

## CHAPTER 9

### RESPIRATORY PROTECTION

#### 1. GENERAL.

a. NAVOSH health standards place primary emphasis on engineering, administrative and work practice controls. Respirators are worn in those instances where these controls are not feasible and/or are ineffective in reducing personnel exposures below permissible exposure limits. Respiratory protection can also be provided as an interim measure while controls are being sought or installed.

b. For the purposes of this chapter, the terms "exposure" and "overexposure" refer to concentrations of air contaminants in the breathing zone of the employee and outside of the respirator. That is, the exposure of the employee regardless of the use of a respirator.

c. Surgical masks worn by operating room personnel, dentists and dental technicians are not considered respirators. They are for medical/dental use only.

d. Details of the Navy respiratory protection program policy are in references 9-1 through 9-3. Reference 9-4 provides guidance to Navy Respiratory Protection Program Managers (RPPMs) on the basic program elements. It also includes fill-in-the-blank standard operating procedures for all elements of the respirator program.

2. WRITTEN OPERATING PROCEDURES. Each activity where respirators are used must have a written respiratory protection program that addresses all of the items specified in References 9-1 through 9-3. A comprehensive written program will include specific provisions and procedures for the selection, use, fit testing, storage, maintenance and care of respirators, and the training and physical qualifications of those personnel required to wear respirators. Worksite standard operating procedures (SOPs) are required in all areas where respirators are used. Each worksite SOP will be worksite specific, telling the wearer which respirator to wear and under what conditions it should be worn. SOPs will also include emergency and rescue guidance where appropriate.

3. **RESPIRATOR SELECTION GUIDELINES.** Use only respirators approved by the National Institute for Occupational Safety and Health (NIOSH) or NIOSH/Mine Safety and Health Administration (MSHA). In selecting the correct respirator for a given circumstance, consider the following:

a. Nature of the Hazard.

(1) Oxygen deficiency. NIOSH approval for air-purifying respirators is valid only for atmospheres containing greater than 19.5% oxygen at altitudes of 8,000 feet and below. If it is determined that an oxygen deficient atmosphere may exist, then selection must be made from either a full facepiece pressure-demand self-contained breathing apparatus (SCBA) or a full facepiece pressure-demand air supplied respirator with auxiliary SCBA escape cylinders. According to reference 9-5, at altitudes 10,000 feet or higher a closed circuit SCBA must be used. Closed circuit SCBAs supply enriched oxygen.

(2) Physical properties of the hazard, including physical state; particle size; molecular weight; and vapor pressure.

(3) Chemical properties of the hazard, including solubility in water and other liquids, reactivity with other chemicals, reactivity with sorbent materials in respirator cartridges/canisters, and hazardous decomposition products. For particulates, it is important to know whether the aerosol does or does not contain oils. This is because the particulate filter approval classification under 42 CFR 84 classifies filters based on whether the aerosols being filtered contain oil. Oil aerosols tend to degrade filter efficiency.

NOTE: The online NIOSH Pocket Guide to Chemical Hazards is available at <http://www.cdc.gov/niosh/npg/pgdstart.html>. This document contains immediately dangerous to life or health (IDLH) atmosphere concentrations, along with exposure limits, chemical and physical properties, health hazards, analytical sampling methods, and much more. The Pocket Guide is linked to the NIOSH Documentation for IDLH Concentrations at <http://www.cdc.gov/niosh/idlh/intridl4.html>. If the contaminant concentration cannot be determined then consider the atmosphere to be IDLH.

(4) Physiological effects on the body, such as eye irritation.

(5) Actual concentration of a toxic compound to determine

the degree of protection necessary.

(6) Navy Occupational Exposure Limits (OELs). The Navy OELs (8 hour time-weighted average or ceiling value) will be used to select the proper respirator.

(7) Warning properties, such as odor, taste, or irritant effects. If the odor or irritation threshold of a substance occurs at concentrations greater than the Navy OEL or the substance causes olfactory fatigue, it should be considered to have poor warning properties. Chemical cartridge air-purifying respirators are appropriate for protection against isocyanates and other substances without good warning properties up to their maximum use concentration if a cartridge change out schedule is developed and implemented. Alternatively, atmosphere supplying respirators or air-purifying respirators equipped with approved end-of-service-life indicators can be used.

b. Nature of the operation. Consider operation or process characteristics; work area characteristics; materials used or produced during the process; workers' duties and actions; and abnormal situation characteristics (e.g., emergencies which may necessitate a different respirator selection).

c. Location of the hazardous area. This is important in the selection process so that backup systems may be planned if necessary. Breathing air locations must be known prior to entry into a hazardous area so escape or emergency operations may be planned.

d. Time respiratory protection is required. The length of time a respirator will have to be worn is a factor which must be considered. This is most evident when using an SCBA, where, by definition, the air supply is finite. However, time is also a factor during routine use of air-purifying respirators when worker acceptance and comfort are essential to ensure proper use of the device.

e. Employee's health. Effective usage of a respirator is dependent on an individual's ability to wear a respirator. Most respiratory protection devices increase physical stress on the body, especially the heart and lungs. Individuals will not wear a respirator on the job or be fit tested unless they have been medically qualified.

f. Respirator characteristics, capabilities, and limitations. Reference 9-5 provides information on respirator characteristics.

g. Protection Factors. The protection afforded by respirators is dependent upon the seal of the facepiece to the face, leakage around valves, and leakage through or around cartridges or canisters. By considering the effect of these variables, the degree of protection may be estimated and combined with a safety factor to assign a protection factor. Protection factors are assigned by either OSHA, NIOSH, or ANSI. ANSI in reference 9-5 and NIOSH in reference 9-6 list conflicting information on assigned protection factors. Some OSHA substance specific standards also may be in conflict with ANSI and/or NIOSH. Navy personnel will use the protection factors listed in Table 9-1. Protection factors are only applicable if all elements of an effective respiratory protection program are in place and being enforced.

(1) Not to be confused with a protection factor, a fit factor is a ratio of the air contaminant concentration outside the respirator to air contaminant concentration inside the respirator facepiece on a particular individual. The higher the fit factor, the better the respirator seals to the individuals's face.

(2) Assigned protection factors (APFs) correspond to the level of protection provided by a class of respirators. APFs are used in conjunction with Navy OELs to determine the maximum use concentration (MUC) in which respirators can be used. The MUC is calculated by multiplying the APF by the PEL. However, if the IDLH concentration is lower than the MUC, the IDLH concentration is used as the MUC.

(3) Protection factors are voided when employees remove their respiratory protection while in the contaminated atmosphere or when respirators are worn improperly such as with facial hair between the face and facepiece seal.

NOTE: Field studies of respirator performance have not correlated well with the laboratory test data. Hence, the reported values should only be taken as estimates. For example, studies have found that some powered air-purifying respirators (PAPRs) have not achieved the protection factors suggested by laboratory data.

#### 4. TRAINING.

a. Requirements. Respirator users must be trained in the proper selection, use, maintenance, and limitations of

respirators. Instruction must include demonstrations on how the respirator should be worn, how to adjust it, and how to determine if it fits properly. Personnel who issue respirators and supervisors of personnel required to wear respirators must also be trained in respiratory protection. The purpose of the training for issuers and supervisors is to further assure the proper selection, use, and maintenance of respirators.

b. Activities shall ensure that training is conducted in a manner that is understandable to the employee and that each employee can demonstrate knowledge of at least the following aspects of respiratory protection:

(1) How to wear the respirator as it was originally intended, which includes the following:

(a) The respirator and all functional parts must be in place and worn in the appropriate positions;

(b) All straps must be secure and properly adjusted;

(c) There must be no modification to the respirator or straps; and

(d) Facelet or knitted coverings that interfere with the facepiece seal will void the approval of the respirator, and so will not be worn. Clothing, such as caps or hoods, will not be worn between the respirator and the skin of the face.

(2) The respirator's capabilities and limitations including:

(a) Why the respirator is necessary, including identification of contaminants or contaminant types against which the respirator is designed to afford protection;

(b) How improper fit, usage, or maintenance can compromise the protection of the respirator;

(c) Limitations on the service life of the cartridge, canister, or filter which is used;

(d) Warning properties of the contaminant(s); and

(e) How to use the respirator in emergency situations, including situations in which the respirator malfunctions.

(3) How to properly inspect, maintain, and store the respirator.

(4) How to perform positive/negative user seal checks. See paragraph 5.d.

(5) How to recognize medical signs and symptoms that may limit or prevent the effective use of respirators.

(6) The general requirements of references 9-2 or 9-3, as applicable.

c. Frequency of training. Respirator wearers, issuers, and their supervisors are to receive initial training and annual refresher training. Retraining is also required when it is apparent that the employee has not retained the information presented in respirator training or when other situations arise in which retraining appears necessary for the employee to safely use the respirator.

## 5. FIT TESTING.

a. Requirements. All tight fitting negative and positive pressure respirators will be fitted properly and be tested for the facepiece to face seal. Positive pressure respirators and PAPRs must be fit tested (qualitatively or quantitatively) in the negative pressure mode. Respirators shall not be worn when conditions prevent a good facepiece to face seal. Examples include:

(1) Sideburns, beards, and/or skull caps that project under the facepiece.

(a) Neither negative pressure nor positive pressure respirators with a tight-fitting facepiece will be fit tested on or worn by persons with beards.

(b) Airline hoods/helmets and PAPR hoods/helmets (i.e., no facepiece to face seal) may be worn by personnel with beards, when such respirators will provide adequate protection.

(2) Temple bars on glasses when wearing full-face respirators.

(3) The absence of one or both dentures.

(4) Facial deformities.

b. Fit test frequency. Personnel required to wear tight fitting respirators shall be qualitatively or quantitatively fit tested annually.

c. Quantitative fit test. Quantitative fit testing determines the amount of leakage occurring between the wearer's face and the sealing surface of the respirator. There are two basic fit testing technologies:

(1) Controlled negative pressure method (e.g., DYNATECH Nevada Fit Tester 3000) - measures the rate of pressure decay as a function of the rate of controlled leakage into an otherwise sealed respirator.

(2) Aerosol challenge method - measures and compares the concentration of a challenge test agent inside and outside of the respirator during a series of test exercises. There are two aerosol fit testing methods: forward light scattering photometry and condensation nuclei counting (e.g., TSI Portacount®). Probed respirators with High-Efficiency Particulate Air (HEPA), N100, R100, or P100 filters are required for aerosol challenge fit tests. As an alternative to probed respirators, fit test adapters made by the same manufacturer can be used to sample inside an individual's own respirator.

(3) Use the quantitative fit test protocols in Appendix A of reference 9-1, which includes each of the quantitative fit test methods referred to in the previous two subparagraphs.

d. Qualitative fit test. Qualitative fit tests involve a test subject's response (either voluntary or involuntary) to a challenge chemical. These tests are fast, easily performed, and use inexpensive equipment. Because they are based on the respirator wearer's subjective response, accuracy may vary. The most popular methods are an irritant smoke test, an odorous vapor test, and two taste tests. Procedures for these test methods are detailed in Appendix A of reference 9-1.

(1) Irritant smoke test.

(a) The irritant smoke test is performed by directing an irritant smoke, usually hydrogen chloride generated from stannic oxychloride, from a ventilation smoke tube towards the respirator while the test subject performs a series of exercises. If the wearer cannot detect the irritant smoke, a satisfactory fit is assumed.

(b) The respirator wearer will react involuntarily, usually by coughing or sneezing, to leakage around or through the respirator. Since this is a qualitative test, the tester is interested in any response to the smoke; the degree of response is not important.

NOTE: The test substances are irritants to the eyes, skin and mucous membranes. Therefore, the respirator wearer must keep his/her eyes closed during testing. It is imperative that this fit test be performed without an enclosure, in a well ventilated area and in strict accordance with the published test protocol in Appendix A of reference 9-1.

(c) The respirator must be equipped with HEPA, N100, R100, or P100 filters.

(2) Odorous vapor test.

(a) The odorous vapor test relies on the respirator wearer's ability to detect isoamyl acetate (i.e., banana oil) inside the respirator. The test is performed by suspending an isoamyl acetate-wetted paper towel inside a test chamber (e.g., inverted 55 gallon drum liner over a suspended frame). The test subject performs a series of exercises, and a satisfactory fit is assumed if the test subject cannot smell the isoamyl acetate.

(b) The respirator must be equipped with organic vapor cartridges or canister.

(c) Limitations of this method include wide variation in individual odor thresholds, olfactory fatigue, and dependence on the wearer's honest response, since there is no involuntary response. This method also requires a screening test to ensure that the test subject can smell banana oil.

(3) Taste test.

(a) The taste test relies on the respirator wearer's ability to detect the sweet taste of sodium saccharin or the bitter taste of Bitrex™ (i.e., denatonium benzoate) inside the respirator. The test is performed by placing an enclosure (i.e., hood) over the respirator wearer's head and shoulders and spraying the test agent into the enclosure with a nebulizer while the test subject performs a series of exercises while breathing through their mouth. If the wearer is unable to taste the sodium saccharin or the Bitrex™, then a satisfactory fit is

assumed.

(b) Respirators must be equipped with a particulate filter cartridge.

(c) Limitations of this method include variation in individual taste thresholds and dependence on the wearer's honest indication of taste since there is no involuntary response. A screening test is needed to ensure that the test subject can taste sodium saccharin or Bitrex™. The wearer must not eat, drink (except plain water), or chew gum for 15 minutes before the test to avoid masking the taste of saccharin or Bitrex™.

e. User seal checks. The user shall check the seal of the respirator by using positive and negative pressure user seal checks every time a respirator is donned. Pressure checks are NOT substitutes for quantitative or qualitative fit tests. It is essential to adequately train respirator users to perform these checks. User seal checks should be done according to the manufacturer's recommendations, or by using the following procedures:

(1) Negative pressure user seal check.

(a) The inlet opening of the respirator's canister(s), cartridge(s), or filter(s) is closed off by covering with the palm of the hand(s) or by squeezing a breathing tube or blocking its inlet so that it will not allow the passage of air.

(b) The wearer is instructed to inhale gently and hold his breath for at least 10 seconds.

(c) If the facepiece collapses slightly and no inward leakage of air is detected, the respirator has been properly donned and the facepiece is not leaking.

(2) Positive pressure user seal check.

(a) The exhalation valve or breathing tube, or both, is closed off and the wearer is instructed to exhale gently.

(b) If a slight positive pressure can be built up inside the facepiece (e.g., facepiece bulges slightly outward) without detecting any outward leakage of air between the sealing surface of the facepiece and the wearer's face, the respirator

has been properly donned.

(c) For some respirators, this test method requires that the respirator wearer first remove the exhalation valve cover from the respirator and then replace it after completion of the test. These tasks are often difficult to carry out without disturbing the fit of the respirator. OSHA states in the preamble to reference 9-1 that there are respirators that user seal checks cannot be performed on and that these respirators cannot be used to control exposure.

## 6. CLEANING.

a. Requirements. Clean and disinfect respirators regularly using the following schedules:

(1) Respirators issued for the exclusive use of one worker will be cleaned and disinfected as often as necessary to be maintained in a sanitary condition.

(2) Respirators used by more than one worker will be thoroughly cleaned and disinfected before use by another worker.

(3) Respirators for emergency use will be cleaned and sanitized after each use.

(4) Respirators used in fit testing and training will be cleaned and disinfected after each use.

b. Methods. Clean and disinfect respirators by the methods in Appendix B-2 of reference 9-1 or by one of the following methods.

### (1) Manual cleaning.

(a) Remove canisters, filters, valves, straps, and speaking diaphragm from the facepiece.

(b) Wash facepiece and accessories in warm soapy water. Gently scrub with a soft brush. Cleaner temperatures should not exceed 110° F (43° C ).

(c) Rinse parts thoroughly in clean water no hotter than 110° F (43° C ) to remove all traces of detergent. This is very important to prevent dermatitis.

(d) Air dry in a clean place or wipe dry with a

lintless cloth.

(e) Reassemble.

NOTE: When using a commercially available cleaner, follow the manufacturer's instructions.

(2) Machine cleaning. Machines may be used to expedite the cleaning, sanitizing, rinsing, and drying of large numbers of respirators.

(a) Extreme care must be taken to ensure against excessive tumbling and agitation, or exposure to temperatures above those recommended by the manufacturer, as these conditions are likely to result in damage to the respirators. Cleaner temperatures should not exceed 110° F (43° C ).

(b) Ultrasonic cleaners, clothes-washing machines, dishwashers, and clothes dryers have been specially adapted and successfully used for cleaning and drying respirators.

(3) Disinfection. Disinfection procedures include:

(a) Immerse the respirator body for two minutes in a hypochlorite (bleach) solution (50 parts per million (ppm) chlorine). Rinse thoroughly in clean water no hotter than 110° F (43° C ) to remove all traces of disinfectant and dry.

(b) Immerse the respirator body for two minutes in a quaternary ammonium solution (200 ppm of quaternary ammonium compounds in water with less than 500 ppm total hardness). Depending on water hardness, different concentrations of quaternary ammonium salts are required to achieve sanitizing strength. Rinse thoroughly in clean water no hotter than 110° F (43° C ) to remove all traces of disinfectant and dry.

(c) Immersion times shall be limited to minimize damage to the respirator. These solutions can age rubber and rust metal parts. Caution must be taken to thoroughly rinse the respirator after cleaning and disinfection to prevent dermatitis.

NOTE: When using a commercially prepared solution for disinfection/decontamination, follow the manufacturer's directions.

## 7. STORAGE.

a. Requirements. Respirators must be stored in a convenient, clean, and sanitary location.

(1) Ensure that respirators are stored in such a manner as to protect against dust, harmful chemicals, sunlight, excessive heat or cold, and excessive moisture. Storage measures which can be used to protect respirators against dusts, chemicals, and moisture include:

(a) Plastic bags capable of being sealed;

(b) Plastic containers with tight-fitting lids, such as freezer containers; and

(c) Cans with tight fitting lids.

(2) Pack or store the respirator so that the facepiece and exhalation valves will rest in a normal position. Do not hang the respirator by its straps. These precautions will help avoid distortion of the respirator parts or stretching of its straps.

b. Emergency use respirators. Respirators placed at stations and work areas for emergency use should be accessible at all times. They should be stored in clearly marked compartments that are dedicated to emergency equipment storage.

## 8. INSPECTION AND MAINTENANCE.

a. Disposable air-purifying respirators.

(1) Check for holes in the filter or damage to sorbent, such as loose charcoal granules.

(2) Check straps for elasticity and deterioration.

(3) Check metal nose clip for rust or deterioration.

b. Reusable air-purifying respirators.

(1) Check rubber facepiece for dirt, pliability of rubber, deterioration, cracks, tears, or holes.

(2) Check straps for breaks, tears, loss of elasticity, broken attachment snaps and proper tightness.

(3) Check valves (exhalation and inhalation) for holes, warpage, cracks, and dirt.

(4) Check filters, cartridges and canisters for dents, corrosion and expiration dates. Check protection afforded by canister and its limitations. Cartridge and canisters are to be changed according to the cartridge change out schedule or immediately if any odors, eye irritation (in the case of full-face masks) or respiratory irritation are detected or increased breathing resistance is noted.

c. Atmosphere-supplying respirators.

(1) Check appropriate items listed under air-purifying respirators.

(2) Check hood, helmet, blouse or suit for cracks, tears, torn seams, and abrasions; check integrity of headgear suspension.

(3) Check face shields for cracks, breaks, abrasions or distortions that would interfere with vision.

(4) Check abrasive blasting protective screen for integrity and condition.

(5) Check air supply system for air quality, breaks or kinks in supply hoses and detachable coupling attachments, tightness of connectors, and manufacturer's recommendations concerning the proper setting of regulators and valves. Ensure the coupling is incompatible with other non-breathing air couplings used at the activity. Check that hose lengths and pressure settings are as specified in the NIOSH approval label.

Ensure hoses are approved for use with the respirator assembly.

(6) When an air compressor is used to provide breathable air, check air-purifying elements, carbon monoxide and/or high temperature alarm and location of compressor air inlet.

d. Self-contained breathing apparatus.

(1) Check the facepiece and breathing hose for integrity as described above for atmosphere-supplying respirators.

(2) Check the integrity of and air pressure in the cylinder. Ensure that cylinders have current hydrostatic test approval stamps/stickers. As shown below, the required test frequency varies based on the cylinder composition. Also check

the integrity of the regulator, harness assembly, and all straps and buckles.

Hydrostatic Test Frequency for SCBA Cylinders

CYLINDER CONSTRUCTION	HYDROSTATIC TEST FREQUENCY
Steel	5 years
Aluminum	5 years
Composite	3 years

(3) Ensure the regulator and warning devices (end-of-service alarm) function properly.

(4) Emergency use respirators will be inspected on a monthly basis in addition to before and after each use. Inspection records must be maintained. The preamble to reference 9-1 states that examining emergency respirator performance before each use is not intended to be as extensive and thorough a process as the monthly inspection, but includes a basic examination conducted prior to each use to assure the wearer that the respirator which they are about to don in an emergency situation will work properly (e.g., that the cylinders on the SCBA are charged, that air is available and flowing). Ensure air cylinders are fully charged (i.e., regulator gauge must read between 90%-100% of the rated cylinder pressure).

9. **WORK AREA SURVEILLANCE.** The industrial hygienist will carefully and fully document any apparent deficiencies in a respirator program and bring them to the attention of the appropriate command personnel. This should include identification of the contaminant, nature of the hazard, concentration in the breathing zone, and, if appropriate, biological monitoring.

10. **EMPLOYEE ACCEPTANCE.** Many factors affect the employee's acceptance of respirators, including comfort, ability to breathe without objectionable effort, adequate visibility under all conditions, provisions for wearing prescription glasses (if necessary), ability to communicate, ability to perform all tasks without undue interference, and confidence in the facepiece fit. Failure to consider these factors is likely to reduce cooperation of the users in promoting a satisfactory program. The industrial hygienist should assist the command in the detection and resolution of these problems.

11. **MEDICAL EVALUATION.** Medical evaluations ensure that employees who are required to wear respiratory protective equipment are physically able to perform their assigned tasks while using the equipment. The cognizant credentialed occupational medicine provider determines the scope of the medical evaluation based on information provided by the user's command concerning the type(s) of respirators used and the conditions and frequency of use.

12. **APPROVED RESPIRATORS.**

a. Approval transition.

(1) Previously, respirators were jointly approved by NIOSH and the Mine Safety and Health Administration (MSHA) under 30 CFR Part 11. On 8 June 1995, NIOSH updated the respirator certification procedures and reissued them under 42 CFR 84.

(2) NIOSH is now the sole certification agency. MSHA only certifies jointly with NIOSH if the respirator is being tested specifically for mine rescue. However, NIOSH/MSHA approved respirators will continue to be used in the workplace for decades.

NOTE: NIOSH identifies approved respirators in the NIOSH Certified Equipment List. The last hard copy of the NIOSH Certified Equipment List was published on 30 September 1993. Since then NIOSH has certified over 3,200 approved respirators. NIOSH provides the NIOSH Certified Equipment List as of 13 February 1998 on four diskettes. Ordering information can be found at <http://www.cdc.gov/niosh/celpamp.html>. The NIOSH Certified Equipment List is public domain software, not subject to copyright law, and is also available for downloading from the Army Center for Health Promotion and Preventive Medicine and the Army Industrial Hygiene Home Page: (<http://chppm-www.apgea.army.mil/Armyih/Docs/cel298.htm>).

(3) The 1995 certification changes, the first in a series of planned changes, affected only non-powered particulate air-purifying respirators. Manufacturers can continue to sell particulate filters approved under 30 CFR 11 procedures until 10 July 1998. Distributors and users can sell and wear 30 CFR 11 approved particulate respirators until their supply is depleted or until the expiration date for combination chemical cartridge/particulate cartridges.

(4) The approval for Bureau of Mines respirators has expired and is not considered valid except in the following two cases:

(a) Gas masks approved by the U.S. Bureau of Mines (Schedule 14F) are approved until further notice.

(b) SCBAs approved under Schedule 13E which have a low air warning device and which were purchased before June 30, 1975 are still valid.

b. Classes of particulate respirators.

(1) There are nine classifications of non-powered particulate air-purifying respirators, certified under three filter classes: N, R and P. Each class has three levels of filter efficiency: 95%, 99% and 99.97% (designated 100 in this new system). N, R, and P 100 filters are equivalent to 30 CFR 11 HEPA filters, however, according to Chapters 17 and 21 of reference 9-2, only P100 filters can be used on air purifying respirators worn for protection against asbestos and lead. All nine classes can be used as protection against tuberculosis in health care facilities per reference 9-7. Oil aerosols tend to degrade filter efficiency. Oils are hydrocarbon liquids with high boiling points, high molecular weights, and low vapor pressure. Oil aerosols can consist of mineral, vegetable, animal and synthetic substances that are slippery, combustible, and soluble in organic solvents such as ether but not soluble in water.

NOTE: Chemical cartridges that include particulate filter elements will have labels indicating the new particulate filter classification.

(a) N-series (i.e., NO oil) filters cannot be used in an atmosphere containing oil aerosols. They generally should be used and reused subject only to considerations of hygiene, damage, and increased breathing resistance. However, for dirty workplaces that could result in high filter loading, service time for N-series filters should only be extended beyond 8 hours of use (continuous or intermittent) by performing an evaluation in specific workplace settings that demonstrates that:

1. Extended use will not degrade the filter efficiency below the efficiency level specified in 42 CFR 84, or

2. that the total mass particulate loading of

the filter(s) is less than 200 mg per respirator (i.e., summed over all filters in a respirator).

NOTE: These determinations would need to be repeated whenever conditions change or modifications are made to processes that could change the type of particulate generated in the user's facility.

(b) R-series (i.e., oil-RESISTANT) filters should be used only for a single shift (or for 8 hours of continuous or intermittent use) when airborne oil mist is present. However, service life for the R-series filter can be extended using the same two methods described above for N-series filters. As above, these determinations would need to be repeated whenever conditions change or modifications are made to processes that could change the type of particulate generated in the user's facility.

(c) P-series (i.e., oil-PROOF) filters should be used and reused according to the manufacturer's time-use limitation recommendations when oil aerosols are present. P-series filters should be used and reused subject only to considerations of hygiene, damage, and increased breathing resistance if oil aerosols are not present.

NOTE: NIOSH guidance concerning these new particulate respirators is provided in reference 9-8 which may be downloaded from <http://www.cdc.gov/niosh/userguid.html>. Additional guidance on the new particulate respirators is available in reference 9-9 which may be downloaded from <http://www.cdc.gov/niosh/pseries.html>. Publication ordering information is available on the NIOSH web site at <http://www.cdc.gov/niosh/pubs.html> or at the following address:

Publications Dissemination, DSDDT  
National Institute for Occupational Safety and Health  
4676 Columbia Parkway  
Cincinnati, Ohio 45226-1998  
Phone number (800) 356-4674

c. Powered Air Purifying Respirator (PAPR) use a motor and blower to pull air through the filter to provide a continuous flow of clean air to the user. This also provides a cooling effect in warm temperatures. PAPRs are manufactured with half-face, full-face, hood, and helmet facepieces. Tight-fitting facepiece PAPRs must supply a minimum of 4 cubic feet per minute (CFM) of air to the user. Loose fitting PAPRs must supply a

minimum of 6 CFM. Under 42 CFR 84, powered air purifying respirators must be equipped with filters meeting the 30 CFR 11 criteria for HEPA filters.

d. Gas and vapor removing air-purifying respirators

(1) Gas and vapor removing air-purifying respirators, remove specific individual contaminants or a combination of contaminants by catalytic reaction or sorption, which includes adsorption, chemisorption, and absorption.

(a) A catalyst is a substance that affects the rate of a chemical reaction but is not itself permanently changed in the reaction. Catalysts usually increase the rate of reaction. Catalytic reactions in respirator filter media are used to capture or inactivate the contaminant. For example hopcalite (a mixture of copper and manganese oxides) removes carbon monoxide by converting it to carbon dioxide in the presence of oxygen in ambient air. Moisture and organic vapors render hopcalite ineffective as a catalyst in this reaction. Therefore, canisters made with the hopcalite are "sandwiched" between layers of drying agent. The Type N canister with hopcalite has an end-of-service life indicator, which turns from dark blue to light blue to indicate when the sorbent is no longer protecting against carbon monoxide.

(b) Sorption means to "to take up and hold." The sorbent in respirator cartridges or canisters (e.g., charcoal) is the material doing the sorption. The sorbate is the contaminant being captured. Types of sorption include adsorption, chemisorption, and absorption.

(2) In adsorption, the contaminant adheres to the surface of the sorbent. Adsorption is a surface attraction, resulting from physical force interactions between sorbent and sorbate. The bonding is weak and it is easy to separate the sorbent and sorbate. For example, heating will drive the gas or vapor off the sorbent. Another mechanism is preferential adsorption which occurs when vapor "B" displaces vapor "A" on the sorbent if the sorbent has a higher affinity for vapor B. Water vapor can drive off a sorbate and decrease the ability of a sorbent to adsorb a vapor or gas. Since adsorption is a physical phenomenon, it is very important to have a large sorbent surface area. Sorbent materials are ground and packed so that there is about 5.6-14 acres of surface area per ounce. The primary sorbent used is activated charcoal. Silica gel, molecular sieve and alumina are also used as sorbents. Activated charcoal is made from coconut shells, coal, petroleum or other carbon

containing raw materials. It is "activated" by heat treating at 800-900°C, which helps create the necessary porosity, giving the charcoal an internal honeycomb structure. The internal surface area averages 10,000 ft<sup>2</sup> per gram. The heating also leaves the carbon "pure" by driving out contaminants from the raw material, making it capable of adsorbing the maximum amount of gas or vapor contaminant.

(3) Chemisorption is similar to adsorption, but results from chemical bonding between the sorbent and the sorbate. The sorbent may be chemically treated to make it more specific for the target gas or vapor. For example, charcoal is treated with nickel chloride to remove ammonia. Another example is treating activated charcoal with iodine to remove mercury. Mercury vapor cartridges have an end-of-service life indicator that turns from orange to brown as the sorbent becomes saturated. The cartridge must be belt-mounted so that the user can see the indicator.

(4) In absorption, the contaminant actually penetrates into the sorbent and is held chemically. It is a slower removal mechanism than adsorption because it involves a chemical reaction. Absorption used to be the method of choice for acid gas removal (using sodium hydroxide or potassium hydroxide with lime), but has been superseded by chemisorptive removal. Many acid gas cartridges used to contain Whetlerite®. Whetlerite® contained chromates that could leach out of the sorbent. On 1 September 1990, NIOSH rescinded the approval of chromium-impregnated cartridges.

(5) Combination particulate/gas and vapor removing respirators, combine the respirator characteristics of both particulate and gas/vapor removing air-purifying respirators. There are no pesticide or spray painting cartridge respirators approved under 42 CFR 84. Instead, either an organic vapor cartridge with a prefilter or a combination organic vapor cartridge/particulate filter is to be used.

(6) Reliance on odor thresholds and other warning properties is no longer permitted as the sole basis for determining that an air-purifying respirator will afford adequate protection against exposure to gas and vapor contaminants. Reference 9-1 requires establishing a change schedule for chemical canisters and cartridges based on objective information or data that will ensure that canisters and cartridges are changed before the end of their service life. This data along with the logic for relying on this change schedule must be described in the respirator program. The basis

for cartridge change schedules ideally should be based on the results of cartridge/canister breakthrough studies that are conducted under worst-case conditions of contaminant concentration, humidity, temperature, and air flow rate through the filter element. Such information may be based on reliable use recommendations from the activity's respirator and/or chemical suppliers. Alternatively, either atmosphere-supplying respirators, or, where they are available and appropriate for the workplace, air-purifying respirators equipped with end-of-service life indicators (ESLIs) can be worn as protection against gases and vapors.

(a) Methods for testing cartridge service life and determining change out schedules include laboratory testing, field testing, and use of respirator carbon tubes.

1. Laboratory measurement of breakthrough time requires challenging the chemical cartridges at the highest contaminant concentration expected in the workplace in an environment that duplicates the worst case temperature, humidity, and work rate. Set the cartridge change out schedule at 90% of the measured breakthrough time.

2. Field testing actually measures cartridge breakthrough time in the workplace. A high flow pump connected to the cartridge simulates the work rate (~30 l/min is light work rate, ~60 l/min is moderate work rate, and ~80 l/min is heavy work rate). Samples are collected downstream to determine breakthrough time. Set the cartridge change out schedule at 90% of the measured breakthrough time.

3. Respirator carbon tubes are small glass tubes filled with sorbent material from the chemical cartridges. Typical industrial hygiene sampling pumps can be used to draw workplace air through the respirator carbon tubes. There is a linear relationship between breakthrough time and bed residence time of the respirator carbon tube (i.e., the time required for a molecule of air to pass through a packed adsorbent bed). Both the bed residence time of the respirator carbon tube and the respirator cartridge can be calculated - then the breakthrough time of the carbon tube is used to predict the cartridge breakthrough time. Set the cartridge change out schedule at 90% of the calculated breakthrough time.

(b) A method for establishing and implementing respirator cartridge change out schedules is provided on the NAVENVIRHLTHCEN Home Page <http://www-nehc.med.navy.mil>.

e. Supplied-air respirators provide breathing air independent of the environment. Such respirators are to be used in place of chemical cartridge, air-purifying respirators when: (1) a cartridge change out schedule has not been established and implemented, (2) there are no appropriate end-of-service-life indicator respirators, or (3) the contaminant is of such high concentration or toxicity that an air-purifying respirator is inadequate. Supplied-air respirators, also called air-line respirators, are classified into the following subgroups: Type A and AE, Type B and BE, Type C and CE.

(1) Type A is a tight fitting facepiece with a large diameter hose (7/8" ID), and a blower that can be operated either electrically or by hand. The blower takes fresh air from a source outside the contaminated atmosphere and blows it to the user inside the contaminated area. The hose length is limited to 300 feet and is Only approved for non-IDLH atmospheres. Per reference 9-10, the Type A respirator lost approval for entry into IDLH atmospheres in 1977.

(2) Type AE is the same as Type A, but also has abrasive blasting approval.

(3) Type B respirators also have large diameter hoses, but no blower. The wearer uses "lung power" to draw air through the hose and into the facepiece. The hose length is limited to 75 feet. Type B respirators must have a tight fitting facepiece to create negative pressure for drawing air through the air hose.

(4) Type BE is the same as Type B, but also has abrasive blasting approval.

NOTE: The NAVENVIRHLTHCEN has written a letter to NIOSH requesting that they revoke the hose mask and hose mask with blower certifications.

(5) Type C respirators are supplied with breathing air from a compressor or a large cylinder that provides air at a maximum of 125 psi using a maximum of 300 feet of hose. The operating pressure and hose lengths must be specified by the manufacturer. Type C respirators operate either in continuous flow, demand, or pressure-demand modes.

(a) In continuous flow Type C respirators, air flows into the facepiece at a continuous rate. For tight-fitting facepieces, the minimum air flow into the facepiece is 4 CFM and maximum is 15 CFM. For loose-fitting facepieces, minimum flow

rate is 6 CFM and the maximum flow rate is 15 CFM.

(b) In demand Type C respirators, air flows through the regulator only during inhalation, which causes air pressure inside the respirator facepiece to be negative relative to the surrounding atmosphere. Leakage into the facepiece may occur if there is a poor seal between the respirator and the user's face.

Demand regulators consist of the regulator housing, diaphragm, inlet port, outlet port to the facepiece, needle valve, and arms. Inhalation creates a negative pressure on the outlet side of the regulator going to the facepiece. This negative pressure causes the diaphragm to be pulled in, raising the arms up against the needle valve. As the needle valve is pushed up, air flows from the air source through the regulator to the facepiece. Flow stops when the user stops inhaling or when the user exhales. When the user exhales, positive pressure builds up in the regulator. This causes the diaphragm and the arms to fall down, relieving pressure on the needle valve. The needle valve closes and cuts off air flow to the facepiece. The cycle repeats when the user inhales again. Along with hose masks and hose masks with blowers, demand respirators should not be worn.

(c) Pressure-demand Type C respirator regulators maintain positive pressure inside the facepiece at all times. The regulators are the same as demand regulators, except there is a spring located on the outside of diaphragm. The spring exerts 1½ inches water gauge (w.g.) of pressure on the diaphragm, which causes levers to push up against the needle valve. The needle valve opens, allowing air to flow through the regulator into the facepiece. Pressure builds up in facepiece, causing the diaphragm to push down against the spring, and the needle valve closes. When the wearer exhales, air is forced out of the exhalation valve, causing pressure in the regulator to drop to less than 1½ inches w.g. The pressure drop forces the spring against the diaphragm and lever arms, which open the needle valve. There is also a spring located in the exhalation valve to release any excess pressure built-up in the facepiece.

f. Self-Contained Breathing Apparatus (SCBA) provides the wearer with a large independent supply of breathable air that is not connected to an outside air source. Pressure-demand SCBAs are approved for IDLH atmospheres. SCBAs are classified as closed-circuit or open-circuit.

(1) Closed-circuit SCBAs are referred to as rebreather devices because they recirculate the user's exhaled breath within the respirator after CO<sub>2</sub> is removed and O<sub>2</sub> is replaced. Closed-circuit SCBAs are smaller and lighter than open-circuit

SCBAs and can be designed to function for longer service times (one to four hours) but still stay within the required weight limitation (i.e., 35 lbs). Closed-circuit SCBAs are typically thought of as negative pressure respirators. However, there are six closed-circuit respirators approved as pressure-demand SCBAs (i.e., positive pressure respirators). Re-oxygenation is accomplished by either a tank of compressed or liquid oxygen or by chemical reaction.

(a) With liquid oxygen, the breathing air is supplied from an inflatable bag. Exhaled air passes through a scrubber where CO<sub>2</sub> is removed using either sodium hydroxide or potassium hydroxide sorbent media. Removal of the CO<sub>2</sub> reduces the air flow going back to the breathing bag causing it to collapse against the admission valve, which opens the valve to admit oxygen until the bag is reinflated. The re-oxygenated air is sent back to the facepiece. Only the oxygen is replenished. Other air constituents, except CO<sub>2</sub>, are recirculated.

(b) With chemically generated O<sub>2</sub>, CO<sub>2</sub> is not removed, but is used to chemically react with potassium superoxide and water vapor (in the exhaled air) to make oxygen. Oxygen is not released until the exhaled breath reaches the potassium superoxide canister, which creates a short delay before oxygen generation. The time delay can be overcome in some closed-circuit SCBAs by striking a chlorate candle, which is designed to provide oxygen until the potassium superoxide reaction starts. The oxygen breathing apparatus (OBA) works this way.

NOTE: OBAs are approved only for damage control and fire fighting aboard ships and for training fire fighters. It is a military-unique item, and is not approved by NIOSH/MSHA for industrial use. OBAs are being replaced by NIOSH/MSHA approved open-circuit SCBAs.

(2) In open-circuit SCBAs, exhaled air is expelled to the outside atmosphere. The advantage over closed-circuit SCBAs is that any contaminant(s) in the facepiece will be purged instead of being recirculated. Open-circuit SCBAs are heavier because of the large tank of atmospheric air that must be carried on the back. Due to the weight restriction, the maximum service time is one hour. Regulators work the same way as in airline respirators, but they are two-stage regulators instead of single-stage. Open-circuit SCBAs also operate as demand or pressure-demand devices. Pressure-demand SCBAs have assigned protection factors up to 10,000; demand SCBAs have protection factors no greater than 50, per reference 9-6.

(3) Escape only SCBAs are available as both open- and closed-circuit. Closed-circuit escape-only respirators operate in the demand mode. Open-circuit escape-only respirators can be demand, pressure demand or continuous flow. They can be mouthpiece, full face or hooded. The emergency escape breathing device (EEBD) is a self-contained respirator especially developed for the Navy. This respirator is to be used only aboard ship for escape from a hazardous atmosphere. It must never be used for entry into a hazardous atmosphere. The EEBD is being replaced by the NIOSH/MSHA approved OCENCO M-20 Self Contained Self Rescuer, which is a 10 minute closed circuit mouthpiece respirator using compressed oxygen for oxygen replenishment.

g. Combination Type C/Self-Contained Breathing Apparatus are Type C supplied-air respirators, operated in demand or pressure-demand mode, in combination with an SCBA as an auxiliary air supply. Continuous flow supplied-air respirators are not compatible for use with an auxiliary SCBA. If the SCBA breathing air were delivered to the facepiece in the continuous flow mode, the auxiliary air supply would be depleted too quickly for escape. Combination Type C/SCBA are approved for IDLH atmospheres if the Type C respirator is operated in the pressure-demand mode. Auxiliary SCBAs have service use times of 3 to 60 minutes. If the auxiliary air supply is rated for 3, 5, or 10 minutes, then the airline mode of operation must be used upon entry into IDLH atmospheres. If the auxiliary air supply is rated for 15 minutes or longer, entry can be made into the IDLH atmosphere on the SCBA, provided that no more than 20% of the rated capacity of the SCBA is used for entry.

h. Combination Type C/air-purifying respirators are approved as air-purifying cartridge respirators. They can be particulate filter or chemical cartridge or canister. They cannot be worn into oxygen-deficient atmospheres or IDLH atmospheres. The supplied air can be continuous flow or pressure-demand. Depending on the respirator, the air-purifying component can be used for:

- (1) Escape-only following loss of air supply,
- (2) Entry and exit to and from air supply, including movement between air supplies, or
- (3) No restrictions

i. Nullification of approval. A respirator's approval is

nullified when:

(1) Components between different types or makes of respirators are mixed.

(2) Unapproved components are used.

(3) A respirator is used in atmospheric concentrations for which it is not approved. That is, airborne concentrations exceed the maximum use concentration calculated from the protection factor assigned to the respirator.

(4) An approved respirator is used in atmospheres for which it is not approved. For example, an organic vapor cartridge respirator cannot be used for protection against mercury vapor. Similarly, a dust respirator is not approved protection for organic vapor exposures.

### 13. BREATHING AIR FOR SUPPLIED-AIR RESPIRATORS.

a. Grade D breathing air. All compressed breathing air will meet the quality specification for grade D breathing air as described in reference 9-11.

b. Breathing air should be sampled and analyzed quarterly for all breathing air compressors (both oil-lubricated and non-oil-lubricated). Newly purchased compressors must be equipped with both high temperature and continuous carbon monoxide monitor and alarm systems. Existing compressors must have high temperature and continuous carbon monoxide monitor and alarm systems installed when they are upgraded during major maintenance. Calibrate monitor and alarm systems on compressors used for supplying breathing air according to the manufacturer's instructions.

NOTE: Ambient Air Breathing Apparatus (AABA) and other comparable portable equipment are exempt from this requirement. However, you must ensure that air inlets are placed in a contaminant-free environment.

c. Collect and analyze breathing air using the procedures specified in reference 9-11. In addition, there are commercially available breathing air test kits which meet the ANSI/CGA analytical requirements. Ensure the following minimum specifications for Grade D (See reference 9-11.) breathing air are met:

Grade D Compressed Air Purity Requirements

Characteristic	CGA G-7.1-1989 Requirement
Oxygen content (v/v)	19.5%-23.5%
Oil (Condensed)	=5 mg/m <sup>3</sup>
Carbon monoxide	=10 ppm
Carbon dioxide	=1,000 ppm
Water content	The dew point must be 10° F lower than the coldest temperature where the respirator is worn
Odor	No pronounced odor

14. **RESPIRATOR PROGRAM AUDIT.**

a. Per references 9-2 and 9-3, the activity's respiratory protection program must be evaluated annually. This may be accomplished in conjunction with the annual industrial hygiene survey.

b. Also, per reference 9-2, the RPPM must audit the program annually. Reference 9-3 requires a quarterly spot check by the Respiratory Protection Officer (RPO). The RPPM/RPO must ensure that each discrepancy is corrected and revise respirator standard operating procedures, if required.

15. **REFERENCES.**

9-1 Code of Federal Regulations, Title 29, Part 1910.134. Respiratory Protection.

9-2 OPNAVINST 5100.23 Series, Chapter 15, Respiratory Protection.

9-3 OPNAVINST 5100.19 Series, Chapter B6, Respiratory Protection Program.

9-4 Navy Environmental Health Center (NEHC). A Guide for Respiratory Protection Program Managers. NEHC Technical Manual, NEHC TM-96-1. 1996.

9-5 ANSI. American National Standard for Respiratory Protection. ANSI Z88.2-1992. New York, NY: American National Standards Institute. 1992.

9-6 National Institute for Occupational Safety and Health

(NIOSH). NIOSH Respirator Decision Logic. DHHS (NIOSH) Pub. No. 87-108. Cincinnati, OH: U.S. Department of Health and Human Services. 1987.

9-7 DHHS(CDC). Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, 1994, Notice of Final Revisions. Federal Register 59:208 of 28 Oct 1994. pp. 54242-54303.

9-8 National Institute for Occupational Safety and Health (NIOSH). NIOSH Guide to the Selection and Use of Particulate Respirators Certified under 42 CFR Part 84. DHHS(NIOSH) Pub. 96-101. Cincinnati, OH: U.S. Department of Health and Human Services. 1996.

9-9 National Institute for Occupational Safety and Health (NIOSH). NIOSH Respirator User Notice May 2, 1997. NIOSH, Cincinnati, OH. 1997.

9-10 Federal Register 42:250 of 30 December 1977. Pages 65167-65168.

9-11 American National Standards Institute/Compressed Gas Association (ANSI/CGA). Commodity Specification For Air. ANSI/CGA G-7.1-1997. Arlington, VA: Compressed Gas Association, Inc. 1997.

#### 16. OTHER USEFUL REFERENCES.

ANSI. Practices for Respiratory Protection for the Fire Service. ANSI Z88.5-1981. New York, NY: American National Standards Institute. 1981.

ANSI. American National Standard for Respiratory Protection - Respirator Use - Physical Qualifications for Personnel. ANSI Z88.6-1984. New York, NY: American National Standards Institute. 1984.

Code of Federal Regulations, Title 42, Part 84. Respiratory Protective Devices.

NIOSH. NIOSH Guide to Industrial Respiratory Protection. DHHS (NIOSH) Pub. No. 87-116. Cincinnati, OH: U.S. Department of Health and Human Services. 1987.

**Table 9-1  
Assigned Protection Factors<sup>1</sup>**

<b>Assigned Protection Factor (APF)</b>	<b>Class of Respirator</b>	<b>Source of APF<sup>2</sup></b>
<b>5</b>	Filtering facepieces <sup>3</sup>	NIOSH
	Quarter mask respirator	NIOSH
<b>10</b>	Elastomeric <sup>4</sup> half mask respirators equipped with particulate filters and/or chemical cartridges, or combination particulate/chemical cartridge filters.	ANSI/NIOSH
	Supplied-air half mask respirators operated in the demand mode	ANSI/NIOSH
<b>25</b>	Powered air-purifying respirators equipped with a hood or helmet	NIOSH
	Supplied-air respirators equipped with a hood or helmet operated in a continuous flow mode	NIOSH
	Powered air-purifying respirators equipped with a loose fitting facepiece <sup>5</sup>	ANSI
<b>50</b>	Air-purifying full face respirator equipped with particulate filters, chemical cartridges or combination particulate/chemical cartridges	NIOSH
	Powered air-purifying full face or half mask respirator equipped with HEPA filters, chemical cartridges, or combination HEPA/chemical cartridges	NIOSH
	Gas mask equipped with chemical canister or combination particulate/chemical canister	NIOSH
	Powered air-purifying gas mask equipped with chemical canister or combination HEPA/chemical canister	NIOSH
	Supplied-air half mask respirator operated in continuous flow mode	ANSI/NIOSH
	Half mask pressure demand supplied-air respirator	ANSI
	Supplied-air full face respirators operated in demand or continuous flow mode	NIOSH
Full face demand SCBA	NIOSH	
<b>2,000</b>	Full face pressure demand supplied-air respirator	NIOSH
<b>&gt;2,000 or IDLH Atmosphere</b>	Full face pressure demand SCBA or combination full face pressure demand supplied-air respirator with auxiliary SCBA	NIOSH
<b>Firefighting</b>	Full face pressure demand SCBA <sup>6</sup>	NIOSH

<sup>1</sup>For protection against contaminants that are regulated by individual standards (e.g., formaldehyde, benzene, vinyl chloride, asbestos, lead), refer to the respiratory protection in the specific standard to obtain the correct APF.

<sup>2</sup>NIOSH reference is NIOSH Respirator Decision Logic. ANSI reference is ANSI Z88.2-1992.

<sup>3</sup>Filtering facepiece respirators are air-purifying respirators with facepieces consisting of filter media. Tight fitting respirators on which user seal checks cannot be performed may not be worn.

<sup>4</sup>Elastomeric facepieces are made of rubber-like synthetic polymer, such as silicone rubber.

<sup>5</sup>Loose-fitting respirators form a partial seal with the face and do not cover the neck and shoulders.

<sup>6</sup>Firefighting SCBAs must meet NFPA 1981 requirements.