CHAPTER 4

RESPIRATOR USE

I. Federal Regulatory Requirements

OSHA 1910.134 states that when effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used pursuant to the following requirements:

- o respirators shall be provided by the employer when such equipment is necessary to protect the health of the employee
- o the employer shall provide the respirators which are applicable and suitable for the purpose intended
- o the employer shall be responsible for the establishment and maintenance of a respiratory protection program.

The respirator protection program prescribed by OSHA contains provisions for the following:

- o written standard operating procedures
- o respirators selected on basis of hazards
- o instruction and training of user
- o cleaning and disinfection
- o storage
- o inspection
- o surveillance of work area conditions
- o evaluation of respirator protection program
- o medical review
- o use of certified respirators.

A. Employer Responsibility

1. Determination of Wearer's Exposure to Hazards

Appropriate surveillance of work area conditions and of worker exposure to respiratory hazards should be carried out using good industrial hygiene practices. This means that the concentration of the respiratory hazard to which workers are exposed should be determined periodically, using NIOSH sampling methods where available, and records should be kept. The monitoring should cover conditions throughout a full work shift as activities in the work area vary during the shift and change the hazard concentration. The time-weighted average concentration and ceiling (peak) concentration of the hazard during the work shift should be determined. Preferably, the air in the work area should be sampled in the workers' breathing zones.

2. Fit Testing Before Use

In order to obtain adequate respiratory protection, there should be a proper match between respirator and wearer. To assure selection of the best fitting respirator, the wearer should be fit tested using a quantitative fit test procedure. Quantitative fit testing procedures are included in Appendix B of this document.

Respirator facepieces should be tested for fit each time they are worn. The wearer can make either the positive or the negative-pressure test before entering a hazardous atmosphere, but a qualitative check using either isoamyl acetate or irritant fume is much preferred. Qualitative fit testing procedures are included in Appendix B of this document.

3. Random Inspection

Respirators in use should be randomly inspected frequently to ensure that those selected for the job are being used and that they are in good condition. Respiratory protection is no better than the respirator in use. Periodic monitoring of respirator use should include:

- o determination that the proper respirators are being used
- o determination that respirators are being worn properly

o consultation with wearers about:

-discomfort
-resistance to breathing
-fatigue
-interference with vision
-interference with communications
-restriction of movement
-interference with job performance
-confidence in the respirator.

In addition to general assessment of overall respiratory protection, specific evaluations should also be conducted of cleaning, inspection, maintenance and storage. Problems discovered during the inspections should be rectified.

B. Employee Responsibility

Proper supervision of respirator use should ensure that each worker understands that he/she has certain responsibilities. Each worker should:

o check the respirator fit after each donning as instructed

o use the respirator as instructed

o guard against damaging the respirator

o go immediately to an area having respirable air if the respirator fails to provide proper protection

o report any respirator malfunction to a person responsible for the respirator program.

III. Program Elements

A. Program Administration

Providing suitable respirators to workers seems simple, but issue of an unsuitable respirator may result in worker injury or death, so the matter cannot be treated lightly. The person responsible for issuing respirators should be adequately trained to make sure that the correct respirator is provided for each job. The respirator program administrator should have the technical and professional background in order to make sound judgments based on hazard evaluation input from the workplace.

Without a definite chain of supervision, there is no assurance that written standard operating procedures will be followed. Therefore, responsibility for the entire respirator program should be assigned to one person.

The large user may find it practical and economical to have a staff of personnel involved in the respirator program, each with his own area of responsibility. Each of these people should report to the one administrator who has overall responsibility for the program. The administrator's technical and professional background should enable him or her to make sound judgments based on hazard evaluation input from the workplace. The Administrator may be a safety engineer, industrial hygienist, health physicist, or physician. The Administrator should have the full support of higher level management; without it, an effective respirator program is difficult to initiate and maintain.

Respirator purchasing should be controlled by the program administrator for good reasons. Several respirator manufacturers produce a wide variety of devices for protection against specific hazards. Although most manufacturers today produce several size facepieces to choose from, not all workers may be able to receive an adequate fit if only one brand of respirator is purchased. However, if more than one brand of respirator is purchased, thus providing a variety of facepiece sizes, it is possible to fit most of a working population. Sometimes more than one type of respirator may be adequate against a particular hazard. The program administrator should select what he/she considers to be the best types of devices, considering comfort and worker acceptance, and ensure that they are purchased. It is unwise to select a respirator on the basis of price alone. A program administrator, with comprehensive knowledge, should have a strong influence on, if not absolute control over, respirator purchases.

Small volume respirator users often feel they cannot afford (and may not need) to involve several people specifically in a respirator program. However, they have to meet the same requirements as the program administrator for the large user because the hazards do not differentiate between large and small volume users. In a small firm, where only a few workers wear respirators for protection against one or very few different hazards, the program administrator may be a foreman or other supervisor. Where only one or two workers wear respirators, the entire program may be the responsibility of the company owner. In an extremely small operation, the entire program may be the responsibility of the worker.

The administrator should keep the respirator program as flexible as possible. Although the written operating procedures meet today's situation, they may not meet tomorrow's. New hazards are continually being identified, and allowable exposure limits often are revised as more knowledge becomes available. The program administrator should stay abreast of these changes by subscribing to pertinent publications, and should not hesitate to modify the program to meet changing conditions.

Thus, the administrator, of a large or small program, should establish a respirator program that meets current needs, ensure that it is carried out satisfactorily, and ensure that it remains effective by continual examination and modification to meet changing conditions.

In summary, the program administrator can be a highly trained professional who oversees several employees responsible for specific phases of the respirator program, or a single employee responsible for the employee's own respirator. Like the written operating procedures, the exact administration of the respirator program should be tailored to the individual situation.

B. Program Components

Unfortunately, respirators can be misused or taken too much on faith, primarily because of lack of knowledge. Such misuse can be avoided by establishing written procedures for respirator selection and use and through proper supervision of all aspects of the respirator program. Following are detailed methods for ensuring that a respirator program remains effective.

1. Written Standard Operating Procedures

The importance of written standard operating procedures is emphasized in OSHA 29 CFR Part 1910.134 which gives the first requirement for a "minimal acceptable (respirator) program" as establishment of "written standard operating procedures governing the selection and use of respirators." Part 1910.134, which is currently undergoing revision, does not provide any guidance on preparation of these procedures and does not differentiate between large and small users. However, the general content of written procedures has been established, and from that information as provided by NIOSH and others, any user, large or small, can formulate procedures.

The written standard operating procedures should contain all information needed to maintain an effective respirator program to meet the user's individual requirements. They should be written so as to be useful to those directly involved in the respirator program, the program administrator, those fitting the respirators and training the workers, respirator maintenance workers, and the supervisors responsible for overseeing respirator use on the job. It is not necessary that the operating procedures be written for the wearer, although in a very small program it may be desirable to direct their content to the wearer. Only analysis of the individual program will show to what extent information for the wearer should be included.

The procedures should contain all information needed to ensure proper respiratory protection of a specific group of workers against a specific hazard or several particular hazards. The hazard(s) should have been assessed thoroughly; otherwise the written procedures will have only limited validity. Generally, the procedures should contain the following:

- o guidance for selection of the approved respirator(s) for protection against particular hazard(s)

- o detailed instructions for training workers in proper use of the respirator(s), including respirator fitting

- o detailed maintenance procedures for:

  -cleaning and disinfection
  -drying
  -inspection
  -repair or replacement of worn or defective components
  -storage

- o administrative procedures for:

  -purchase of approved or accepted respirator(s)
  -control of inventory of spare parts, new respirators, and respirators ready for reissue after maintenance
  -issuance of respirators to ensure use of the proper one for a given hazard
  -guidance of supervisory personnel in continued surveillance of respirator use and determination of workers' exposure to respiratory hazards

- o instructions for respirator use during emergencies, including fire, which can create an atmosphere immediately hazardous to life or health

- o guidelines for medical surveillance of workers, including pre-employment physical examinations to eliminate those physically or psychologically unfit to wear respirators, and periodic physical examinations to review the overall effectiveness of the respirator program on the basis of physiological factors

- o procedures for evaluating the respirator program's effectiveness

Obviously, the above essentially restates the OSHA requirements for a minimal acceptable respirator program. The point is that all the information needed to establish and maintain an adequate respirator program should be written down.

The exact format of written standard operating procedures may vary widely. The large user who has many workers wearing respirators and, perhaps, several respiratory hazards to consider, may formulate separate procedures for selection and use of respirators for each hazard. For a small user, who has only a few workers to protect from only one or very few hazards, a much simplified document may serve; but it must cover the same subjects. In general, the complexity of the procedures increases as respirator use increases. The procedures also become more extensive as the toxicity of the respiratory hazard(s) increases, demanding better and more reliable protection. It is better to be overly detailed in developing written operating procedures than not detailed enough.

Some firms have developed an elaborate system wherein each wearer is issued a card that specifies what type of respirator the wearer can be issued for protection against a particular hazard. The wearer is required to show this card to the issuer, who can issue only the type of respirator listed. Often, such a card lists a particular brand of respirator on the basis of fitting tests.

When practical, a respirator should be assigned to each worker for exclusive use, and should be permanently marked to indicate to whom it is assigned. Care should be taken to ensure that the marking does not affect the respirator performance. If possible, records should be kept on the issuance and use of each respirator. To do so, each should be permanently identified. Records should include the date of initial issue, the dates of reissue, and a listing of repairs.

Particularly important are procedures for respirator use during emergencies such as fire, large spillage of toxic material, accidental release of a potentially lethal substance, or failure of a ventilation system. All possible emergencies should be considered in advance and prepared for in the written procedure. In the stress of an emergency, memories may be faulty. Furthermore, these emergency procedures should be used in training emergency response teams. A sample of and a check list for a respirator standard operating procedure are included in Appendix A.

2. Medical Surveillance

OSHA 29 CFR 1910.134 states that no one should be assigned a task requiring use of respirators unless found physically able to do the work while wearing the respirator. In addition, some regulatory standards for specific substances and occupations may also contain requirements for medical examinations. Both types of standards declare that a physician should determine what health and physical conditions are pertinent, and that respirator wearers' medical status should be reviewed periodically.

Pre-placement medical examinations should screen out those who are physically or psychologically unfit to wear respirators. As another part of this examination, medical tests pertinent to the respiratory hazards that workers may encounter should be made to get baseline data against which to assess physiological changes in respirator wearers. In addition, the workers' previous medical and employment history should also be considered.

The types of information which should be obtained from the worker include:

a. History of respiratory disease--identifies workers with a history of asthma, emphysema, or chronic lung disease. These people may be at risk when wearing a respirator.

b. Work history--identifies workers who have been exposed to asbestos, silica, cotton dust, beryllium, etc., within the past ten years, or workers who have worked in occupations or industries where such exposure was probable. If past exposures are identified, medical tests can be obtained for comparison. Some of the specific items of information which might be obtained include:

- o previous occupations
- o problems associated with breathing during normal work activities
- o past problems with respirator use.

c. Any other medical information -which might offer evidence of the worker's ability or inability to wear and use respirators, such as:

- o psychological problems or symptoms including claustrophobia
- o any known physical deformities or abnormalities, including those which may interfere with respirator use
- o past and current usage of medication
- o tolerance to increased heart rate, which can be produced by heat stress.

Periodic routine medical examinations should be made to determine whether respirator wearers have been exposed to harmful levels of respiratory hazards. Examination frequency should be tailored to particular situations and in accordance with specific substance standards. Tests to determine whether harmful amounts of hazardous substances have been taken into the body should be used. The results of the periodic examinations should be compared with those

of the pre-employment examinations and previous periodic examinations to determine whether the respirators used are adequate. If possible, periodic biochemical tests should be made to measure respirator wearers' exposures to respiratory hazards.

3. Training

a. Elements of an adequate training program

Selecting the respirator appropriate to a given hazard is important, but equally important is using the selected device properly. Proper use can be ensured by carefully training both supervisors and workers in selection, use, and maintenance of respirators. This implies that there should be a training program.

Like the overall respirator program, the content of the training program can vary widely, depending on circumstances. However, OSHA 29 CFR 1910.134 requires that training of both workers and supervisors include the following, no matter what the circumstances:

- o an opportunity to handle the respirator
- o proper fitting
- o test of facepiece-to-face seal, and
- o a long familiarizing period of wear in normal air.

Furthermore, OSHA requires that the wearer receive fitting instructions including demonstrations and practice in wearing, adjusting, and determining the fit of the respirator.

Training of supervisors and workers also should include:

- o discussion of the engineering and administrative controls in use and why respirators also are needed
- o explanation of the nature of the respiratory hazard and what happens if the respirator is not used properly
- o explanation of why a particular type of respirator has been selected, and
- o discussion of how to recognize and handle emergencies.

These training requirements apply to large and small organizations, with no differentiation to meet individual needs. The training the supervisor needs may differ from that for the individual worker, and both may differ markedly from that needed by members of

emergency response teams. This chapter summarizes methods for satisfying the OSHA requirements and suggests ways that respiratory protection training may be tailored to individual needs based on job function.

The exact format of the training program will vary widely, depending upon the organization. The large user may need a full-time professional instructor. At the other extreme is the very small user who may be forced into a do it yourself training program. Respirator training courses are available from NIOSH and others. It must be emphasized again, however, that the OSHA requirements apply to large and small users alike.

b. Supervisor Training

Supervisors, at least those who oversee the daily activities of one or more workers who wear respirators frequently, should have a reasonably comprehensive knowledge of respirators and respiratory protection practices. Their training should include, but not necessarily be limited to, knowledge of the following:

- worker training and instruction
- basic respiratory protection practices
- selection and use of respirators to protect each worker against every respiratory hazard to which the worker may be exposed
- the nature and extent of the respiratory hazards to which the workers may be exposed
- the structure and operation of the entire respirator program, and
- the legal requirements pertinent to use of respirators in their respective situations.

The supervisor should understand the responsibility to facilitate functioning of the program, including maintenance that the worker may be expected to do, issuance of respirators, control of their use, and evaluation of the program's effectiveness.

These suggestions obviously apply to the large organization. A smaller organization may have to combine the supervisor training with that of the workers. This benefits the workers as they receive more comprehensive training.

c. Worker Training

The extent and frequency of the workers' training depends primarily on the complexity of the respirator, nature and extent of the hazard. Training for respiratory protection against highly toxic chemicals may need to be more stringent than for less toxic chemicals. If the hazard is a nuisance particulate, for example, the danger from misuse of the respirator is not likely to be as serious as with a highly toxic particulate where a single misuse may have serious consequences. The same holds true, of course, for gases and vapors. If the respirator is to be used in an emergency, training in its use should be very thorough and complete. In any case, the worker should be given some instruction in respiratory protection practices.

As a bare minimum, both worker and supervisor should be trained in basic respiratory protection practices. Also, each should be trained in use of the respirators selected for a particular situation. Because proper respirator use depends especially upon the wearer's motivation, it is important that the need for the respirator be explained fully. ANSI Standard Z88.2 (1969), Section 7.4 lists the following points to be included in a minimal acceptable respirator program:

> "(1) Instruction in the nature of the hazard, whether acute, chronic, or both, and an honest appraisal of what may happen if the respirator is not used.
> (2) Explanation of why more positive control is not immediately feasible. This shall include recognition that every reasonable effort is being made to reduce or eliminate the need for respirators.
> (3) A discussion of why this is the proper type of respirator for the particular purpose.
> (4) A discussion of the respirator's capabilities and limitations.
> (5) Instruction and training in actual use of the respirator (especially a respirator for emergency use) and close and frequent supervision to assure that it continues to be properly used.
> (6) Classroom and field training to recognize and cope with emergency situations.
> (7) Other special training as needed for special use."

A major thrust in this training is toward explaining as much as possible about the need and reasons for wearing a respirator. This, of course, is to motivate the user to accept the fact that protection is necessary, and to instill the desire to wear and maintain a respirator properly. Just handing a respirator to a worker with orders to wear it because OSHA says so is one of the easiest ways to ensure its misuse.

At best, a respirator may cause discomfort and inconvenience, so there is a natural resistance toward wearing it conscientiously. Much of this natural resistance can be overcome by taking the time and effort to inform the wearer as thoroughly as possible why the respirator is necessary. This effort will create acceptance of respirators and contribute to correct use.

4. Fitting

All the care that goes into the design, manufacture and certification of a respirator to ensure its maximum efficiency will not protect the wearer if there is an improper match between facepiece and wearer or improper wearing practices. The problem is twofold. Assuming that more than one brand of a particular type of facepiece is available, the first problem is to determine which fits best. The second problem is to ensure that the user knows when the respirator fits properly. Both problems can be solved by use of some sort of fitting test, which is one of the OSHA requirements.

Determination of facepiece fit should involve both qualitative and quantitative tests. A qualitative test relies on the wearer's subjective response. A quantitative test uses some other means of detecting facepiece leakage. The general advantages and disadvantages of each are as follows:

Advantages of Qualitative Tests:

Usually, qualitative tests are fast, require no complicated, expensive equipment, and are easily performed in the field.

Disadvantages of Qualitative Tests:

Most qualitative tests rely on the wearer's subjective response, so they may not be entirely reliable.

Advantages of Quantitative Tests:

The greatest advantage of a quantitative test is that it does not rely on a subjective response. The quantitative test is recommended when facepiece leakage must be minimized for work in highly toxic atmospheres or those immediately dangerous to life or health.

Disadvantages of Quantitative Tests:

Quantitative fitting tests require expensive equipment that can be operated only by highly trained personnel. Each test respirator must be equipped with a sampling probe to allow removal of a continuous air sample from the facepiece, so the same facepiece cannot be worn in actual service.

In addition, recent NIOSH studies have indicated that the sampling bias for the current quantitative fit tests technique is unsatisfactory. NIOSH is performing research into probe location and probe design in an effort to decrease this sampling bias (see Chapter 6).

Selection of a qualitative and/or quantitative fitting test depends upon circumstances such as the severity and extent of the respiratory hazard and the size of the organization. Ideally, both qualitative and quantitative tests should be used. A quantitative test can be used in selecting the best respirator for each worker during training. To supplement the periodic quantitative fitting, a qualitative test can be used before each entry into a contaminated atmosphere. Again, this is only a suggested procedure that can be modified on the basis of an objective professional evaluation of the circumstances.

Quarter- and half-masks, and full-facepieces have inherently different fitting characteristics. Moreover, several brands of each are marketed, each having slightly different fitting characteristics. Although every manufacturer designs facepieces to fit as broad a section of the working population as possible, no respirator marketed will fit everyone. Therefore, more than one brand of a given type of respirator should be purchased to take advantage of the different fitting characteristics of each. In this way, the chances of properly fitting all workers are increased. Having more than one facepiece to choose from also gives the worker a better chance of finding a respirator that is reasonably comfortable while providing good protection. It is in this process of matching the respirator to the individual user that the fitting test, particularly the quantitative test, has the greatest impact.

Respirator fit testing procedures are included in Appendix B.

5. Respirator Inspection, Cleaning, Maintenance, and Storage

Scrupulous respirator maintenance should be made an integral part of the overall respirator program. Manufacturers' instructions for inspection, cleaning, and maintenance of respirators should be followed to ensure that the respirator continues to function properly. Wearing poorly maintained or malfunctioning respirators may be more dangerous than not wearing a respirator at all. The

worker wearing a defective device may falsely assume that protection is being provided. Emergency escape and rescue devices are particularly vulnerable to inadequate inspection and maintenance, although they generally are used infrequently, and then in the most hazardous and demanding circumstances. The possible consequences of wearing a defective emergency escape and rescue device are lethal.

The OSHA standards strongly emphasize the importance of an adequate maintenance program, but permit its tailoring to the type of plant, working conditions, and hazards involved. However, all programs are required to include at least:

- o inspection for defects (including a leak check)
- o cleaning and disinfecting
- o repair, and
- o storage.

A proper maintenance program ensures that the worker's respirator remains as effective as when it was new.

a. Inspection for Defects

Probably the most important part of a respirator maintenance program is frequent inspection of the devices. If conscientiously performed, inspections will identify damaged or malfunctioning respirators before they can be used. The OSHA requirements outline two primary types of inspection, that while the respirator is in use and that while it is being cleaned. In a small operation, where workers maintain their own respirators, the two types of inspection become essentially one and the same. In a large organization with a central respirator maintenance facility, the inspections differ. A sample respirator inspection record is included in Appendix A.

b. Frequency of Inspection

OSHA requires that "all respirators be inspected before and after each use," and that those not used routinely, i.e. emergency escape and rescue devices, "shall be inspected after each use and at least monthly..." NIOSH, however, recommends that all stored SCBA be inspected weekly. In one case, the respirator is to be inspected both before and after each use, in the other case, only after use. However, it is highly unlikely that anyone needing a respirator in a hurry, as during an emergency, is going to inspect it. In fact, it could be dangerous to take time to do so.

c. Inspection Procedures

Inspection procedures differ depending upon whether air-purifying or atmosphere-supplying devices are involved, and whether the inspection is to be conducted in the field during use, or during routine cleaning.

The OSHA standards require that respirator inspection include:

- o a check of the tightness of the connections,
- o a check of the facepiece, valves, connecting tube, canisters, and
- o a check of the regulator and warning devices on SCBA for proper functioning.

d. Field inspection of air-purifying respirators

Routinely used air-purifying respirators should be checked as follows before and after each use:

i. Examine the facepiece for:

- o excessive dirt
- o cracks, tears, holes, or distortion from improper storage
- o inflexibility (stretch and massage to restore flexibility)
- o cracked or badly scratched lenses in full-facepieces
- o incorrectly mounted full-facepiece lens or broken or missing mounting clips, and
- o cracked or broken air-purifying element holder(s), badly worn threads, or missing gasket(s) (if required).

ii. Examine the headstraps or head harness for:

- o breaks
- o loss of elasticity
- o broken or malfunctioning buckles and attachments, and
- o excessively worn serrations on the head harness which might permit slippage (full-facepieces only).

iii. After removing its cover, examine the exhalation valve for:

- o foreign material, such as detergent residue, dust particles, or human hair under the valve seat
- o cracks, tears, or distortion in the valve material
- o improper insertion of the valve body in the facepiece
- o cracks, breaks, or chips in the valve body, particularly in the sealing surface
- o missing or defective valve cover, and
- o improper installation of the valve in the valve body.

iv. Examine the air-purifying elements for:

- o incorrect cartridge, canister, or filter for the hazard
- o incorrect installation, loose connections, missing or worn gaskets, or cross-threading in holder
- o expired shelf-life date on cartridge or canister
- o cracks or dents in outside case of filter, cartridge, or canister, and
- o evidence of prior use of sorbent cartridge or canister, indicated by absence of sealing material, tape, foil, etc., over inlet.

v. If the device has a corrugated breathing tube, examine it for:

- o broken or missing end connectors, gaskets, or o-rings
- o missing or loose hose clamps, and
- o deterioration, determined by stretching the tube and looking for cracks.

vi. Examine the harness of a front- or back-mounted gas mask for:

- o damage to wear to the canister holder which may prevent its being held securely in place, and
- o broken harness straps or fastenings.

e. Field Inspection of Atmosphere-Supplying Respirators

For a routinely used atmosphere-supplying device, use the following procedures.

i. If the device has a tight-fitting facepiece, use the procedures outlined above for air-purifying respirators, except those pertaining to the air-purifying elements.

ii. If the device is a hood, helmet, blouse, or full suit, use the following procedures:

- o Examine the hood, blouse, or full suit for rips and tears, seam integrity, etc.
- o Examine the protective headgear, if required, for general condition, with emphasis on the suspension inside the headgear.
- o Examine the protective faceshield, if any, for cracks or breaks or impaired vision due to rebounding abrasive particles.
- o Make sure that the protective screen is intact and secured correctly over the faceshield of abrasive blasting hoods and blouses.

iii. Examine the air supply system for:

- o integrity and good condition of air supply lines and hoses, including attachments and end fittings, and
- o correct operation and condition of all regulators, valves, or other air-flow regulators.

On SCBA, determine that the high pressure cylinder of compressed air or oxygen is sufficiently charged for the intended use, preferably fully charged (mandatory on an emergency device). On closed circuit SCBA, make sure that a fresh canister of CO_2 sorbent is installed before use, or in accordance with manufacturers instructions. On open-circuit SCBA, recharge the cylinder if less than 80% of the useful service time remains. However, it is much preferred that an open-circuit SCBA be fully charged before use.

When an air-purifying or atmosphere-supplying device is used nonroutinely, all the above procedures should be followed after each use. OSHA requires that devices for emergency use be inspected once a month and that "a record shall be kept of inspection dates and findings for respirators maintained for emergency use." NIOSH recommends that such inspections be conducted at least weekly, because of the hazard that undetected loss of breathing gas from emergency SCBA will present to the wearer.

If defects are found during any field inspection, two remedies are possible. If the defect is minor, repair and/or adjustment may be made on the spot as in Figure 4-1. If it is major, the device should be removed from service until it can be repaired. **UNDER NO CIRCUMSTANCES SHOULD A DEVICE THAT IS KNOWN TO BE DEFECTIVE BE USED OR STORED FOR FUTURE USE.**

f. Inspection during cleaning

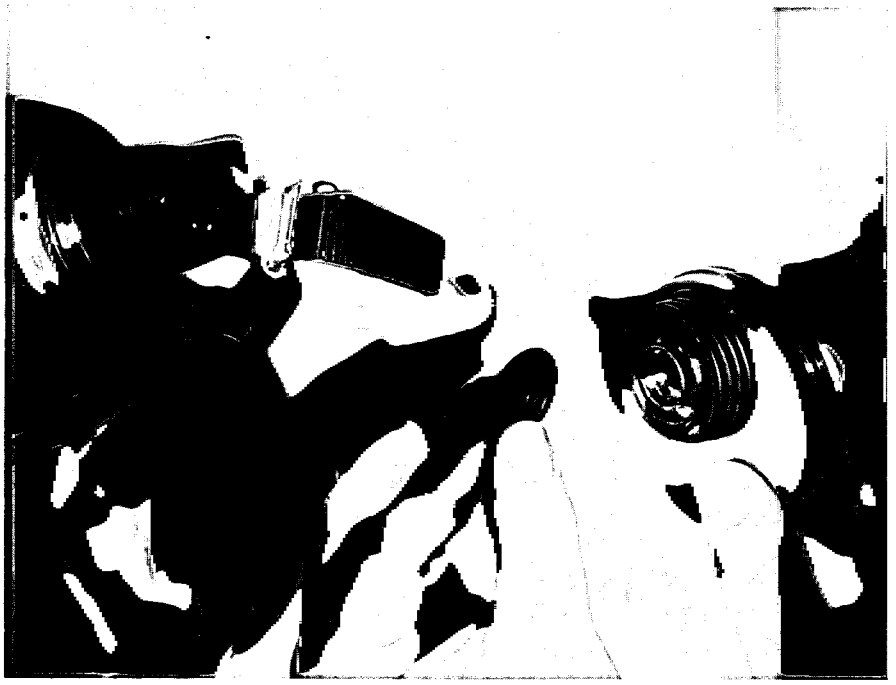
Because respirator cleaning usually involves some disassembly, it presents a good opportunity to examine each respirator thoroughly. Figure 4-2 shows inspection of the valve. The procedures outlined above for a field inspection should be used, but only after the respirator is cleaned and reassembled prior to returning it to service.

During this inspection, the respirator should be leak checked, as OSHA requires. The exact meaning of "leak check" has been much discussed, but no universal definition has emerged. Generally, a "leak check" is an examination of the freshly cleaned and reassembled respirator to determine that the complete assembly is gastight.

Several methods could be devised for meeting this requirement. One is worthy of mention as it is being used in several existing respirator programs. The respirator facepiece is placed over a machined metal head form with an inflated sealing surface. The straps are fastened down, and the inflatable seal built into the headform is pressurized to provide gastight seal between the headform and the facepiece. A continuous air sample is withdrawn from inside the facepiece, through the headform, and is passed through an aerosol detector like that described in Appendix B. An aerosol stream is directed through a small diameter tube around the potential leak points in the facepiece. Any leaks are shown by the penetration meter or recorder of the aerosol analyzing system, if it is set on the most sensitive scale.

Photograph Courtesy of Powermaster, Inc.

FIGURE 4-1. **Repair of a Helmet**



Photograph Courtesy of ISI

FIGURE 4-2. **Inspection of the Valve**

This procedure will detect leak sources and indicate the magnitude of the leak. However, it must be considered a qualitative, rather than quantitative, test. Some users have built a small test chamber around the headform. Instead of the aerosol being passed around the facepiece, the chamber contains an aerosol-laden atmosphere that permits actual quantitative determination of leakage in a manner similar to a quantitative fitting test.

This test requires use of the expensive aerosol system which is practical only for large organizations. The small respirator user is in the difficult position of not being able to afford this sophisticated equipment, although bound by the same requirements as the larger user. The best advice for the small user is to use ingenuity and devise a method that will satisfy the basic purpose of the leak check without adversely affecting the filter element, and assure that the reassembled respirator is leak free.

g. Cleaning and disinfecting

The OSHA requirements in 29 CFR 1910.134 are not specific about cleaning and disinfecting procedures, stating that "routinely used respirators shall be collected, cleaned, and disinfected as frequently as necessary to insure that proper protection is provided." and that emergency use respirators "shall be cleaned and disinfected after each use."

In a large respirator program in which respirators are used routinely, they should be exchanged daily for cleaning and inspection. In a small program involving only occasional respirator use, this period could be weekly or monthly. Each worker who maintains a respirator should be thoroughly briefed on cleaning and disinfecting it. Although a worker may not be required to maintain the respirator, briefings on the cleaning procedure will encourage acceptance of the respirator by providing assurance that the worker will receives a clean, disinfected, properly maintained device. This is particularly important where respirators are not individually assigned. Where respirators are individually assigned, they should be durably identified to ensure that the worker always receives the same device. Identification markers should neither penetrate the facepiece nor block filters, cartridge ports, or exhalation valves.

In a small respirator program, or where workers clean their own respirators, washing with detergent in warm water using a brush, thorough rinsing in clean water, and air drying in a clean place is generally accepted as sound procedure. Precautions should be taken to prevent damage from rough handling during this procedure. Precautions should also be taken to prevent exposure of the person cleaning the respirator to the contaminant in the respirator and to cleaning agents.

In a large program, there may be a centralized cleaning and maintenance facility with specialized equipment and personnel trained in respirator maintenance. Figure 4-3 shows a typical, hypothetical, large respirator maintenance facility. Good features are the separate areas for disassembly of used respirators and assembly of freshly cleaned and maintained devices which ensure that the clean respirators do not become contaminated. Also, there is ample storage space for the clean respirators, and spare parts (filters, exhalation valves, headbands, etc.) are readily available. There is also a test bench for checking the operation of SCBA regulators as well as a leak test system. A facility of this type would take up about 500 ft^2.

In the following discussion of cleaning and maintenance procedures, reference to Figure 4-3 should help in understanding the overall process.

h. Disassembly

The used respirators are collected and deposited in a central location, (A) of Figure 4-3. They are taken to an area (C) where the filters, cartridges, or canisters are removed and discarded. Canisters and cartridges should be intentionally damaged to prevent reuse. If the facepieces are equipped with reusable dust filters, they may be cleaned with compressed air in a hood (B) that prevents dust from getting into the room and affecting the maintenance personnel. The air tanks from SCBA are removed and connected to the charging station (J), and the rest of the unit is sent to the SCBA test bench (I) where the regulator is tested. SCBA facepieces are cleaned like air-purifying respirator facepieces.

CAUTION: Improper disposal of an oxygen-generating canister from a closed circuit SCBA is dangerous. Mine Safety Appliances Company suggests the following procedure for disposing of their "Chemox" oxygen generating canister:

"Punch a hole in the front, back, and bottom of the canister, and gently place it in a bucket of clean water deep enough to cover it by at least 3 inches. When bubbling stops, any residual oxygen has been dissipated and the canister is expended. Pour the water, which is caustic, down a drain or dispose of it in any other suitable manner." This procedure is safe. Not following this procedure recommended by the manufacturer, particularly, can cause a violent explosion.

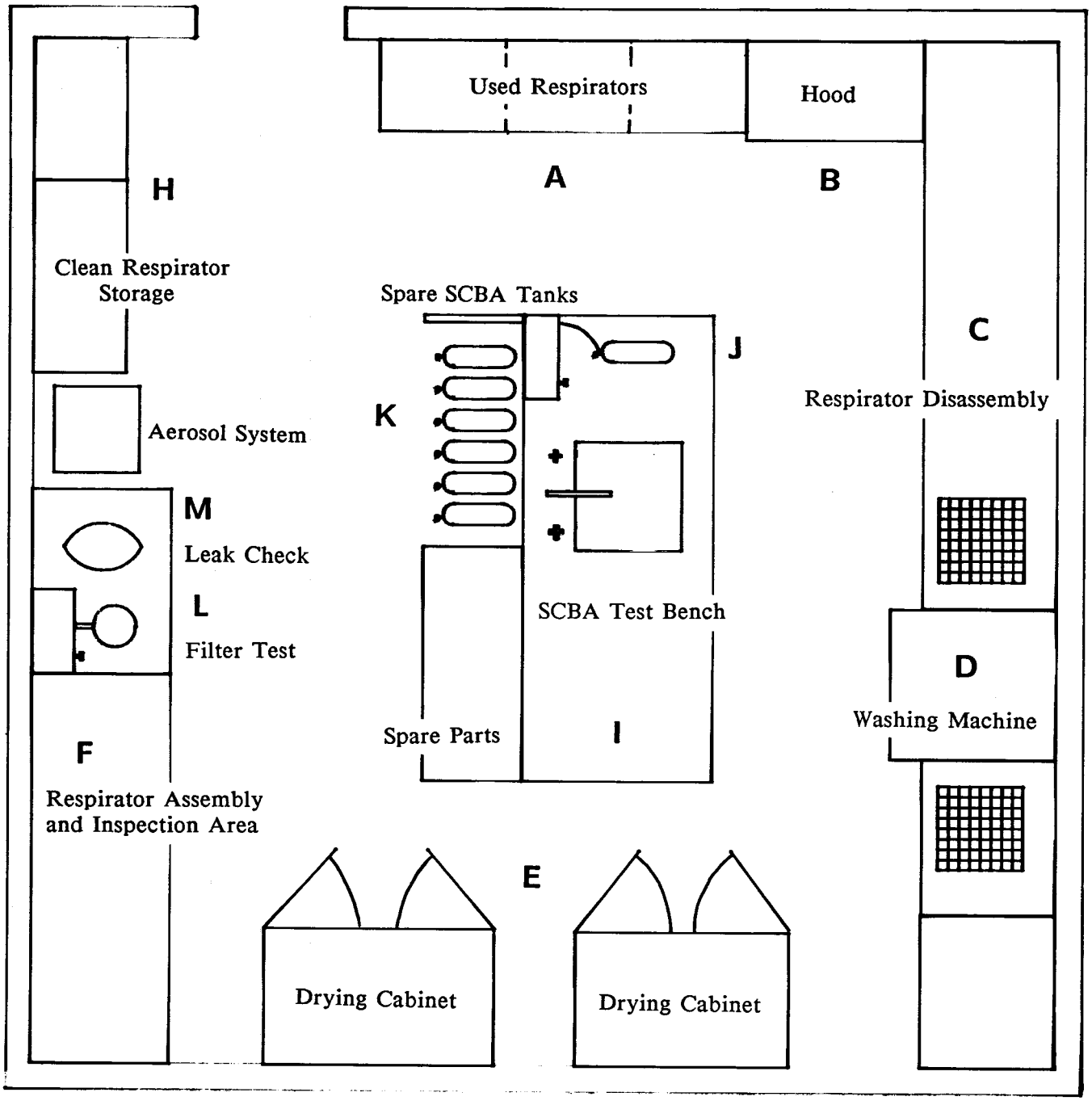


FIGURE 4-3. **Typical Large Respirator Maintenance Facility**

i. Cleaning and sanitizing

The Manufacturer's instructions should be followed for cleaning and sanitizing respirators, especially in regard to maximum temperatures.

The actual cleaning may be done in a variety of ways. In Figure 4-3, it is assumed that a commercial dishwasher (D) is used. A standard domestic type clothes washer also may be used if a rack is installed around the agitator to hold the facepieces in fixed positions. If the facepieces are placed loose in a washer, the agitator may damage them. A standard domestic dishwasher also may be used, but it is not preferred because it will not immerse the facepieces.

Any good detergent may be used, but cleaner and sanitizer solutions that clean effectively and contain a bactericide are available. The bactericide is generally a quaternary ammonium compound, which has some disadvantages, because its concentration must be adjusted to the composition of the local water to provide a constant degree of disinfection. Also, there is a possibility of dermatitis if the quaternary ammonium salts are not completely rinsed from the respirator.

An alternative is to wash the respirators in detergent, followed by a disinfecting rinse. Disinfection is not absolutely necessary if the respirator is reused by the same worker. However, where individual issue is not practiced, disinfection is strongly recommended. Reliable, effective disinfectants may be made from readily available household solutions, including:

- Hypochlorite solution (50 ppm of chlorine) made by adding approximately 2 ml of hypochlorite (laundry) bleach to 1 liter of water. A 2-minute immersion disinfects the respirators.

- Aqueous solution of iodine (50 ppm of iodine) made by adding approximately 0.8 ml tincture of iodine per liter of water. The iodine is approximately 7% ammonium and potassium iodide, 45% alcohol, and 48% water. Again, a 2-minute immersion is sufficient.

If the respirators are washed by hand, a separate disinfecting rinse may be provided. If a washing machine is used, the disinfectant should be added to the rinse cycle, and the amount of water in the machine at that time will have to be measured to determine the correct amount of disinfectant.

To avoid damaging the rubber and plastic in the respirator facepieces, the cleaner and disinfectant temperatures should not exceed 140°F, but they should not be less than 120°F to ensure adequate cleaning.

j. Rinsing

The cleaned and disinfected respirators should be rinsed thoroughly in clean water (140°F maximum) to remove all traces of detergent, cleaner and sanitizer, and disinfectant. This is very important to prevent dermatitis.

k. Drying

The respirators may be allowed to dry by themselves on a clean surface. They also may be hung from a horizontal wire, like drying clothes, but care must be taken not to damage the facepieces. A better method is to use a commercially available, electrically heated steel storage cabinet, Figure 4-3(E), with a built-in circulating fan, and replacing the solid shelves with steel mesh, if necessary.

l. Reassembly and Inspection

The clean dry respirator facepieces should be reassembled and inspected in an area, Figure 4-3(F), separate from the disassembly area to avoid contamination. The inspection procedures have been discussed, but there may be more things to look for because of the cleaning. The most common is detergent or soap residue left by inadequate rinsing. This appears most often under the seat of the exhalation valve, and can cause valve leakage or sticking.

At this time, the respirators should be thoroughly inspected and all defects corrected. New or retested filters, or new cartridges and canisters should be installed, and the completely reassembled respirator should be tested for leaks, Figure 4-3(M).

The facepiece of a SCBA can now be combined with the tested regulator from (I) and a full charged cylinder from the storage rack (K), and an operational check can be performed.

m. Maintenance and Repair

The OSHA standards state that "replacement or repairs shall be done by experienced persons with parts designed for the respirator." Besides being contrary to OSHA requirements, substitution of parts from a different brand or type of respirator invalidates MSHA/NIOSH certification of the device. Therefore, the user would be wearing an uncertified device, in violation of the OSHA requirement.

Maintenance personnel should be thoroughly trained. They should be aware of their limitations and never try to replace components or make repairs and adjustments beyond manufacturer's recommendations, unless they have been specially trained by the manufacturer.

These restrictions apply primarily to maintenance of the more complicated devices, especially closed and open circuit SCBA, and even more specifically their reducing or admission valves (regulators) which "... shall be returned to the manufacturer or to a trained technician for adjustment or repair." Figure 4-4 shows a complicated inspection being performed at the factory prior to delivery of the respirator to a user. There should be no problems in repairing and maintaining most other respirators, particularly the most commonly used air-purifying types.

An important aspect of any maintenance program is having enough spare parts on hand. Only continual surveillance of replacement rate will determine what parts in what quantities should be kept in stock. It is desirable to have some sort of recordkeeping system to indicate spare parts usage and the inventory on hand.

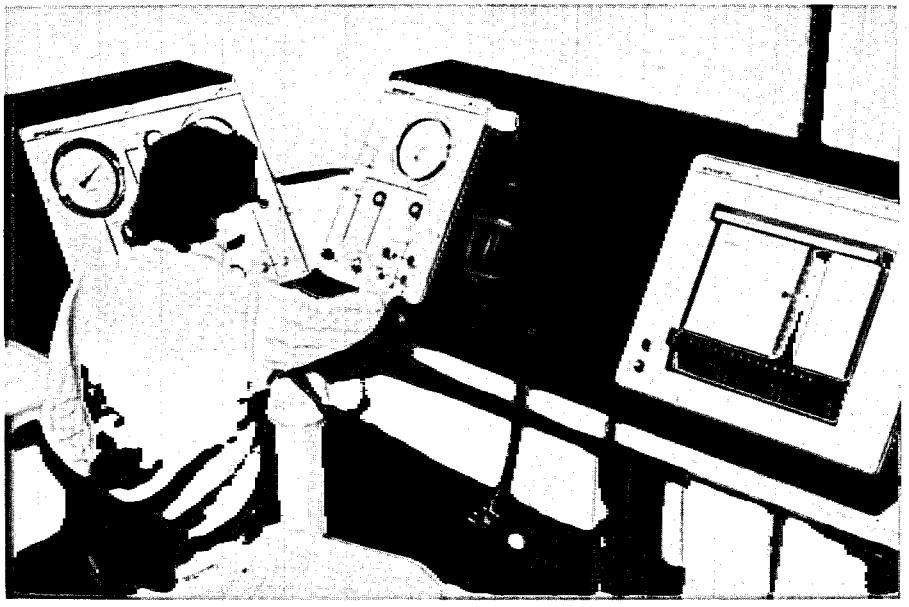
n. Storage

All the care that has gone into cleaning and maintenance of a respirator can be negated by improper storage. OSHA requires that respirators be stored to protect against:

- o dust
- o sunlight
- o heat
- o extreme cold
- o excessive moisture, and
- o damaging chemicals.

What is omitted, though implied in a later statement, is protection against mechanical damage. Leaving a respirator unprotected, as on a workbench, or in a tool cabinet or tool box among heavy wrenches, etc., may damage it.

It is strongly recommended that freshly cleaned respirators be placed in heat-sealed or reusable plastic bags until reissue. They should be stored in a clean, dry location away from direct sunlight. They should be stored in a single layer with the facepiece and exhalation valve in a more or less normal position to prevent the rubber or plastic from taking a permanent distorted "set."



Photograph Courtesy of Interspiro

FIGURE 4-4. **Inspection at the Factory**

Air-purifying respirators kept ready for nonroutine or emergency use should be stored in a cabinet in individual compartments. A steel wall-mounted cabinet, with six compartments is shown in Figure 4-5. Note that each compartment is clearly labeled with the user's name and that the respirators are in plastic bags. Note also that the respirator in the lower right compartment is stored improperly. Another acceptable method of storage in a standard steel storage cabinet is shown in Figure 4-5. Note that the respirators are stored in a single layer.

The storage cabinet should be readily accessible, and all workers should be made aware of its location, as is done for fire extinguishers. Avoidance of serious injury from inhalation of a toxic substance may depend entirely on how quickly workers can get to the emergency respirators. This type of storage should be encouraged for routinely used respirators if it does not interfere with the normal work routine. A little inconvenience here is justified to prevent use of a respirator damaged by improper storage.

A chest or wall mounted case, Figure 4-6, may be purchased from the respirator manufacturer for storing a SCBA for use in emergencies. Again, the locations of SCBA should be well known and clearly marked. Unlike fire extinguishers, however, they should be located in an area that will predictably remain uncontaminated. Even highly trained workers take 30 seconds to 1 minute to put on these devices. In a highly contaminated atmosphere such as might be created by massive release of a toxic material, this may be too long a time to stay safely in the area. Therefore, the first reaction should be to escape to an uncontaminated area, then put on the SCBA which should be located there and re-enter the hazardous area for whatever task must be done. There are undoubtedly exceptions to this general rule, and only thorough evaluation of the potential hazard, taking into account the physical configuration of the work area, will permit a final decision about the correct storage location for a SCBA.

Routinely used respirators may be stored in a variety of ways if they are protected against the substances and conditions listed at the beginning of this section. This means that when a respirator is not in use, it should be stored in a plastic bag inside a rigid container. The OSHA requirements suggest that respirators be stored in the cartons in which they came, but these usually provide only minimal protection from mechanical damage.

The adequately trained worker should develop a respect for respirators which will automatically provide incentive to protect it from damage. Besides providing better assurance of adequate protection, this training will lower maintenance costs because of decreased damage.

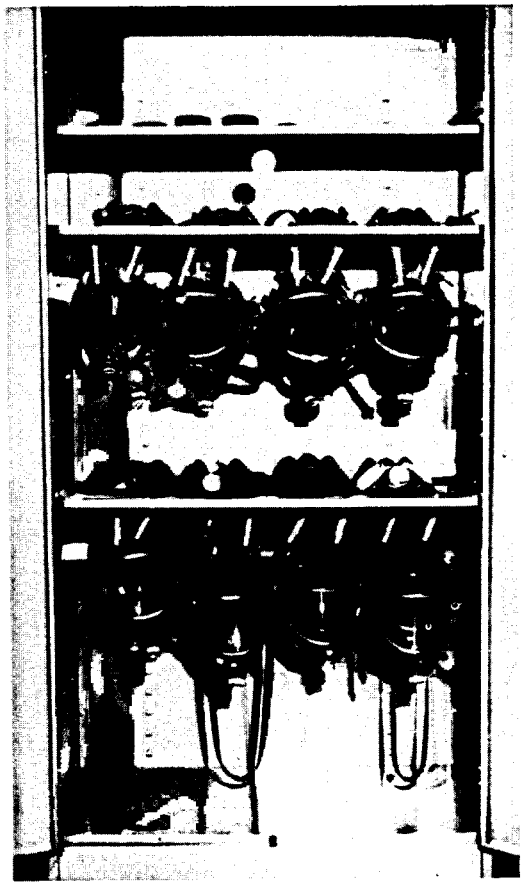


FIGURE 4-5. **Storage Cabinet for Facepieces**

FIGURE 4-6. **Wall-mounted Storage Cabinet for SCBA**

6. Surveillance of Work Area Conditions and Worker Exposure

OSHA 29 CFR 1910.134 states, "appropriate surveillance of work area conditions and degree of employee exposure or stress shall be maintained." This necessitates periodic monitoring of the air contaminant concentration to which the respirator wearer is exposed. Many things such as changes in the operation or process, air movement, temperature, or humidity, affect the concentration of a substance in the work area atmosphere. Therefore, the air contaminant should be sampled. Preferably, sampling should be in the respirator wearer's breathing zone. Both the time-weighted average and peak concentrations of the contaminant should be determined. Comparing the measured time-weighted average concentration with the maximum use concentration determined for the type of respirator being used is a means of checking that the proper respirator has been selected.

7. Respirator Program Evaluation

OSHA 29 CFR 1910.134 states, "There shall be regular inspection and evaluation to determine the continued effectiveness of the program." Periodic monitoring is necessary to ensure that workers are adequately protected. The program should be evaluated at least annually, and the written operating procedures should be modified to reflect the evaluation results if necessary. A sample respirator program and checklist are included in Appendix A.

Frequent inspection of respirator use will determine whether the correct respirators are being used and worn properly. Examination of respirators in use and in storage will indicate how well they are maintained. Wearers should be consulted periodically about their acceptance of respirators, including the discomfort, resistance to breathing, fatigue, interference with vision and communication, restriction of movement, and interference with job performance, and their confidence in the respirator's effectiveness.

The results of periodic inspections of respirator use, consultations with wearers, measurements of hazard levels in work areas, and medical surveillance of wearers should be reviewed, studied, and analyzed to determine the effectiveness of the respirator program. Evidence of excessive exposure to hazards should be followed up to determine why inadequate protection was provided, and action should be taken to remedy the problem. The results of the program evaluation should be presented in a written report that lists plans to correct faults and the target dates for their implementation.