

RESEARCH NEEDS IN RESPIRATORY PROTECTION

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During the 1960's and 1970's I was fortunate to be at the Harvard School of Public Health in a setting where I could pursue applied research activities in industrial hygiene. One of my interests was respirators. Joining with a number of persons with specific research interests we published results of work in design approaches, impact of respirators on workers, and the level of protection afforded by these devices. In considering the subject of this conference I asked myself the question, "What would I do if I were again in that setting?" The answer was not unexpected--a similar wide range of cooperative studies. The topics would include anthropometric adequacy, physiologic impact of respirators on the wearer, the performance of critical respirator elements such as filter media, adsorbents, valves and seals, procedures for evaluating fit, and, of course, innovative respirator design. The importance of cooperative studies is highlighted by this list and reflects my feeling that the ideal respirator research group would include a general practitioner of industrial hygiene working with physiologists, human factors specialists, aerosol physicists, chemists, and design engineers. I am sure that all of these research areas will be endorsed by the participants at the meeting.

If I were forced to choose one research area and were asked to champion it at this gathering I would choose the study of the actual protection afforded by respirators in the workplace. This is obviously the bottom line in any respirator program. If one reviews the limited number of in-plant studies completed over past decades one becomes concerned about the total impact of respirator programs on worker exposure. My first interest in this topic was generated at the 1968 American Industrial Hygiene Conference when Caldwell and Schnell¹ displayed dismal protection factors in the application of half mask air-purifying respirators for protection against uranium dioxide. The authors concluded "Air-purifying half-face respirators are supposed to provide better than a factor of 10 protection. The computed average for the data shown is 2.1." These data were based on biological monitoring and therefore effective protection factors and not conventional protection factors were calculated in this study.*

A field study by Revoir to evaluate single use respirators against cotton dust revealed more impressive protection factors ranging from 8 to 84.²

In a NIOSH sponsored study of respirator use in abrasive blasting³, Blair has shown the large variability in protection encountered in the use of air supplied respirators. These devices are normally considered to provide excellent protection with a protection factor of 2,000.

"Where air supplied helmets were used, protection factors from 1.9 to 3750 were noted. The remarkable range of these later figures is attributable to the condition of the individual equipment rather than to any particular brand superiority."

* Protection factor is defined as the ratio of the contaminant concentration outside the respirator divided by the concentration of the contaminant inside the respirator. The inside concentration is determined by air sampling only when the respirator is in place on the face. The effective protection factor is evaluated by continuous air sampling inside the respirator both when the mask is on the face and when it is periodically removed from the face.

Additional evidence of the limited **effectiveness** of air supplied hoods used in sandblasting has been provided by **Samini et al.**⁴

In a study of dust respirator performance in coal mines conducted by Eastern Associated Coal Company in cooperation with the Harvard School of Public Health under a NIOSH contract the same pattern was revealed with lower protection obtained than predicted by application **guidelines**⁵. **However**, this study evaluated effective protection factors and introduces the issue of effective choice of use time by the wearer.

A study of the paint spray **industry**⁶ revealed that conventional air-purifying paint spray respirators provided an average protection factor of 3 for vapors and not the 10 one might anticipate from the protection factor tables. In the case of air supplied half **masks**, the observed protection factors ranged from 3 to 30, and not the 1000 one would expect from the **guidelines**.

In a study of in-plant respirator protection factors for protection against sulfur dioxide in copper **smelters**⁷ Moore showed that the protection afforded by three different half mask respirators was quite variable with mean protection factors of 22, 18, and 13. Although the mean values exceeded the guideline protection factor of 10, the best respirator had 30.4% of its tests with factors less than 10, and the worst had 56% with factors less than 10.

Smith has evaluated the effective protection factors (EPF) provided by intermittent use of a combination acid gas and metal fume respirator **and** a filter respirator for protection against cadmium. A wide variability on protection was demonstrated with a geometric mean EPF of 5.6. One worker in this population was atypical of the group. He was fastidious in the use of his respirator and obtained consistently high protection factors. If his data are not included the geometric mean EPF becomes 3.9 and approaches the 3.2 noted by **Harris**.

The reasons for the low **PF's** and **EPF's** and the high variability in these studies are numerous and are known to all of those attending this meeting. It is important that we recognize that they do exist and that in-plant testing is the only technique available to evaluate the actual protection afforded by the respirator. Obviously there are difficulties in conducting such studies. Caught up in the excitement of this topic and hoping to share experiences with you on this matter I invoked my credentials as a gadgeteer to present some approaches to the field sampling problems which might make the technique more acceptable. This is obviously a research **job--to** explore the possible approaches and demonstrate that they may be used in industry to carry out the mission of the **standard**, namely **"the employer must demonstrate the protection provided by respirators as worn in the plant."**

I will discuss workplace monitoring techniques to evaluate the performance of respirators used for protection against gases and vapors. The conventional system is the use of two pumps as shown in (A). The first alternative is to package a double acting pump (B). A miniature pump can be placed inside the respirator and controlled remotely as shown in (C). The use of passive samplers as shown in (D) may be an effective system with minimum interference with the respirator. This approach would not require penetration of the facepiece. A more complicated approach is shown in (E) which does not involve facepiece penetration. In this system the air from the exhalation valve is dumped to a 200 ml bellows element attached to the valve and a sample is taken from that reservoir to the sampler. An alternate method is stowing an aliquot of this exhaled air in a bag **clipped** to the belt or attached to a jacket. The final scheme shown in (F) is left to your imagination and **someone's** contract money. It involves the design of chemical or **electrochemical** sensors that provide direct **read-out** of concentration inside the facepiece.

In my opinion respirator research must be continued on techniques for evaluating the ultimate performance of the device in the workplace. Although I have permitted myself the luxury of brainstorming the in-mask sampling **possibilities**, one can use more conventional techniques at the present time to evaluate the total effectiveness of an **in-plant** program.

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