PERSONAL RESPIRATORY PROTECTION

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Preventing Inhalation of Airborne Hazards

The human body has marvelous defense mechanisms against air pollutants which ensure effective functioning of the lungs. However, when exposed to specific hazards in the workplace, including certain chemical vapors, gases, biological agents, mineral dusts or agricultural products, we require additional protection to prevent the development of disease. Some of these occupational lung diseases include asbestosis, lung cancer, beryllium disease, silicosis, asthma and tuberculosis. Inhaled agents do not always target the lungs, but the respiratory tract may be the organ of uptake. Therefore, preventing inhalation of noxious materials may prevent other forms of disease as well as respiratory disease.

Photos by Barry Silverstein

When in Rome...

The concept of personal respiratory protection is not new; as early as the first century A.D., Roman mine workers wore masks made from dried animal bladders to shield their lungs from toxic vermilion. Today, technological advances continue to create thousands of new chemicals, some of which may be new occupational hazards. Fortunately, progress has also heralded the development of more sophisticated methods for protecting workers. While the challenges may be new, the principles remain the same.

Principles of Respiratory Protection

In general, a respirator is any device designed to protect the wearer from inhaling hazardous air. More specifically, a respirator is a face piece, hood or helmet that is equipped with a filter or connected to a breathable air source. (A surgical mask, designed to protect a sterile environment from the wearer, is not a respirator.) It is important to emphasize that engineering and administrative strategies (e.g., well-designed exhaust ventilation or the use of less hazardous materials) should be the major control measures to prevent worker exposure. When these measures are not adequate, not feasible or not yet implemented, a respirator may be required to protect the employee and mitigate the hazard.

In the United States, the National Institute of Occupational Health and Safety (NIOSH) tests and certifies respirators. The Occupational Safety and Health Administration (OSHA), a division of the U.S. Department of Labor, sets standards and enforces regulations regarding the use of respirators.

NATIONAL JEWISH Medical and Research Center
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MEDICAL SCIENTIFIC UPDATE Vol. 15 No. 2, Fall 1997

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CENTENNIAL SINCE 1899

Under current OSHA standards, the employer is responsible for implementing a personal respiratory protection program and assuring that regulatory requirements are met. A complete program, detailed in written guidelines, is necessary to instruct workers on the fit, care, use and limitations of NIOSH-certified respirators so that protection is optimized. Respirators may not be used in the workplace without such a program.

An initial medical evaluation is required to determine whether or not a worker is able to use a respirator. A high-risk worker with cardiac disease, for instance, would not be able to support a heavier respirator like a self-contained breathing apparatus, which could weigh as much as 40 pounds. The medical screening may involve a specially designed questionnaire, or, if necessary, a more thorough physical exam conducted by a physician. Finally, the program administrator, who is trained in respiratory protection, considers the type of exposure, the demands of the job and the physical characteristics of the worker to select which type of respirator is most appropriate.

A successful respiratory protection program encompasses three basic principles: obtaining information about the hazard; following an employer's written program; and, using a respirator properly. This last concept sounds simple, but respirator protection can be rendered ineffective when not given the careful attention it requires. Worker education and compliance are critical in determining the ultimate degree of respiratory protection achieved.

Types of Respirators

There are two major categories of respirators: air-supplied respirators and air-purifying respirators. With air-supplied respirators, air travels to the mask or suit through a hose from an independent source outside the environment or from a compressed air cylinder worn on the back. Air-supplied set-ups offer the greatest amount of protection but can be heavy, cumbersome and expensive.

Air-purifying respirators remove hazardous agents from the air that are present in the work environment. This is accomplished through filtration, adsorption or chemical reaction. Within this category are negative-pressure respirators, which work when the user inhales air that passes through a filter. A second type, powered air-purifying respirators (PAPRs), uses a fan unit to blow air through a filter to a mask, helmet or hood. The motorized air pump, battery and filter usually are worn on a waist belt. PAPRs offer minimal breathing resistance since the blower supplies the filtered air to the breathing zone of the wearer.

Negative-pressure respirators are the most frequently used because of their versatility, light weight and low cost. Disposable particulate respirators look similar to surgical masks and are often used in healthcare environments. Elastomeric respirators, available in half-face or full-face designs, function like disposable particulate respirators but are reusable and made from flexible materials that create a more effective face-mask seal.

A well-fitting face piece is essential for protection. The face-mask seal is the "weak link" in personal respiratory protection. Fit testing is intended to provide each individual with a respirator that has a minimum amount of leakage through the face-mask seal. Quantitative fit testing can provide a "fit factor", which is the ratio of particles outside the respirator to those inside the face piece.

Assigned protection factors (APF) estimate the protection expected for a particular type of respirator when it is worn by workers who have been fitted and trained in its use. The protection factor is the ratio of the contaminant concentration outside the respirator to the contaminant concentration inside the face piece. For example, a protection factor of 10 means that the concentration of a contaminant inside the mask is one-tenth of that outside.

To summarize, the major factor that limits effectiveness of most respirators is the leakage between the face and the mask. Workers who do not strictly adhere to respirator-use guidelines also contribute to ineffective protection. A conflict of comfort versus efficiency arises when more cumbersome or complicated respirators that may provide greater protection are rejected for respirators that are easy and convenient to use. Even these, however, must be used properly. There are some data suggesting that traditional fit testing of respirators does not adequately predict the degree of protection in actual use, and more research is underway.

The Personal Respiratory Protection Program (PRPP) at National Jewish provides training, fit testing and medical clearance for the use of respirators. The following three examples illustrate how an individual's unique circumstances are evaluated to determine the most appropriate respiratory protection:

*COMPARISON OF TYPES OF RESPIRATORS

Characteristic	N95	Elastomeric 1/2Face	PAPR-hood
Assigned protection factor	N/A	10	25
Approximate cost	<$1	$20-$25	$300-$600
Comfort	good	fair	fair-good
Ease of use	good	fair	fair-poor
Impairment of speech	mild	severe	moderate
Fit test required	yes	yes	no
Face shield protection	no	no	yes

PAPR = powered air-purifying respirator; N/A = not available

Chart reprinted with permission. Kevin P. Fennelly, MD, MPH, Personal Respiratory Protection Against Mycobacterium Tuberculosis, Clinics In Chest Medicine, Volume 18, Number 1, March 1997, p. 13.

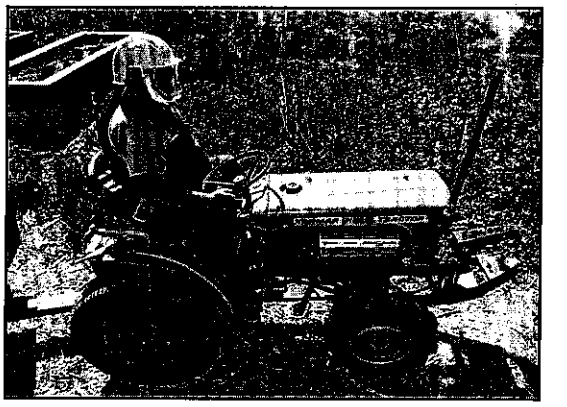
CASE STUDY #1

Occupation: Farmer

Problems:

1. He performs multiple duties around the farm. His exposures include dust, hog-confinement houses, pesticides and diesel fumes.
2. He is unable to wear a negative-pressure respirator due to the following:
   a) he has a beard
   b) he has discomfort during hot weather
   c) he has claustrophobia
   d) some of his work requires a hard hat and eye protection
   e) he has mild asthma
   f) he wears glasses

SOLUTION: His allergist referred him to our PRPP. Our respirator fit technician determined that the loose-fitting PAPR Helmet would accommodate his beard and glasses, while delivering a constant flow of cool air for comfort during a long summer work day. He received literature on the product as well as information on where to purchase the respirator set-up. He was advised to follow-up with the PRPP regarding any problems.



Powered air-purifying respirator (PAPR) helmet. This device provides a higher level of protection than disposable particulate and half-face negative pressure respirators, and it is the only type of respirator which is effective for men with beards. The constant flow of air keeps the respirator cooler and more comfortable than non-powered air purifying respirators.

CASE STUDY #2

Occupation: Welder

Problems: 1. He needed a half-face negative-pressure respirator that would fit under a welding mask and not restrict his movement.
2. He forwarded his Material Safety Data Sheets containing information on the treated metals he works with.

Half-face negative pressure respirator with backpack harness. This allows the wearer to fit a welding shield over the respirator.

SOLUTION: The PRPP was consulted regarding the proper filters to wear on his standard mask. We recommended a backpack set-up with a harness system to keep away the filters from the exposure. This arrangement allows a welding shield to be placed over the mask, keeping the filters tight to the body and away from the immediate exposure area. The PRPP provided quantitative fit testing and recommended follow-up as needed.

CASE STUDY #3

Occupation: Respiratory Therapist

Problems: 1. She has a latex allergy.
2. She works on a medical/surgical floor, occasionally caring for patients with TB, including multi-drug resistant TB.
3. She needs personal respiratory protection against TB because she assists with bronchoscopies and intubations, and she performs sputum inductions.

N95 disposable particulate respirator. These are now commonly used in healthcare settings for protection against tuberculosis because of acceptable appearance, low cost, and practicality.

SOLUTION: The PRPP conducted a qualitative fit test for a latex-free N95 respirator for the therapist to wear in TB isolation rooms. In addition, she received training on a powered air-purifying respirator (PAPR) with a hood to provide a higher level of protection during bronchoscopies.

Healthcare Workers and the Prevention of Tuberculosis

Healthcare workers are in a unique position; they work closely with tuberculosis patients, and they need adequate protection against infectious aerosols, yet they do not want to discourage or frighten a patient by using a respirator that hinders communication or looks intimidating. There must be a balance between this need for protection and the need for comfort, communication, practicality and efficient patient care.

Since the resurgence of tuberculosis in the late 1980's, there has been increased interest in the prevention of occupational tuberculosis (i.e., transmission of tuberculosis from patients to healthcare workers). Outbreaks of multi-drug resistant TB were associated with significant mortality and morbidity among healthcare workers. In 1990, the Centers for Disease Control first recommended the use of disposable particulate respirators for the prevention of occupational TB, since surgical masks did not provide adequate protection. In 1993, this recommendation was changed to the use of disposable respirators with high efficiency particulate (HEPA) air filters, which generated considerable controversy. In 1995, NIOSH revised the process for certifying particulate respirators. OSHA now mandates the use of the N95 class (N=not resistant to oil; 95=95% efficient) of respirators, at minimum, for protecting against tuberculosis. (Ed. note: OSHA is in the process of proposing its standard for protection against TB as this article goes to press.)

The disposable N95 particulate respirators commonly used in healthcare settings have advantages of acceptable appearance, low cost, and practicality. A disadvantage of this type of respirator is the difficulty in assuring a reliable face-mask seal with each use.

An important cautionary note: Respirators with an exhalation or exhaust valve should never be provided to patients with infectious TB, exhaust valves allow droplets and particles exhaled or coughed by the patient to escape, thereby releasing

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potentially infectious aerosol.

The importance of using a respirator properly is paramount. Understanding how to fit, care for and use a respirator is the only means to ensure protection. Just as medication is ineffective when not taken properly, respiratory protection, when not given the careful attention it requires, is ineffective.

Quantitative fit testing procedure

The National Jewish Personal Respiratory Protection Program

The National Jewish Personal Respiratory Protection Program (PRPP) benefits both employers and employees by helping to protect workers exposed to potentially harmful air contaminants on the job. The program is designed to help safeguard workers' health and to enable both companies and workers to comply with government standards.

Serving both industries and individuals, the National Jewish PRPP provides comprehensive training in the use, care and limitations of specific masks, including "hands on" instruction, fit testing and take-home pamphlets of information. For larger groups, the PRPP is able to perform on-site quantitative fit testing using the TSI Portacount®, a portable state-of-the-art instrument that meets all regulatory requirements for respiratory protection. The program provides a choice of 12 different brands of negative pressure respirators in multiple sizes. Many of these brands are available in both full-face and half-face models. Several positive pressure respirators also are available for demonstration and training.

Worksite evaluation, a vital component of any effective respiratory protection program, is available from National Jewish to assure continued compliance with OSHA requirements. A certified industrial hygienist provides on-site consultation with personalized services that include air sampling, exposure analysis, hazard communication, toxicology assessment and ventilation evaluations.

National Jewish also has an active research program that continues to investigate the efficacy, use and limitations of respirators.

In summary, the National Jewish PRPP offers comprehensive services designed to meet all OSHA requirements:

- selection of a respirator on the basis of the hazards to which the worker will be exposed
- examination by our Environmental and Occupational Health physicians to determine whether the worker is able to wear a respirator
- training of the worker in the proper use, cleaning, storage and limitations of respirators
- quantitative and qualitative respirator fit testing
- provision of written standard operating procedures governing respirator use, selection, cleaning and storage

Qualitative fit testing procedure

Additional Information

Questions about respiratory protection can be addressed to local OSHA or NIOSH offices.

Individuals, industries or physicians with patients in need of respiratory protection services should refer to a qualified respirator fit program in their state. They may also contact the PRPP at the National Jewish Medical and Research Center, Division of Environmental and Occupational Health Sciences, (303) 398-1539.

References

1. Respiratory Protection Guidelines. *Am J Respir Crit Care Med* 154:1153, 1165, 1996.

2. NIOSH *Guide to the Selection and Use of Particulate Respirators Certified under 42 CFR84. DHHS (NIOSH)* Publication No. 96-101, 1996.

3. Protect Yourself Against Tuberculosis: *A Respiratory Protection Guide for Healthcare Workers.* DHHS (NIOSH) Publication No. 96-102, 1995.

4. Fennelly, K. Personal Respiratory Protection Against Mycobacterium Tuberculosis. *Clinics in Chest Med* 18:1-17, 1997.

Referrals for Personal Respiratory Protection:
(800) NJC-9555
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