported a WPF of 40, it could only be stated that this respirator would provide protection at an ambient concentration up to 40 times the detection limit of the analytical method, since there is no available data to indicate that this respirator would provide the same protection at much higher ambient atmosphere at concentrations up to 40 times the PEL of the air contaminant.

A study on a disposable respirator reported a minimum fifth-percentile protection factor of 20. By examining the raw data, it was found that the study was conducted in a workplace having an average concentration only 1/50 of the applicable PEL. It is not clear how it could be concluded that such a high protection factor could be obtained in the average workplace, since the testing took place in a workplace where a respirator was not even required. The high PFs were obtained in the presence of large particles and the use of a highly sensitive analytical method, proton-induced x-ray emission analysis (PIXEA). This method has a detection limit in the nanogram range, which extended the range of WPFs in this study. The PIXEA is a non-destructive method that directly analyzes the particles deposited on the filter.

However, there is no validation data available to indicate that the PIXEA method is independent of particle size, concentration, or density of the contaminant deposited on the filter.

The ambient concentrations of contaminants measured in most published WPF studies are far below the level where the device is assigned to perform. For example, one study on a half-mask tight-fitting powered air-purifying respirator (PAPR) was conducted in a lead smelter. The study concluded that the PAPR did not provide a PF of 1,000 as it was assigned. However, there was no mention in this study that the WPF of the PAPR was determined at the same time with a negative-pressure air-purifying respirator at an ambient concentration of less than ten times the PEL for lead.

The presence of a significant percentage of large particles in the ambient atmosphere being tested would artificially boost the WPF in a study, since these large particles do not readily penetrate through the facepiece. However, they do contribute in the calculation of protection factors, since they are measured in determining the challenge concentration outside the facepiece. The physical state of the particulates when the sampling took place could also affect the particle size. For example, when a water spray is applied during an asbestos-abatement operation, the wetted asbestos fibers become larger and may not penetrate as readily through the facepiece as dry fibers. However, these fibers are counted in the dry state when calculating the WPF.

WPF studies are performed under uncontrolled test conditions that vary from site to site and from day to day. This uncertainty creates many unanswered questions: Are the test results independent of ambient concentration, particle size, environmental conditions, work rate, and work duration? If a WPF study is performed at a sinter plant of a lead smelter with particulate

contaminant, will this respirator provide the same degree of protection at a gas-recovery plant of the same plant with gaseous contaminants? If a respirator obtained a WPF of 30 at a workplace having an ambient concentration of less than three times the PEL, will this respirator provide the same level of protection at a workplace with an ambient concentration of 30 times the PEL?

A disposable respirator has been evaluated by NIOSH, a user, and a respirator manufacturer. Why did NIOSH report the lowest WPF, while the manufacturer reported the highest WPF for this model of respirator? Why did a study with a four-hour wearing period show much lower WPFs than the WPF reported in another study with a single donning? If the WPF study is the "standard" method for assigning the protection factor of a respirator, why are inconsistent results obtained with the same respirator model during different studies?

The controlled-environment chamber study may provide answers to these questions, since the test conditions are reproducible, and different respirators can be evaluated under the same stressful test conditions. The simulated exercises performed inside the chamber have been criticized as not being representative of workplace conditions. However, the activities performed by workers at one test site may not be the same at another site. An analogy exists between the chamber study and the EPA automobile fuel-efficiency test. EPA has been criticized that their testing does not reflect actual driving conditions. However, no one disputes that a car with an EPA rating of 20 miles per gallon is more fuel-efficiency than a car having a rating of 10 miles per gallon. One may be able to bias a WPF study by tailoring the test conditions in order to claim that a disposable respirator outperforms a positive-pressure PAPR. However, it is doubtful that the same results would be duplicated inside the chamber.

Suggested Reading

Chemical Manufacturers' Association, *Performance of Disposable Respirators in a Cadmium Pigment Factory*, Chemical Manufacturers' Association, Washington, DC (unpublished—contact Tom Nelson).

S.W. Dixon and T.J. Nelson, "Workplace Protection Factors for Negative-Pressure Half-Mask Respirators," *JISRP*, 2:347 (1984).

A.R. Johnstone and H.E. Mullins, "Workplace Protection Factor Study for Airborne Metal Dusts," presented at the American Industrial Hygiene Conference, Montreal, Canada (1987).

S.W. Lenhart and D.L. Campbell, "Assigned Protection Factors for Two Respirator Types Based upon Workplace Performance Testing," *Ann. Occu. Hyg.*, 28:173 (1984).

W.R. Myers, et al, "Performance Measures on a Powered Air-Purifying Respirator Made During Actual Field Use in a Silica Bagging Operation," *Ann. Occu. Hyg.*, 27:251 (1983).

The National Paints and Coatings Association, *Research Protocol to Measure Workplace Protection Factors on Selected Elastomeric and Disposable Respirators*, The National Paints and Coatings Association, Washington, DC.

T.J. Nelson and S.W. Dixon, "Respirator Workplace Protection Factors for Asbestos," presented at the American Industrial Hygiene Conference, Las Vegas, NV (1985).

L.D. Reed, et al, "Workplace Evaluation of a Disposable Respirator in a Dusty Environment," *Appl. Ind. Hyg.*, 2:53 (1987).

3M Company, *Performance of a Helmeted Sand-Blasting Unit in Actual Work Conditions*, 3M Company, St. Paul, MN (unpublished—contact Don Wilmes).