



American Industrial Hygiene Association Respiratory Protection Committee Research Needs in Respiratory Protection

White Paper

Executive Summary

In recent years, the field of respiratory protection has experienced unprecedented, substantial opportunities and challenges. The establishment of the National Institute for Occupational Safety and Health (NIOSH) National Personal Protective Technology Laboratory (NPPTL) provides a focal point for research and standard setting for new classes of respiratory protective devices. The increased demand for protection from chemical, biological, radiological, and nuclear (CBRN) hazards; outbreaks of life threatening viruses; and new technologies for more precise characterization of aerosol particle sizes, respiratory hazards and respirator performance have created increased interest in this subject area. The AIHA Respiratory Protection Committee determined this is an opportune time to consider respiratory protection research topics and priorities.

Having a very diverse membership, the committee established a project team consisting of users, government officials, manufacturers, researchers, standards developers, and other interested industrial hygienists. The project group identified seven (7) high priority research topics including:

- 1) Measurement of respirator performance;
- 2) Qualitative fit testing for full facepiece respirators;
- 3) Appropriateness of fit factor safety margin criterion;
- 4) In-facepiece measurements;
- 5) Effectiveness of respiratory protection program requirements;
- 6) Effectiveness of user seal checks; and
- 7) Organic vapor cartridge desorption.

These topics are presented to influence NIOSH, universities and independent researchers to further investigate the benefits and to improve available respiratory protection.

Research Priorities

Proposal 1: Measurement of respirator performance. AIHA recommends a comprehensive literature search on the measurement of respirator performance. The objective of this project is to summarize the base of knowledge on the topic. The studies should be properly classified by utilizing the performance terminology published by the AIHA Respiratory Protection Committee:⁽¹⁾ Workplace Protection Factor, Effective Protection Factor, Simulated Workplace Protection Factor, Program Protection Factor, etc. This review should result in the recommendation of research projects to fill information and technology gaps so that respirator performance can be reliably assessed both in the laboratory and in the workplace.

Background: The U.S. Bureau of Mines first considered respirator performance measurement when it began to evaluate and certify respirators in the early 1900s. Uncertainty about acceptable measurement methods remains today. In the 1970s, Hyatt measured respirator performance in various laboratory settings.⁽²⁾ Shortly thereafter, Myers and others measured respirator performance in the field^(3,4) and today the National Personal Protective Technology Laboratory (NPPTL) has proposed using total inward leakage (TIL) measurements in the laboratory.⁽⁵⁾ There continues to be much debate in the respiratory protection community and there is no clear consensus on the “correct” way to measure respirator performance or on the interpretation of the results from various techniques.

Proposal 2: Qualitative fit testing for full facepiece respirators. AIHA recommends development of a qualitative fit test (QLFT) capable of screening for a minimum fit factor of 500. Under current practice and U.S. regulation⁽⁶⁾ this would allow full facepieces to be qualitatively fit tested and allow them to be used in atmospheres in which exposures are up to 50 times the occupational exposure limit (OEL).

Background: Because current QLFT screen for a fit factor of 100, full facepiece respirators must be quantitatively fit tested to be used for exposures between 10 and 50 times the OEL. Qualitative fit testing appeals to smaller employers with limited resources. A QLFT with a screening level of 500 would assure the same minimum fit required when QLFT is used. This would increase small employers’ compliance with fit test requirements, thereby enhancing worker protection.

Proposal 3: Appropriateness of fit factor safety margin criterion. AIHA recommends studies to determine if the current fit factor screening level of 100 for qualitative and quantitative fit testing of half facepieces is necessary and appropriate.

Background: The reason the screening level of 100 is used for half facepieces is not well documented. Limited simulated workplace protection factor (SWPF) information indicates that a SWPF of 50 might be acceptable while still maintaining wearer protection at an assigned protection factor of 10.⁽⁷⁾ If research

were to indicate that an APF of 10 is still supported when using a screening fit factor, employers and employees would potentially have more options in respirator selection. Comfort could be increased, fit testing time could be reduced and program costs lowered.

Proposal 4: In-facepiece measurements. AIHA recommends investigation of in-facepiece contaminant measurement technology and methodology. The objective of this recommendation is to determine if current methods are providing reasonably accurate estimates of inward leakage. A second objective is to identify potential improvements for in-facepiece sampling techniques.

Background: The performance of respiratory protection is often assessed by measuring the concentration of a challenge agent both outside and inside the device. For example, quantitative fit tests and simulated workplace protection factor (SWPF) studies have historically used generated or naturally occurring submicrometer aerosol challenges. These measurements of performance can be meaningful only if the inside sample accurately represents penetration into the device. Earlier work has shown that challenge agents do not mix uniformly within the respirator cavity, which can result in biased estimates of in-respirator concentration.⁽⁸⁻¹¹⁾ The factors that contribute may include probe position and depth, leak location, and breathing pattern. The nature of the detector and its response time, the measurement intervals, and lung retention of the challenge agent may also influence the measurement. Current U.S. regulations specify probe placement midway between the nose and mouth with the probe extending into the facepiece cavity at least 1/4 inch.⁽⁶⁾

Proposal 5: Effectiveness of respiratory protection program requirements. AIHA recommends a methodical study to determine the necessity and value of each element of an acceptable respiratory protection program. The objective of this recommendation is to ascertain if streamlined programs could be as effective as “traditional” programs in protecting workers from inhalation hazards.

Background: The importance of the traditional respirator program elements, such as those required by the U.S. Occupational Safety and Health Administration (OSHA)⁽⁶⁾ has never been systematically studied. Workplace protection factor studies have demonstrated that respirators used in programs that include all the specified elements achieve their expected level of protection.^(4,12,13) It is possible that all the program elements are necessary to assure protection. However, it is also possible that one or more of the elements may not be necessary to provide respirator users the same level of protection. If one or more program elements could be eliminated without decreasing protection, programs could be simplified and compliance increased. The NIOSH/NPPTL BLS Survey results⁽¹⁴⁾ as well as the planned follow up survey results could be used as part of this assessment. Since a correlation between SWPF studies and workplace protection has not been

demonstrated, this research would best be performed in workplaces in which contaminant exposures do not exceed published exposure limits. This environment would assure that actual workplace conditions are taken into account without risk of overexposure to the study participants.

Proposal 6: Effectiveness of user seal checks. AIHA recommends a systematic study to determine the efficacy of user seal checks in trained user populations. The objective of this recommendation is to gather evidence to determine if seal checks are necessary to assure protection. If user seal checks are found to be necessary, a second objective is to determine how often they should be done. Are user seal checks only necessary at each donning, or should they be done every time the seal may be compromised by coughing, talking, or extreme movements? Both elastomeric and filtering facepiece respirator user seal checks should be included in the study.

Background: The value of user seal checks in assuring or improving protection in the workplace has not been studied. While these simple tests are required by regulation⁽⁶⁾ and emphasized in user training programs, it is likely that few workers do them at every donning in the workplace. A laboratory study compared user seal checks on elastomeric and filtering half facepiece respirators⁽¹⁵⁾ and suggested they do an adequate job of detecting poor fits for both respirator types under defined conditions. The value of user seal checks of either respirator type in increasing workplace protection has not been shown. If user seal checks do not improve protection, the fact that many workers may not do them becomes less of a concern. If they are shown to improve protection, recommendations to increase the likelihood that they will be used should be made. As with the recommendation in Proposal 5, this research would best be performed in workplaces in which contaminant exposures do not exceed published exposure limits

Proposal 7: Organic vapor cartridge desorption. AIHA recommends a study to determine if there are conditions under which organic vapors are significantly desorbed from powered air purifying respirator (PAPR) cartridges during periods of non-exposure. For this study, significant desorption means a wearer's inhaled dose could be increased to the point of overexposure under foreseeable use conditions. Both physically adsorbed and chemisorbed materials should be studied.

Background: It is known that respirator cartridges packed with activated carbon can, when properly selected and used, protect users from a wide range of organic vapor contaminants. A recent laboratory study suggested that cyclohexane and ammonia could be desorbed under specific conditions.⁽¹⁶⁾ More work is needed to determine if this type of desorption could potentially result in overexposure of the wearer under realistic respirator use conditions.

Summary

Many current practices in respiratory protection are based on assumptions, past practices or extrapolation from laboratory studies. Few studies have been done to evaluate the efficacy of, or the need for, each of these practices. AIHA believes the results of research on the practical, applied topics presented in this paper may significantly enhance the safe and effective use of respiratory protection.

References

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