CHAPTER 5

RESPIRATOR USE UNDER SPECIAL CONDITIONS

The following are special problems which may be encountered in the wearing and use of respiratory protective equipment:

A. Facial Hair

Facial hair that lies along the sealing area of the respirator, such as beards, sideburns, moustaches, or even a few days growth of stubble, should not be permitted on employees who are required to wear respirators that rely on a tight facepiece fit to achieve maximum protection. Facial hair between the wearer's skin and the sealing surfaces of the respirator will prevent a good seal. A respirator that permits negative air pressure inside the facepiece during inhalation may allow leakage and, in the case of positive pressure devices, will either reduce service time or waste breathing air. A worker should not enter a contaminated work area when conditions prevent a good seal of the respirator facepiece to the face.

B. Eye Glasses

Ordinary eye glasses should not be used with full-facepiece respirators. Eye glasses with temple bars or straps that pass between the sealing surface of a full-facepiece and the worker's face will prevent a good seal, and should not be used. Special corrective lenses can be mounted inside a full-facepiece respirator and are available from all manufacturers of full-facepiece respirators. To ensure good vision, comfort, and proper sealing of the facepiece, these corrective lenses should be mounted by an individual designated by the manufacturer as qualified to install accessory items.

Eye glasses or goggles may interfere with the half facepieces. When interference occurs, a full-facepiece with special corrective lenses should be provided and worn.

C. Contact Lenses

Several factors may restrict or even prohibit the use of contact lenses while wearing any type of respiratory device. This is especially true of atmosphere-supplying respirators. With full-facepieces, incoming air directed toward the eye can cause discomfort from dirt, lint, or other debris lodging between the contact lens and the pupil.

OSHA is considering a change in their respiratory standard, with regard to use of contact lenses under respirators. Data generated by Lawrence Livermore National Laboratory is being taken into consideration.

D. Facial Deformities

Facial deformities, such as scars, deep skin creases, prominent cheekbones, severe acne, and the lack of teeth or dentures, can prevent a respirator from sealing properly.

E. Communications

Talking while wearing a respirator equipped with a facepiece may break the seal of the facepiece. When communication is necessary within a contaminated area, it should be done with the help of special communicating equipment obtained from the manufacturer of the respirator.

F. In Dangerous Atmospheres

Written procedures should be prepared for safe respirator use in IDLH atmospheres that may occur in normal operations or emergencies. Personnel should be familiar with these procedures and respirators. At least one standby person, equipped with proper rescue equipment including an SCBA should be present in the nearest safe area for emergency rescue of those wearing respirators in an IDLH atmosphere. Communications (visual, voice, signal line, telephone, radio, or other suitable type) should be maintained among all persons present (those in the IDLH atmosphere and the standby person or persons). The respirator wearers should be equipped with safety harnesses and safety lines to permit their removal from the IDLH atmosphere if they are overcome.

Confined spaces are enclosures that are difficult to get out of, such as storage tanks, tank cars, boilers, sewers, tunnels, pipelines, pits, and tubs. The atmospheres in a confined space may be immediately dangerous to life or health because of toxic air contaminants or lack of oxygen. Before anyone enters a confined space, tests should be made to determine the presence and concentration of any flammable vapor or gas, or any toxic airborne particulate, vapor, or gas, and to determine the oxygen concentration.

The confined space should be force-ventilated to keep the concentration of a flammable substance at a safe level. No one should enter if a flammable substance exceeds the lower explosive limit. No one should enter without wearing the proper type of respirator if any air contaminant exceeds the established permissible exposure limit or if there is an oxygen deficiency. Even if the contaminant concentration is below the established breathing time-weighted average limit and there is

enough oxygen, the safest procedure is to ventilate the entire space continuously and to monitor the contaminant and oxygen concentrations continuously if people are to work in the confined space without respirators.

Airline and hose mask type supplied-air respirators or appropriate air-purifying respirators may be worn in a confined space only if tests show that the atmosphere contains adequate oxygen and that air contaminants are below levels immediately dangerous to life or health. While people wearing these types of respirators are in a confined space, its atmosphere should be monitored continuously.

If the atmosphere in a confined space is immediately dangerous to life or health owing to a high concentration of air contaminant or oxygen deficiency, those who must enter the space should wear a pressure-demand SCBA or a combination pressure-demand airline and self-contained breathing apparatus that always maintains positive air pressure inside the respiratory inlet covering. This is the best safety practice for confined spaces.

While personnel are in a confined space, at least one standby person with proper rescue equipment, including an SCBA, should be present outside for emergency rescue. Communications (visual, voice, signal line, telephone, radio, or other suitable type) should be maintained with those inside. Also, those inside the space should be equipped with safety harnesses and safety lines to allow their removal in case they are overcome.

G. In Low and High Temperatures

Low temperatures may fog respirator lenses. Coating the inner surface of the lens with the anti-fogging compound normally available from the respirator manufacturer should prevent fogging down to 32°F, but severe fogging may occur below 0°F. Full facepieces with nose cups that direct the warm, moist exhaled air through the exhalation valve without its touching the lens, are available. They should provide satisfactory vision at as low as -30°F. At very low temperatures, exhalation valves may freeze due to moisture. Dry respirable air should be used with airline respirators and with the type of SCBA that has an air cylinder when they are used in low temperatures.

NIOSH performs cold temperature testing on SCBA. The minimum temperature that the SCBA has been tested to and approved for is listed on the approval label.

A person working in high temperature air is under stress. Wearing a respirator causes additional stress which should be minimized by using a light-weight respirator with low breathing resistance. In atmospheres that are not immediately dangerous to life or health the airline type supplied-air respirator is recommended. Such a respirator used in low or high temperature atmospheres may be equipped with a vortex tube to either warm or cool the air supplied.

H. Physiological Response of Respirator Use

Wearing any respirator, alone or in conjunction with other types of protective equipment, will impose some physiological stress on the wearer. Weight of the equipment, for example, increases the energy requirement for a given task. Selection of respiratory protective devices should be based on the breathing resistance, weight of the respirator, the type and amount of protection needed as well as the individual's tolerance of the given device.

Use of respirators in conjunction with protective clothing can greatly affect the human response and endurance, especially in hot environments. Normally, in hot environments or during heavy work, the body relies a great deal on heat loss through the evaporation of sweat. With impermeable clothing, the heat loss by water evaporation is not possible. Additionally, the weight of the respirator (up to 35 pounds for an SCBA) adds to the metabolic rate of workers, increasing the amount of heat the body produces. The net effect is one of heat stress.

NIOSH studies of workers wearing chemical protective clothing (CPC) and firefighters' ensembles have indicated that heat stress is a serious consideration. Significant physiological stress was observed, even at low work intensities (30% of maximum work capacity--level walking at 3.4 miles per hour) in a neutral environment (23°C and 55% R.H.). With the chemical protective (CPC) ensemble, worker tolerance time was reduced by 56% as compared to light work clothing only. Elevated rectal temperatures (in excess of 39.0°C) were observed in three of the nine subjects. With the heavier firefighters' ensemble, tolerance time was reduced by 84% as compared to light work clothing only and heart rates averaged 25-50 beats per minute higher than with lightweight work clothing. At higher work intensities (60% of maximum), tolerance time was decreased by as much as 96%.

Based upon this limited research, the following recommendations are made:

1. Select the lightest weight protective ensembles and respiratory protective devices that adequately protect the worker. This will minimize the physiological demands placed on the worker by carrying the weight of this equipment.

2. If available, select protective clothing made of material that will allow evaporation of water vapor, while providing skin protection from the contaminant.

3. Reduce work rate by:

   a. adjusting the work/rest schedules,

   b. using automated procedures and/or mechanical assistance where possible, and

   c. minimizing the work intensity,

4. Educate workers on the symptoms and prevention of heat illness and schedule periodic fluid replacement breaks,

5. Reduce heat stress by scheduling work at night or early morning or by providing external cooling, where possible (either through cooling garments and/or by providing cool respirable breathing air through pressure-demand air supplied respirators), and

6. When conducting pipe/boiler lagging removal, ensure that steam lines are cool to minimize heat exposure from these sources.

CHAPTER 6.

NEW DEVELOPMENTS AT NIOSH

While conducting the MSHA/NIOSH-certification program for respirators, NIOSH has been actively interested in new developments in respiratory protection. To support such development work, which is dedicated toward improvement of worker protection, NIOSH has funded respirator research through contracts and grants, has sponsored meetings and workshops on respirator research, and has conducted in-house research projects. Most of the NIOSH respirator research projects have been directed toward improving the performance of respirators through development of new and more severe requirements for 30 CFR 11. However, some fundamental research projects in respiratory physiology, filtration mechanics, sorption technology, and quantitative respirator efficiency testing, have been undertaken.

A. Respiratory Physiology

To develop guidelines for workers wearing respirators and associated protective clothing, NIOSH has undertaken several research projects examining physiological response and worker tolerance at a variety of work rates and temperatures. The initial studies examined the effects of wearing four types of clothing/respirator ensembles while the subjects were performing at 30 and 60 percent of their individual aerobic capacity. Thermal, cardiovascular, respiratory, and subjective parameters were measured. Further work has recently been conducted examining responses at 10, 20 and 30 degrees Centigrade. Additional types of protective ensembles have also been studied. Preliminary results show that significant stress occurs with workload and temperature. These factors, as well as type of ensemble should be considered in determining safe work practices.

B. Filtration Mechanics

Research projects are underway and are planned to study the effects of several parameters, such as particle size, particle weight, particle shape, and material, on the efficiency of various filter materials. A study with a lead aerosol indicated that particle weight had no significant effect on filter efficiency. A study of fibrous aerosols is beginning. A filtration study with variably sized latex spheres is nearly complete.

C. Sorption Technology

In addition to conducting tests of MSHA/NIOSH-certified respirator cartridges against a variety of organic vapors, to determine the relation of the service times and resistances to the carbon tetrachloride test now in 30 CFR 11, NIOSH is studying the applicability of the Jonas Kinetic Model for predicting organic vapor permeation. Test data indicate that sorbents tested against carbon tetrachloride have above average service life, in comparison with other organic vapors tested thus far.

D. Quantitative Respirator Efficiency Testing

NIOSH is presently conducting research studies to evaluate published assigned protection factors and to determine the causes of known variability in quantitative fit testing. Quantitative workplace fit tests of powered air-purifying respirators have demonstrated that the previously assigned protection factors for that type of respirator were too high. The lower assigned protection factors for powered air-purifying respirators, prescribed in this publication, reflect this research. A similar study of pressure-demand self-contained breathing apparatus during firefighting operations has been initiated in 1987. NIOSH has determined that several factors variously affect the magnitude of a respirator leak, during quantitative fit testing, both in the laboratory and in workplace studies. The greatest effects have been found to be from leak site and probe location.

E. Certification of New Types of Respirators

Acting in accordance with the authority in 30 CFR 11 Section 11.30 (b), which permits MSHA/NIOSH to certify other types of respirators not described in 30 CFR 11, NIOSH has issued a number of special minimum requirements documents which permit the testing and certification of special respirators. NIOSH issues such requirements only after thorough investigation of the respirators and their use, and after extensive discussion and review by users, regulatory agencies and respirator manufacturers.

Other types of respirators which have been or may be certified under these special requirements include vinyl chloride, formaldehyde and other chemical cartridge respirators, and combination high-efficiency filter and supplied-air respirators.

On November 18, 1985, a Federal Register Notice was published detailing the requirements for certification of positive pressure closed-circuit self-contained breathing apparatus. Basically, there are two types which may be certified: (1) apparatus which use a breathing gas of pure oxygen, and (2) apparatus which use a breathing gas in which the oxygen

concentration is not greater than 30 percent by volume. The following requirements, limitations, and cautions apply under present 30 CFR 11 Federal regulations:

Requirements for Certification of Positive-Pressure Closed-Circuit Self-Contained Breathing Apparatus

1. Where the apparatus uses a breathing gas (other than pure oxygen) the breathing gas will be respirable and not contain more than 30 percent by volume of oxygen.

2. The positive pressure closed-circuit self-contained breathing apparatus will meet all applicable requirements of 30 CFR 11 as prescribed for closed-circuit self-contained breathing apparatus, including those designed as demand flow devices.

3. The positive pressure closed-circuit self-contained breathing apparatus will maintain a positive pressure in the facepiece during all pressure and flow tests.

Certification Label Specifications

The following minimum limitations and conditions apply to positive pressure closed-circuit self-contained breathing apparatus and will appear on the certification label for each device:

Limitations

1. Do not use this apparatus where there is direct exposure to open flames or in high radiant heat. (This limitation applies to 100 percent oxygen apparatus only.)

2. Provide proper care, training, and maintenance of the apparatus as specifically described in the manufacturer's instructions and maintenance manuals.

3. After each use of this apparatus, a fully charged breathing gas container and a recharge of carbon dioxide scrubber shall be installed.

4. Thorough cleaning and disinfecting of facepiece, breathing tube, and breathing bag must be done in accordance with the manufacturer's instructions.

Cautions

1. Keep exposed hair to a minimum when using apparatus near open flames or in high radiant heat.

2. A good facepiece seal is important since facepiece leakage will seriously reduce service time.

3. Use of pure oxygen or oxygen enriched air increases flammability and lowers the ignition temperature of most materials.

In addition, presently available information indicates that the use of pure oxygen during direct exposure to open flames and/or high radiant heat should not be permitted. Further, NIOSH has determined that until it has been demonstrated satisfactorily that these devices can be worn safely under such conditions they should be presently limited to use which do not involve exposure to open flames or high radiant heat. Therefore, the oxygen concentration in a mixed gas system is limited to between 23 and 30 percent for use under these conditions. These limitations are based on what is physiologically safe for the necessary oxygen level at the lower end and on the effects of increased oxygen concentrations on both combustion and ignition temperatures at the upper end. These requirements are in addition to those presently listed in 30 CFR 11, both of which must be met by the SCBA prior to certification.

Consequently, when positive pressure closed-circuit breathing apparatus become available as certified devices, then the present closed circuit limitations and recommendations will be expanded to give users more selection guidance for safe application. That is, apparatus selection could become more performance oriented versus design oriented as present considerations and practices require.

F. NIOSH Respirator Problem Investigation

Since July 1, 1982, NIOSH has been investigating reports of problems with MSHA/NIOSH-certified respirators. These reports are from NIOSH audits of certified respirators, and from regulatory agencies and users and manufacturers of respirators. As of August 1, 1987, a total of 215 reports were received. The total includes 15 fatalities of employees who were wearing self-contained breathing apparatus at the time of their deaths.

The goals of the program are to increasingly justify the user's reliance on the MSHA/NIOSH respirator certification program and to indicate to respirator manufacturers that NIOSH is sincere in its desire to increase the safety and reliability of certified respirators.

During the last year of the program, NIOSH has noted that more manufacturers are receiving and directly investigating reports of problems on their own. They are advising NIOSH of the receipt of each problem and are providing NIOSH with follow-up information concerning the investigation and resolution of each problem. NIOSH regards this as an advantageous development, since it promotes more prompt response to and resolution of problems, increases customer satisfaction, and offers the manufacturer opportunities to learn about users' needs and wishes on a first-hand basis.

NIOSH will continue this program and encourages users to contact respirator manufacturers and NIOSH concerning problems with MSHA/NIOSH-certified respirators.

REFERENCES

Janpuntich, DA. (1984) Respiratory Particulate Filtration. **J. Ind. Soc. Respir. Prot.** 2(1):137-169.

NIOSH. (1976) *A Guide to Industrial Respiratory Protection*, DHEW (NIOSH) Pub. No. 76-189. Cincinnati: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health.

Code of Federal Regulations, Title 30, Part 11, revised July 1, 1986.

American National Standards Institute, Inc. (1984) *American National Standard for Respirator Protection-Respirator Use-Physical Qualifications for Personnel*, ANSI Z88.6-1984. New York: ANSI, Inc.

NIOSH. (1987) *NIOSH Certified Equipment List as of October 1, 1986*, DHHS (NIOSH) Pub. No. 87-102. Cincinnati: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health.

Myers WR, Peach MJ, Cutright K, and Iskander W. (1984) Workplace Protection Factor Measurements on Powered Air-Purifying Respirators at a Secondary Lead Smelter: Results and Discussion. **Am. Ind. Hyg. Assoc. J.** 45(10):681-688.

Myers WR, Peach MJ, and Cutright K. (1984) Field Test of Powered Air-Purifying Respirators at a Battery Manufacturing Facility. **J. of the Int. Soc. for Resp. Prot.** 4(1):62-89.

Lenhart SW. and Campbell DL. (1984) Assigned Protection Factors for Two Respirator Types Based Upon Workplace Performance Testing. **Ann. Occup. Hyg.** 28(2):173-182.

Myers WR, and Peach MJ III. (1983) Performance Measurements on a Powered Air-Purifying Respirator Made During Actual Field Use in a Silica Bagging Operation. **Ann. Occup. Hyg.** 27(3):251-259.

Dixon SW, and Nelson TJ. (1984) Workplace Protection Factors for negative Pressure Half-Mask Facepiece Respirators. **J. of the Int. Soc. for Resp. Prot.** 2(4):347-361.

Dixon SW, Nelson TJ, and Wright JE. (1984) Program Protection Factor Study on the 3M W316 Airhat. Presented at the American Industrial Hygiene Conference, May 22, 1984, Detroit, Michigan. E. I. duPont deNemours and Company.

daRoza RA, and Weaver W. (1985) *Is it Safe to Wear Contact Lenses with a Full-Facepiece Respirator?* Lawrence Livermore National Laboratory manuscript UCRL-53653.

NIOSH. (1978) *NIOSH Pocket Guide to Chemical Hazards*, DHEW (NIOSH) Pub. No. 78-210. Cincinnati: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health.

NIOSH. (1985) *NIOSH Pocket Guide to Chemical Hazards*, DHHS (NIOSH) Pub. No. 85-114. Cincinnati: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health.

Code of Federal Regulations, Title 29, Part 1910, Section 134, revised July 1, 1986.

Compressed Gas Association, Inc. (1966) *Commodity Specification for Air* CGA, G-7.1-1966. New York: CGA.

Code of Federal Regulations, Title 30, Part 70, revised July 1, 1986.

Code of Federal Regulations, Title 40, Part 750, revised July 1, 1986.

American National Standards Institute, Inc. (1973) *American National Standard for Identificaton of Air Purifying Respirator Canisters and Cartridges*, ANSI K13.1-1973. New York: ANSI.

Public Law 91-173, U.S. Congress: *Coal Mine Health and Safety Act of 1969.* 30 U.S. Code; secs. 301(a) and 302(a).

Public Law 95-164, U.S. Congress: *Federal Mine Health and Safety Act of 1977.* 30 U.S. Code; sec. 508.

Noonan GP, Linn HI, and Reed LD. (1986) *A Guide to Respiratory Protection for the Asbestos Abatement Industry*, EPA publication no. DW75932235-01-1. Washington, D.C.: U.S. Environmental Protection Agency, Office of Pesticide and Toxic Substances.

American National Standards Institute, Inc. (1969) *American National Standard for Practices for Respiratory Protection*, ANSI Z88.2-1969. New York: ANSI.

American National Standards Institute, Inc. (1980) *American National Standard for Practices for Respiratory Protection*, ANSI Z88.2-1980. New York: ANSI.