3M JobHealth
HIGHLIGHTS

Technical Information for Occupational Health and Safety Professionals

What is a positive pressure respirator?

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Introduction

It is common to find references to the use of positive pressure respirators in respiratory protection regulations and literature. The term "positive pressure" implies that the pressure within the respiratory inlet covering (facepiece, hood or helmet) is somewhat greater than ambient pressure, and that any air movement will be outward. Since air contaminants are unlikely to travel upstream, it follows that positive pressure devices should provide high levels of protection. This belief is reflected in assigned protection factor (APF) tables, which generally grant higher APFs to positive pressure devices.

It is interesting that the term "positive pressure" became a part of accepted respiratory protection terminology without a formal definition. Over the years, most people have come to consider the following to be "positive pressure respirators":

- Pressure demand supplied air respirators (SAR)
- Continuous flow supplied air respirators
- Powered air purifying respirators (PAPR)
- Pressure demand self-contained breathing apparatus (SCBA)

Various definitions of "positive pressure respirator" began to appear after the term became a part of common usage. Different interpretations regarding the types of respirators that meet these definitions have also evolved. This article will discuss existing definitions of "positive pressure" and the confusion created by the inconsistent use of the term.

What "positive pressure" is and is not

"Positive pressure" is not a specific type of respirator

Respirator types that can be tested and approved by the National Institute for Occupational Safety and Health (NIOSH) are defined in 42 CFR Part 84.[1] Approval criteria for the following types of respirators are included:

- Self-Contained Breathing Apparatus
- Gas Masks
- Supplied-Air Respirators
- Non-Powered Air-Purifying Particulate Respirators
- Chemical Cartridge Respirators
- Special Use Respirators
- Dust, Fume and Mist; Pesticide; Paint Spray; Powered Air-Purifying High Efficiency Respirators and Combination Gas Masks

"Positive pressure respirator" is not listed. Since NIOSH only issues approvals for respirator types that are listed in 42 CFR Part 84, *no respirator is approved as a "positive pressure" device.*

"Positive pressure" is not a discrete mode of operation

Within the approval criteria for Self-Contained Breathing Apparatus, 42 CFR Part 84 defines two modes of operation for open circuit apparatus:

- "Demand-Type Apparatus," which has facepiece pressure that is "positive during exhalation and negative during inhalation"
- "Pressure-Demand-Type Apparatus," which has facepiece pressure that is "positive during both inhalation and exhalation."

There is no definition for "positive pressure" or "positive-pressure apparatus." However, it is clear from the above definition that, in concept, pressure demand is a positive pressure mode of operation.

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The Supplied Air Respirator approval criteria also use demand and pressure demand to describe two classes of Type C (airline) respirators. Test criteria for continuous flow, a third mode of operation for SAR, are also included. There is no definition for continuous flow, and no indication as to whether continuous flow SAR are considered to be positive pressure devices.

"Positive pressure" is work rate dependent

NIOSH testing for pressure demand SCBA and SAR approval includes a requirement that the facepiece pressure remain positive when tested on a breathing machine. The breathing machine is operated at 24 respirations per minute and a minute volume of 40 liters. Peak inhalation flow under these conditions is approximately 115 liters per minute (about 4 cubic feet per minute). These values are based on the respiration requirements of an average worker performing at a moderate, sustainable work rate.[2] Four cfm is also the minimum air flow requirement for both continuous flow SAR and PAPR with tight fitting facepieces. Permissible air flow in continuous flow SAR is limited to a maximum of 15 cfm.

Positive pressure can be maintained within a facepiece only if the respirator's flow capabilities exceed both the user's minute volume (the volume of air drawn into the lungs each minute) and the peak inhalation flow rate (the maximum instantaneous flow rate at which air is inhaled). Both minute volume and peak inhalation flow rates increase with an increasing work rate. Because the minimum NIOSH air flow rates exceed the worker's requirements only at low to moderate work rates, modern SCBA, SAR, and PAPR are designed to exceed the minimum NIOSH requirements. This substantially reduces the likelihood of the user "overbreathing" the respirator and creating a negative pressure in the facepiece.

The National Fire Protection Association (NFPA) has also addressed the "work rate" issue in its performance standard for SCBA used in firefighting.[3] The NFPA airflow criteria require an SCBA to maintain positive pressure in the facepiece when tested on a breathing machine operated at 30 respirations per minute with a minute volume of 103 liters. The peak inhalation flow rate under these conditions is approximately 330 lpm (about 12 cfm). NFPA states that this performance should supply the respiration requirements of the 98th percentile firefighter. In other words, at very high work rates (which could only be sustained for a few minutes), two percent of firefighters might be expected to have peak flow requirements that exceed the capability of an SCBA performing at the NFPA flow rates. It is therefore not surprising that there have been reports of firefighters overbreathing SCBA that meet the NFPA performance requirements.[4]

The existence of these momentary excursions of negative pressure is probably not significant from a worker exposure standpoint, and it does not mean that the SCBA airflows are inadequate.[4] It simply means that even respirators with very high performance capabilities may not maintain positive pressure 100 percent of the time for all workers. With the right combination of worker and high work rate, it is likely that nearly any tight fitting "positive pressure" respirator can be overbreathed.

Definitions

There is no legally-enforceable definition of "positive pressure respirator." The Occupational Safety and Health Administration (OSHA) has no definition in its respiratory protection regulation. Substance specific health standards imply that pressure demand SCBA, pressure demand and continuous flow SAR, and PAPRs are positive pressure respirators. An OSHA memorandum specifically states that PAPRs are positive pressure devices.[5] In most situations, OSHA requires fit testing of negative pressure respirators only. When this is the case, pressure demand SCBA, pressure demand and continuous flow SAR, and PAPRs are excluded from these requirements.[6]

Table 1.1 lists three published definitions of "positive pressure respirator." Note that the two more recent definitions acknowledge the fact that few respirators can assure positive pressure at all times. Certainly pressure demand SCBA, pressure demand and continuous flow SAR, and PAPRs are positive pressure respirators according to these definitions.

A new and significantly different definition of "positive pressure respirator" is currently being used by NIOSH. This is readily seen in a recent Respirator Users Notice, which included the respiratory protection recommendations shown in Table 2.[10]

It is not the purpose of this article to discuss the specific APFs that NIOSH recommends. However, it should be mentioned that these APFs are NIOSH recommendations and not legal requirements. 3M supports the APFs found in ANSI Z88.2-1992, which are significantly different than these recommendations.[9]

Examination of Table 1.2 shows that:

1. NIOSH is using "positive pressure" in a manner that is inconsistent with existing definitions,

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Table 1.1 Positive pressure respirator definitions

Year	Definition
1980	A respirator in which the air pressure inside the respiratory inlet covering is positive in relation to the air pressure of the outside atmosphere during exhalation and inhalation.[7]
1991	A respirator in which normally a positive pressure is maintained inside the hood or facepiece; may be an air-purifying or an atmosphere-supplying respirator.[8]
1992	A respirator in which the pressure inside the respiratory inlet covering is normally positive with respect to ambient air pressure.[9]

Table 1.2 NIOSH APF recommendations for abrasive blasting

APF	Respirator
25	Continuous flow respirator with a loose-fitting hood
50	Continuous flow respirator with a tight fitting facepiece
1000	Positive-pressure respirator with a tight fitting half-mask facepiece
2000	Pressure demand or positive pressure respirator with a tight fitting full facepiece

2. NIOSH does not consider continuous flow to be a "positive pressure" mode of operation, and
3. "Positive pressure respirator" is different than pressure demand and continuous flow.

Since the Users Notice was published, NIOSH has given the following explanation of its use of "positive pressure respirator":[11]

A positive pressure tight fitting full face piece respirator is one which operates in the continuous flow mode by design, but was submitted to NIOSH for a pressure-demand class approval, has been tested under the applicable requirements for that class, and meets all the requirements for a pressure-demand class approval."

In other words, in the NIOSH Users Notice, a "positive pressure respirator" is a continuous flow SAR that has a pressure demand approval.

Discussion

A number of issues are raised by NIOSH's unique definition of "positive pressure respirator." First, it is confusing to respirator users to see APFs recommended for respirator types that are not defined in the 42 CFR Part 84 approval regulations. It should be noted that the approvals for these "positive pressure respirators" are issued under pressure demand criteria, and that the approval labels identify them as "Pressure Demand Class" respirators. It would seem that the APF recommendation for pressure demand should cover all approved pressure demand respirators, regardless of their actual mode of operation.

Secondly, one might question the need for issuing pressure demand approvals to continuous flow respirators. While the reasons this practice began are not entirely clear, it was likely in response to specific APF tables that allowed higher APFs for pressure demand than for continuous flow respirators. For example, the OSHA asbestos regulations allow an APF of 100 for continuous flow SAR and an APF of 1000 for full facepiece pressure demand SAR.[12]

Finally, it should be mentioned that the difference between a continuous flow SAR and a "positive pressure" SAR is a matter of which approval tests are conducted rather than a true performance difference. A number of respirators have been tested and approved as *both* continuous flow and pressure demand ("positive pressure") SAR. All parts and operating conditions (hose lengths and pressure ranges) are identical for both approvals; only the wording on the approval label is different.

Summary

"Positive pressure" is a term that has been used to describe respirator performance for many years. Confusion has been created by the existence of various definitions. A single definition is needed. Since the ability of a respirator to maintain positive pressure depends on the air consumption rate of the user, the definition should specify conditions of minute volume and peak inhalation flow rate under which positive pressure must be maintained. The values chosen for these parameters should be based on a work rate that can be sustained for a reasonable period of time. The definition and performance specifications should eventually be incorporated into the respirator approval regulations.

Few respirators, if any, can assure positive pressure under all working conditions. Negative pressure excursions are possible even with respirators whose performance far exceeds minimum NIOSH requirements. While these excursions are most likely not a significant source of worker exposure, their effect can be minimized by assuring an adequate

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Positive pressure respirator

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facepiece-to-face seal. Tight fitting positive pressure respirators should be fit tested in a negative pressure mode, in accordance with ANSI Z88.2-1992 recommendations.

References

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11. U.S. Department of Health and Human Services/NIOSH: Morgantown, W.V., July 30, 1996 [Letter to L. Janssen].
12. "Asbestos," *Code of Federal Regulations* Title 29, Part 1910. 1986.

Performance evaluation of organic vapor diffusion monitors

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Introduction

All sampling devices, both active and passive, have performance limitations. 3M has developed a protocol to describe the operational boundaries of diffusion monitors.[1] This protocol included evaluating performance criteria such as desorption efficiency, reverse diffusion, storage, and the effects of sampling time, concentration, humidity, temperature, air velocity and sampler orientation on the sampling rate. The protocol was intended to include all the parameters of the National Institute for Occupational Safety and Health (NIOSH) and the European Committee for Standardization (CEN) monitor validation protocols.

This article will review the operational limits of a diffusion monitor when sampling for toluene, 1,1,1-trichloroethane (TCE), isopropanol (IPA), methyl ethyl ketone (MEK), styrene, hexane and methylene chloride. The monitors used in this study were either the 3M 3500 Organic Vapor Monitor or the 3M 3520 Organic Vapor Monitor with backup section. The monitors were exposed to fractions or multiples of an exposure limit (EL). The EL was chosen from either a proposed or current Threshold Limit Value (TLV) or Permissible Exposure Limit (PEL). Actual levels may have varied slightly depending upon the ability to generate concentrations at fractions of the EL and the analytical detection limit for the substance.

Results

Desorption efficiency

Four monitors were spiked at 1, 0.5 and 0.1 times the EL. Table 2.1 lists the percent recovery and coefficient of variation (CV) by compound. All of the chemicals in this study were desorbed with carbon disulfide, except for IPA which was desorbed with acetonitrile. All recoveries were above 75%, indicating that the desorbing solvent was appropriate for recovery according to our criteria.

Reverse diffusion

Twelve monitors were exposed to concentrations of 2 EL for 30 minutes at 23°C, 80% relative humidity (RH). Six monitors were capped and the remaining six were exposed to clean air for an additional 450 minutes. Measured mean concentrations of the two sets, for all of the compounds tested, differed by less than 10%, which met our criteria.

Humidity

Three monitors were exposed for 2-, 4-, 6- and 8-hour periods at 1 EL and relative humidities of 50% and 80%. For proper sampling, the uptake should be linear. Our criteria required that the measured sampling rate should not deviate more than 5% from linearity. Sampling time restrictions are recommended when deviations

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from our criteria occur. For toluene, styrene, hexane and MEK, the 3M 3500 Monitor could be used for all of the above conditions. As shown in Figure 2.1, methylene chloride should be sampled with the 3M 3520 Monitor (with backup section) and limited to a sampling time of 6 hours. For IPA, the 3M 3520 Monitor should be used when sampling for concentrations above 400 ppm for longer than 4 hours at 80% RH (see Figure 2.2). Similarly, for TCE, the 3M 3520 Monitor should be used when sampling for concentrations above 350 ppm for longer than 6 hours at 80% RH (see Figure 2.3).

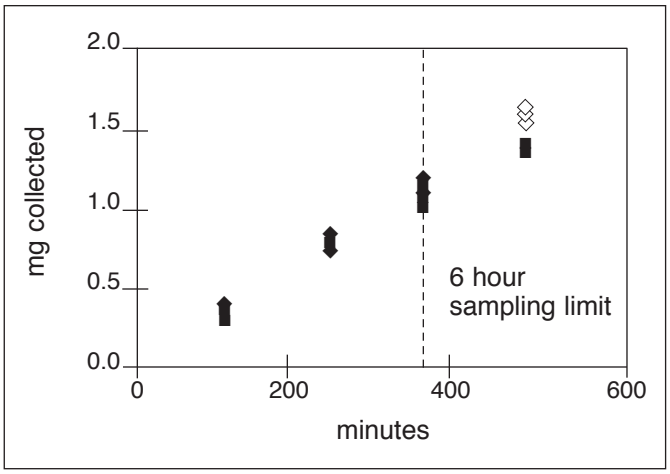

Figure 2.1
Methylene chloride uptake on 3520 at 50% and 80% RH, 25 ppm

Key:
◇ *50% RH*
■ *80% RH*

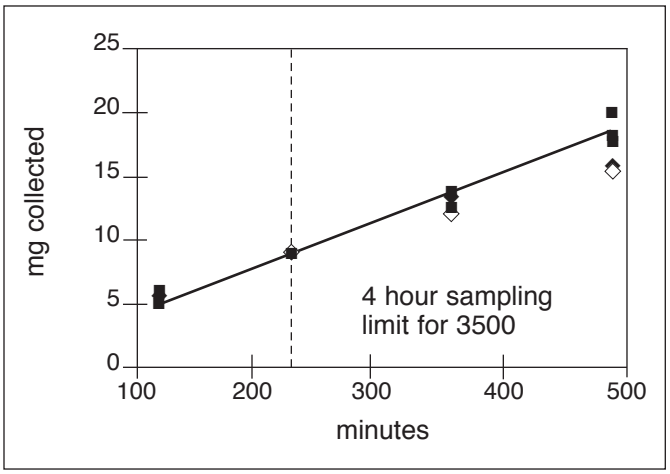

Figure 2.2
IPA uptake at 80% RH, 400 ppm

Key:
◇ *3500*
■ *3520*
— *Linear (3520)*

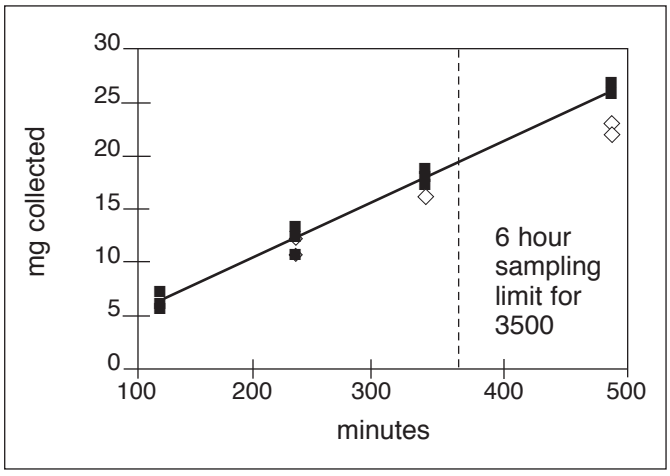

Figure 2.3
1,1,1-Trichloroethane uptake at 80%RH, 350ppm

Key:
◇ *3500*
■ *3520*
— *Linear (3520)*

Accuracy

It is impractical to evaluate the accuracy at every possible combination of concentration and sampling time. Therefore, to bracket the most common use conditions, six monitors were exposed at 0.1 and 2 EL for 15 and 480 minutes. Tables 2.2 through 2.8 give accuracies for the compounds by time and concentration at 50% RH (Accuracy = 2 * CV + |Bias|). Only in the case of methylene chloride at 4 ppm for 8 hours, did the accuracy exceed the recommended 25% level.

Temperature

The sampling rate of six monitors exposed at 10˚C and 40˚C was compared to the sampling rate at 23˚C. No significant effects were seen for toluene, hexane, TCE or methylene chloride. Based on these results, this experiment was not performed for either MEK, styrene or IPA.

Orientation/Air velocity

Monitors were placed parallel and perpendicular to air flows of 3 to 400 ft/min to determine if the sampling rate deviated by more than 5% relative to the published sampling rate. This experiment was performed for toluene, hexane and 1,1,1-trichloroethane. Orientation had no significant effect on the sampling rate. We recommend a minimum air velocity of 25 ft/min to ensure accurate sampling at any orientation. The results of this experiment depend on the design of the monitor and not on the specific analyte, so it is not necessary to repeat this experiment for every compound.

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Table 2.1 Desorption efficiency

Name	Toluene	Methylene Chloride	TCE	IPA	MEK	Styrene	Hexane
% Recovery	100	87	100	96	91	88	107
% CV	3.5	2.6	2.0	3.8	1.9	2.0	1.1

Table 2.2 Percent accuracies for TCE

	15 Minutes	8 Hours
35 ppm	12.9%	5.2%
700 ppm	12.9%	16.6% (3500) 14.4% (3520)

Table 2.3 Percent accuracies for IPA

	15 Minutes	8 Hours
40 ppm	10.4%	6.6%
800 ppm	18.7%	20.5% (3500) 6.8% (3520)

Table 2.4 Percent accuracies for MEK

	15 Minutes	8 Hours
10 ppm	13.1%	10.3%
200 ppm	19.9%	8.0%

Table 2.5 Percent accuracies (3520) for methylene chloride

	15 Minutes	8 Hours
4 ppm	—	26.6%
10 ppm	16.7%	—
50 ppm	14.3%	7.7%

Table 2.6 Percent accuracies for toluene

	15 Minutes	8 Hours
10 ppm	23.8%	12.1%
200 ppm	11.3%	6.8%

Table 2.7 Percent accuracies for styrene

	15 Minutes	8 Hours
8 ppm	12.6%	16.9%
93 ppm	9.7%	10.1%

Table 2.8 Percent accuracies for hexane

	15 Minutes	8 Hours
6 ppm	18.2%	11.8%
107 ppm	14.2%	9.5%

Storage

The recovery coefficient was calculated after spiking 20 monitors, adding an equivalent amount of water that would be adsorbed at 80% relative humidity, and then storing the monitors at room temperature (23˚C) and at 4˚C for 0 to 3 weeks. Toluene, methylene chloride, IPA, styrene, hexane and TCE had recovery coefficients within 10% of the initial recovery coefficient under the parameters listed above. MEK, however, should be stored refrigerated for less than 3 weeks.

Conclusion

Validation studies assist the user in understanding the accuracy and limitations of their sampling device and aid in developing sampling strategies where reliable results can be demonstrated. The information in this paper will add to the data available regarding organic vapor diffusion monitor performance. This data validates our previously-published sampling rates for toluene, methylene chloride, IPA, MEK, hexane and TCE.[2] However, the data indicated a new sampling rate for styrene of 28.9 cm^3/min, replacing the previous sampling rate of 26.8 cm^3/min. Therefore, the old sampling rate may have slightly overestimated the concentration of styrene.

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Motivating, training and educating for hearing protection

By Alice H. Suter, Ph.D.

Editor's Note: This is another in a periodic series of articles for JobHealth Highlights on noise, hearing conservation and hearing protection.

These articles are written by Dr. Alice Suter, consultant in industrial audiology and community noise. Dr. Suter is well known for her role as principal author of OSHA's hearing conservation amendment to the standard for occupational noise exposure.

The information contained and the opinions expressed in this article are those of the author, who is solely responsible for their content and accuracy. The opinions expressed may not necessarily reflect the opinions of 3M.

Some good reasons to protect hearing

Most of us need to be taught, or at least reminded of, the reasons for preserving hearing. Some of them are obvious — like preserving the ability to hear our families, friends and children. Protecting hearing is also important for the ability to hear our grandchildren, because the aging process slowly and inevitably adds to the burden caused by noise-induced hearing loss. But there are other reasons to protect hearing. One of the most vital is to avoid the social isolation, loneliness and depression that often accompany hearing impairment, especially later in life. Another reason is to avoid accidents, both on and off the job, due to the inability to hear oncoming vehicles and other sounds of impending danger. We also want to preserve the ability to hear music, the sounds of nature, and all the familiar sounds in our environment that are always taken for granted until they are lost.

There are other reasons besides hearing conservation to wear hearing protection effectively. Many workers report less fatigue when they first begin to wear protectors and sometimes say they don't feel as nervous. Some even report they sleep better at night. These extra "dividends" may be very welcome.

The importance of motivation

If employees are adequately motivated to wear hearing protectors, a hearing conservation program's chances of success are significantly better. This is especially true when working in moderate noise exposure levels (about 85 dB(A) to values in the low 90s), as well as in intermittent noise conditions, where workers need to don protectors and take them off periodically. In addition, older workers, who have been exposed to noise for many years and who may have acquired some noise-induced hearing loss, may lack motivation for wearing hearing protection. They may feel they are already hearing-impaired, saying, "why bother to wear these things?"

It seems to be more difficult to instill an understanding of the risks and hazards of noise than it is for many other safety and health hazards. For one thing, noise-induced hearing loss is invisible — ears don't bleed or *appear* to be affected in any way. Also, the growth of hearing loss is insidious. Some workers may notice a temporary dullness of hearing after the workshift, but the hearing often improves after 16 hours of rest. What they are not aware of is that this temporary loss begins to become permanent if it continues, day after day.

In addition, the nature of noise-induced hearing loss tends to be ambiguous, meaning that a person may be able to hear well in some circumstances, such as face-to-face conversation in quiet surroundings, but will have difficulty in other situations, such as conversation in groups or in places where there is background noise.

Finally, there is a reluctance to acknowledge hearing loss because it is often associated with old age and infirmity. This results in denial, both of the noise hazard and the hearing loss it causes. For these reasons, the people who conduct hearing conservation programs need to be diplomatic, understanding, knowledgeable and vigilant in the training and motivation of workers.

OSHA's requirements for training programs

Section (k) of OSHA's noise standard requires that employers conduct annual training programs for all employees exposed to noise at or above an 8-hour TWA (time-weighted average) noise level of 85 dB(A). The program must include (1) information on the effects of noise on hearing; (2) the purposes of hearing protectors, including their advantages and disadvantages, the attenuation provided by various types, and instructions on their selection, fitting, use and care; and (3) the purpose of audiometric testing and an explanation of the testing procedures.

Section (i)(3) of the standard requires that employees be given the opportunity to select their hearing protectors from a variety of suitable protectors. This means that employers should have on hand at least two or three types of protectors with attenuation sufficient for an employee's particular exposure. Giving the employee a choice may make a big difference in that person's motivation to wear the protector.

Management must be involved

If the hearing conservation program is to be successful, salaried personnel, even top management, must support and be involved in the program. These

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people often need to be motivated themselves. They need to understand the reasons for the program, why hearing is so important to preserve, what happens to the unprotected noise-exposed ear, and that they should always wear hearing protectors in posted areas, not only to provide a consistent example for employees, but to protect their own hearing.

Conducting training and motivation programs

Training and motivation should occur in groups as well as individually. Group programs provide employees with the opportunity to ask questions, learn from each other, and know that they are not alone in their concerns. Videos and pamphlets can be useful but they must never take the place of face-to-face instruction. The groups should not be so large that they preclude an informal, seminar-type atmosphere. Sessions should not be too long; a maximum of 15-20 minutes. Instructors should be knowledgeable in their subject matter and should relate well to workers. They should encourage workers to ask questions and to come forward with any problems. In turn, these problems should be resolved as promptly and efficiently as possible.

Training sessions should be interesting but not too technical. Many employees, however, will be curious about the workings of the ear, so a chart showing a cross-section of the hearing mechanism may be useful, along with an explanation of how the ear operates, both normally and when exposed by noise. Some trainers like to use the metaphor of grass to represent the inner ear's tiny hair cells, (the sensory cells of the inner ear). You can walk on a patch of grass, causing the blades to bend over, but after you leave, they will usually regenerate. If, however, you keep treading on the same patch day after day and year after year, the grass will eventually die off, leaving a bare spot. The same is true of the ear's hair cells.

The group should be told about the keys to identifying noise-induced hearing loss: persistent tinnitus (ringing in the ears), a sensation of "muffled" hearing after the workshift, difficulty understanding what people are saying when listening in groups or in noisy surroundings, and the belief that people are mumbling and not speaking clearly.

Training and motivating does not end with the group session. The program must be an on-going concern. The trainer or hearing conservationist should stop and speak to employees on the job, during breaks, and whenever appropriate, notice whether ear plugs are inserted correctly, check ear muff headbands and cushions, and ask questions about their use and comfort. The annual audiometric test (or the follow-up re-test) is also a good time to counsel employees about the status of their hearing and their use of hearing protectors.

If individual employees have problems adjusting to wearing hearing protectors, a break-in period may be required. During the break-in period, an employee wears the protector for only a few minutes the first day, then for longer and longer periods on subsequent days, working up to the necessary durations as quickly as possible. Sometimes workers will complain that their machines sound different when they wear protectors. They may need a gradual break-in period to become used to the new "acoustic signature" of the machine.

Motivational techniques

One of the most valuable and simple techniques for motivating employees is to explain their audiometric test results; teaching them the meaning of the audiogram and comparing a current audiogram to previous audiograms and possibly to that of a hypothetical person with "normal" hearing, matched for age and sex. If threshold levels remain stable, the employee should appreciate this good news. If threshold levels are deteriorating, the time is ripe for a counseling session, which should include a refresher course in fitting and wearing hearing protection.

It is important to reward employees for wearing hearing protection effectively and not to reward them for failure to use it or for using it ineffectively. This involves working with the employee to improve the situation. The protector may be uncomfortable, requiring a change to a different size or type, or it may be damaged or worn, requiring a replacement. Alternatively, the employee may be wearing the protector, but failing to insert it correctly.

Then again, the worker may be fearful of a safety hazard caused by the inability to hear indications of trouble, such as malfunctions in his or her machine. A worker also may fear the inability to communicate when protectors are worn properly. This problem needs considerable sensitivity on the part of the hearing conservationist or supervisor, because the employee's fears could be quite legitimate. The professional needs to work with the employee to uncover the problem areas and investigate solutions. Noise control measures may need to be undertaken, or the employee may need to be fitted with special protectors that attenuate evenly across the frequency spectrum. If communication is an integral part of the job, ear muffs with active noise reduction or communication headsets would be indicated.

Some companies provide institutional rewards, such as cash or lottery tickets for employees or departments with good safety

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records, including hearing conservation. Some companies make wearing hearing protectors a condition of employment and some use disciplinary actions for recalcitrant employees. Punishment, if it is a company policy, should be used only as a last resort, because many cases of resistance are due either to ignorance or to legitimate concerns, and there are many positive methods that may be employed to change uncooperative behavior.

Demonstrations

Certain demonstrations may be useful in motivating workers to protect their hearing. One very effective demonstration is practical only with ear plugs (not muffs) at this time, and can be conducted only in an audiometric booth or in a mobile audiometric testing unit. The demonstration involves taking individual workers away from the work station, cautioning them not to touch their plugs, and then testing their hearing with the plugs in place. After that, the plugs are removed and the test is repeated. The difference between the "plugged" and "unplugged" hearing thresholds gives an approximation of the attenuation currently being achieved. This is not a scientific test because the results may not be exact for various reasons. For example, during the test, the ear plug may come into contact with the headphone's cushion or receiver. However, the demonstration gives a good indication of how well the plugs are working.

Another interesting demonstration involves testing a worker's hearing before and after the workshift. If the protectors are working properly, the post-workshift threshold levels should be just as good as or slightly better than the pre-workshift levels. If they are worse, it is an indication that a temporary threshold shift (TTS) is taking place and there is inadequate protection from noise.

Audiograms may also be used as a demonstration in group training sessions. The trainer may make a composite audiogram for a particular group or department, or may create a hypothetical audiogram, typical of the group, and compare it to another, standard audiogram, matched for age and other factors. It is not good practice to use an individual employee's audiogram in front of the group, especially if it is identified with an employee's name.

Involving the family

Employees sometimes seem to be more interested in the hearing health of their families than they are in their own hearing health! Consequently, some companies have a special day on which they provide audiometric tests for workers' spouses and children. This presents an opportunity for discussions about noise exposure and hearing conservation with spouses, who very often *are* extremely interested in the hearing health of the employee. It also provides the opportunity to encourage employees to take hearing protectors home and use them when engaging in noisy activities, such as target practice or when using noisy equipment such as chain saws or shop tools.

Educational aids

As mentioned above, educational materials, such as videos and pamphlets, are not a substitute for person-to-person contact, but can be helpful as supplemental aids. Videos should be lively and informative, and no longer than about 10-12 minutes. Written materials should be readable, easy to understand and up-to-date. All materials should reflect the hearing protector options provided by the specific company, and, if possible, should reflect the conditions encountered within that company. For example, a video filmed in a textile plant would not be appropriate for workers in metal fabrication plant.

It's worth the time and effort

Hearing conservation programs administered to unmotivated employees are likely to be a waste of time and resources. But, when employees are given the information and attention they need, encouraged to participate in the program and rewarded for wearing protectors effectively, the success in terms of hearing conserved is worth the time and effort.

Resources

3M Hearing Conservation Program Support Materials:

- Hearing Protection Training Video
- "If You Do Not Protect Your Ears from NOISE. . . "
- "What Did You Say?" Guide to Hearing Protection
- "A Few Reminders About Using and Caring for Hearing Protectors"

"Resources in Hearing Conservation: References and Films Listed in *Spectrum*," available from the National Hearing Conservation Association, 611 E. Wells St., Milwaukee, WI 53202-3892.

For further reading

Gasaway, D.C., *Hearing Conservation: A Practical Manual and Guide*, Prentice-Hall, Englewood Cliffs, NJ, 1985.

Merry, C.J., "The role of expectancies in workers' compliance with a hearing loss prevention program." In *The 21st Annual NHCA Conference*, National Hearing Conservation Association, 611 E. Wells St., Milwaukee, WI 53202-3892, 1996.

Suter, A.H., *Hearing Conservation Manual (3rd ed.)*, Council for Accreditation in Occupational Hearing Conservation, Milwaukee, WI. 1993.

Suter, A.H. and Franks, J.R. (Eds.), "*A Practical Guide to Effective Hearing Conservation Programs in the Workplace*." DHHS (NIOSH) Publication No. 90-120. National Institute for Occupational Safety and Health, Cincinnati, OH, 1990. Also published as "*Hearing Conservation in the Workplace: A Practical Guide*," National Safety Council, Chicago, IL, 1992.

OSHA issues new standards for exposure to 1,3-butadiene and methylene chloride

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Introduction

The Occupational Health and Safety Administration (OSHA) recently issued two final rules for occupational exposure to 1,3-butadiene and to methylene chloride. This article presents a brief summary of each rule, focusing primarily on the respiratory protection aspects of these standards. These summaries do not represent official, legal or complete interpretations of the standards. If specific questions arise, the standards themselves should be referred to and relied upon.

The OSHA standard for 1,3-butadiene

The chemical 1,3-butadiene (CAS #106-99-0) is a colorless, noncorrosive, flammable gas. A major commodity product of the petrochemical industry, 1,3-butadiene (BD) is used to manufacture rubber, nylon and ABS (acylonitrile-butadiene-styrene) resins.

Breathing very high levels of BD for a short time can cause central nervous system irregularities, blurred vision, nausea, fatigue, headache and unconsciousness. Breathing lower levels of BD may cause irritation of the eyes, nose and throat. Skin contact with liquefied BD may cause irritation and frostbite.

OSHA has concluded there is strong evidence that workplace exposure to BD poses an increased risk of death from cancers of the lymphohematopoetic (lymph and blood-forming) system.

While the standard became effective on February 3, 1997, several start-up dates have been designated. Although the exposure goal program has a November 4, 1999 start-up date, engineering controls must be implemented by November 4, 1998. Initial monitoring must begin on April 4, 1997 and all other requirements must be implemented by August 4, 1997.

This standard applies to all occupational exposures to 1,3-butadiene, with three exemptions for those situations where OSHA concluded the likelihood of significant exposures is quite low (See 29 CFR 1910.1051(a)(2).)[1]

The action level is a 0.5 parts per million (ppm) airborne concentration of BD calculated as an eight (8)-hour time-weighted average (TWA). Under the new standard, an employer must ensure that no employee is exposed to an airborne concentration of BD in excess of one (1) part of BD per million parts of air (1 ppm) measured as an eight (8)-hour time-weighted average. The OSHA short-term exposure limit (STEL) states that an employer must ensure no employee is exposed to an airborne concentration of BD in excess of five (5) parts of BD per million parts of air as determined over a sampling period of fifteen (15) minutes.

Exposure monitoring

Determinations of employee exposure to BD must be made from breathing zone samples that are representative of the 8-hour and 15-minute short-term exposures for each employee. Representative 8-hour TWA employee exposure must be determined on the basis of one or more samples representing full-shift exposure for each shift and for each job classification in each work area. Representative 15-minute short-term employee exposure must be determined on the basis of one or more samples representing 15-minute exposures associated with operations that are most likely to produce exposures above the STEL for each shift and each job classification in each work area.

Employers must perform initial monitoring to determine BD concentrations or rely on objective data. These results, in turn, determine the frequency required for periodic monitoring. Table 4.1 shows various BD exposure scenarios and their required monitoring frequencies. Appendix D of the standard describes the validated method of sampling and analysis that has been tested by OSHA for use with BD.

Exposure goal

This requirement is unique to the 1,3-butadiene standard. For those operations and job classifications where employee exposures are greater than the action level, in addition to compliance with the permissible exposure limits (PELs), the employer must have an exposure goal program that is intended to limit employee exposure to below the action level during normal operations.

Respiratory protection

Employers must provide respirators that comply with the requirements of the standard, at no cost, to each affected employee and ensure that employees use the respirators where required by the standard.

Respirators must be used in the following circumstances:

(see OSHA standards on page 11)

(continued from page 10)

Table 4.1 Five exposure scenarios for 1.3-butadiene and their associated monitoring frequencies

Action Level	8-hr TWA	STEL	Required Monitoring Activity
-*	-	-	No 8-hr TWA or STEL monitoring required.
+*	-	-	No STEL monitoring required. Monitor 8-hr TWA annually.
+	+	-	No STEL monitoring required. Quarterly monitoring for 8-hr TWA.**
+	+	+	Quarterly monitoring for 8-hr TWA and STEL.**
+	-	+	Quarterly monitoring for STEL.** Monitor 8-hr TWA annually.

* Exposure Scenario, Limit Exceeded: + = Yes, - = No.

** The employer may decrease the frequency of exposure monitoring to annually when at least 2 consecutive measurements taken at least 7 days apart show exposures to be below the 8-hr TWA, but at or above the action level.

1. During the time interval necessary to install or implement feasible engineering and work practice controls;
2. In non-routine work operations that are performed infrequently and in which exposures are limited in duration;
3. In work situations where feasible engineering controls and work practice controls are not yet sufficient to reduce exposures to or below the PELs;
4. In emergencies.

Respirator selection

Where respirators are required, employers must select and provide the appropriate respirators, as specified in Table 4.2, and ensure their use. The respirator must be among those approved by the National Institute for Occupational Safety and Health (NIOSH) under the provisions of 42 CFR Part 84, "Respiratory Protection Devices." If an employee whose job requires the use of a respirator cannot use a negative pressure respirator, the employee must be provided with a respirator that has less breathing resistance, such as a powered-air purifying respirator or supplied air respirator, if the employee is able to use it and if it will provide adequate protection.

Respirator program

Where respiratory protection is required, the employer must institute a respirator program in accordance with 29 CFR 1910.134.

Respirator use

Detailed instructions for respirator use are provided in the BD standard. The instructions in the respirator selection table include a chemical cartridge change-out schedule that varies with airborne concentration. The BD standard is the first OSHA rule to include instructions of this type.

Respirator fit testing

Appendix E of the standard provides mandatory requirements for fit testing of respirators. Some of these requirements are unique to the BD standard.

Fit testing must be used to select a respirator facepiece that exhibits minimum acceptable leakage and provides the required protection as prescribed in Table 4.2. Employers must conduct either qualitative (QLFT) or quantitative fit testing (QNFT), as required in Appendix E, at the time of initial respirator fitting and at least annually thereafter for employees who wear tight-fitting negative pressure respirators. Quantitative fit testing (QNFT) must be performed at initial fitting and at least annually thereafter for each employee wearing a tight-fitting full facepiece negative pressure respirator who is exposed to airborne concentrations of BD that exceed 10 times the TWA PEL (10 ppm).

Employers must ensure that employees wearing tight-fitting respirators perform a facepiece seal fit check to ensure that a proper facepiece seal is obtained prior to each entry into a BD atmosphere. Employers should use the recommended positive and negative fit check procedures listed in Appendix E of the standard or the manufacturer's recommended fit check procedure.

Additional requirements

The OSHA standard for 1,3-butadiene provides additional requirements for medical screening and surveillance, communications with employees, and record keeping. The BD standard also has six appendices, although only Appendix E, which describes fit testing procedures, contains mandatory requirements.

A copy of the standard (29 CFR 1910.1051) can be found in the *Federal Register.*[1]

(see OSHA standards on page 12)

(continued from page 11)

Table 4.2 Minimum requirements for respiratory protection for airborne 1,3-butadiene

Concentration of Airborne BD (ppm) or Condition of Use	Minimum Required Respirator	3M Suggested Respirator
≤ 5 ppm (5 times PEL)	a) Air-purifying half mask or full facepiece respirator equipped with approved BD or organic vapor cartridges or canisters. **Cartridges or canisters shall be replaced every 4 hours.**	a) 6000 or 700X Series Half Facepiece Respirators with 6001 organic vapor cartridges; 7X00 Series Half Facepiece Respirators with 7251 organic vapor cartridges; 5X01 Organic Vapor Respirator.
10 ppm (10 times PEL)	a) Air-purifying half mask or full facepiece respirator equipped with approved BD or organic vapor cartridges or canisters. **Cartridges or canisters shall be replaced every 3 hours.**	a) 6000 or 700X Series Half Facepiece Respirators with 6001 organic vapor cartridges; 7X00 Series Half Facepiece Respirators with 7251 organic vapor cartridges; 5X01 Organic Vapor Respirator.
≤ 25 ppm (25 times PEL)	a) Air-purifying full facepiece respirator equipped with approved BD or organic vapor cartridges or canisters. **Cartridges or canisters shall be replaced every 2 hours.**	a) 6000 Series Full Facepiece with 6001 organic vapor cartridge; 7800 Series Full Facepiece with 7251 organic vapor cartridges.
	b) Any powered air-purifying respirator equipped with approved BD or organic vapor cartridges. **PAPR cartridges shall be replaced every 2 hours.**	b) Any 3M Belt-Mounted PAPR with GVP-401 organic vapor cartridge.
	c) Continuous flow supplied air respirator equipped with a hood or helmet.	c) Whitecap II Series, Snapcap Series, Hardcap and Airhat continuous flow airline respirators.
≤ 50 ppm (50 times PEL)	a) Air-purifying full facepiece respirator equipped with approved BD or organic vapor cartridges or canisters. **Cartridges or canisters shall be replaced every (1) hour.**	a) 6000 Series Full Facepiece with 6001 organic vapor cartridge; 7800 Series Full Facepiece with 7251 organic vapor cartridges.
	b) Powered air-purifying respirator equipped with a tight-fitting facepiece and an approved BD or organic vapor cartridges. **PAPR cartridges shall be replaced every (1) hour.**	b) GVP-4 PAPR with GVP-401 organic vapor cartridge.

(see Table 4.2 continued on page 13)

The OSHA standard for methylene chloride

OSHA has issued a final rule that significantly reduces occupational exposure to methylene chloride (CAS #75-09-2). A volatile, colorless liquid with a chloroform-like odor, methylene chloride is used in industrial processes such as paint stripping, and metal cleaning and degreasing. It is also used in the manufacture of a wide range of products including pharmaceuticals, paint remover, adhesives, polyurethane foam, film bases, polycarbonate resins and solvents.

Inhaling methylene chloride vapor causes mental confusion, light-headedness, nausea, vomiting and headache. OSHA considers methylene chloride to be a suspected human carcinogen.

The standard applies to all occupational exposures in general industry, construction and shipyard employment. The standard is scheduled to become effective on April 10, 1997 with multiple start-up dates for various activities. However, it should be noted that this standard is subject to review by both houses of the U.S. Congress under provisions of a 1996 law and implementation of part or all of the standard could be delayed.

The action level is an airborne concentration of 12.5 parts per million (ppm) calculated as an eight (8)-hour time-weighted average (TWA). Under the new rule, employers must ensure that no worker is exposed to an airborne concentration of methylene chloride in excess of 25 ppm as an eight (8)-hour TWA. (The previous occupational exposure level was 500 ppm TWA.) In addition, the new standard defines the short-term exposure limit (STEL) as 125 ppm when determined over a sampling period of 15 minutes.

(see OSHA standards on page 13)

(continued from page 12)

Table 4.2 (continued)

Concentration of Airborne BD (ppm) or Condition of Use	Minimum Required Respirator	3M Suggested Respirator
≤ 1,000 ppm (1,000 times PEL)	a) Supplied air respirator equipped with a half mask or full facepiece and operated in a pressure demand or other positive pressure mode.	a) 6000 or 7000 Series Half Mask Airline; 6000 or 7800 Series Full Facepiece Continuous Flow; 7800 Full Facepiece-Pressure Demand Airline Respirators.
> 1000 ppm, unknown concentration or firefighting	a) Self-contained breathing apparatus equipped with a full facepiece and operated in a pressure demand or other positive pressure mode.	a) None available from 3M.
	b) Any supplied air respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure demand or other positive pressure mode.	b) 3M 7800 Full Facepiece Pressure Demand Combination Airline/5-Minute Escape SCBA (a.k.a. 5 Minute Escape System)
Escape from IDLH conditions	a) Any positive pressure self-contained breathing apparatus with an appropriate service life.	a) None available from 3M.
	b) An air-purifying full facepiece respirator equipped with a front or back mounted BD or organic vapor canister.	b) None available from 3M.

Notes: Respirators approved for use in higher concentrations are permitted to be used in lower concentrations. Full facepiece is required whenever eye irritation is anticipated.

[Note: The BD standard is the first OSHA standard to contain a chemical cartridge change-out schedule in the selection table that varies with the airborne concentration. For example, a half facepiece organic vapor respirator can be used up to 10 times the PEL (10 ppm), but the cartridge must be changed more frequently when used for airborne BD concentrations of 10 ppm (every 3 hours) than when used for airborne BD concentrations of 5 ppm (every 4 hours). Full facepiece organic vapor respirators can be used in airborne BD concentrations up to 50 ppm, but the chemical cartridge change-out schedule is more frequent.]

Exposure monitoring

Table 4.3 lists requirements for monitoring methylene chloride exposures. Monitoring is required at three- or six-month intervals depending on the relationship of measured exposures to the action level, the TWA and the STEL.

Respiratory protection

Employers must provide respirators, at no cost, to employees and ensure they are used where appropriate. Respirators must be used in the following circumstances:

1. Whenever an employee's exposure exceeds or can reasonably be expected to exceed the TWA or the STEL (e.g. when using methylene chloride in a regulated area);
2. During the time period necessary to install or implement feasible engineering and work practice controls;
3. Where engineering and work practice controls are not sufficient to reduce exposure below the PELs;
4. In emergencies.

Respirator selection

Workers exposed to methylene chloride should use supplied air respirator systems. These include continuous flow supplied-air full facepiece, hood or helmet systems. (See Table 4.4.) All respirators must be approved by the National Institute for Occupational Safety and Health (NIOSH).

Respirator program

Where respirators are required, employers must establish a respirator program in accordance with 29 CFR 1910.134.

Respirator fit testing

Employers must assure that respirators are fitted properly and exhibit the least possible facepiece leakage. Qualitative (QLFT) or quantitative fit testing (QNFT) of respirators is required initially and annually for all negative pressure tight-fitting respirators, including escape gas masks. The only atmosphere supplying respirators to which this provision applies are

(see OSHA standards on page 14)

(continued from page 13)

negative pressure SCBA (self-contained breathing apparatus) and SAR (supplied air respirators). While protocols for fit testing are not included in the standard, the small business compliance guidelines will contain examples of protocols for QLFT and QNFT.

Additional requirements

The new rule also establishes provisions for regulated areas, medical surveillance and evaluations, hazard communications, protective clothing and record keeping.

A copy of the standard (29 CFR 1910.1052) can be found in the *Federal Register.*[2]

References

1. *Federal Register*, 61(214):56745-56795 (1996).

2. *Federal Register*, 62(7):1493-1543 (1997).

Table 4.3 Exposure monitoring requirements for methylene chloride

Exposures < action level, > STEL: Monitor STEL every 3 months.
Exposures ≥ action level, ≤ TWA, ≤ STEL: Monitor TWA every 6 months.
Exposures ≥ action level, ≤ TWA, > STEL: Monitor TWA every 6 months. Monitor STEL every 3 months.
Exposures > TWA, ≤ STEL: Monitor TWA every 3 mo nths.
Exposures > TWA and > STEL: Monitor TWA and STEL every 3 months.

Table 4.4 Respirator selection requirements for methylene chloride

≤25 x PEL:	Continuous flow supplied air respirator with hood or helmet.
≤50 x PEL:	Full facepiece supplied air respirator, demand mode; full facepiece SCBA, demand mode.
≤200 x PEL:	Full facepiece pressure demand or continuous flow supplied air respirator; pressure demand SCBA.
>200 x PEL or unknown:	Pressure demand SCBA; full facepiece pressure demand supplied air respirator with auxiliary SCBA.
Fire fighting:	Pressure demand SCBA.
Emergency escape:	Continuous flow or pressure demand SCBA; gas mask with organic vapor canister.

Tech line

To reach 3M's Technical Service staff with questions regarding our products, you can call 1-800-243-4630. If you wish to contact your local sales representative, you can leave a message by calling 1-800-896-4223.

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