

RESPIRATOR CLASSIFICATION

I. APPROVED RESPIRATORS.

A. The Occupational Safety and Health Administration (OSHA) respirator standard (reference 1) requires using NIOSH (National Institute for Occupational Safety and Health) approved respirators to protect workers against inhalation hazards. On 8 June 1995, NIOSH updated the respirator certification procedures and reissued them under 42 CFR 84 (reference 2). Previously, respirators were jointly approved by NIOSH and the Mine Safety and Health Administration (MSHA) under 30 CFR Part 11. For more details on the evolution of respirator certification, please see the article entitled *History of Negative Pressure Particulate Respirator Certification* under the NMCPHC [Industrial Hygiene](#) homepage.

1. NIOSH is now the sole certification agency. MSHA only certifies jointly with NIOSH if the respirator is being tested specifically for mine rescue. Both NIOSH approved and NIOSH/MSHA approved respirators are approved for use. 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 thousands of respirators. NIOSH now provides the [NIOSH Certified Equipment List](#) electronically. Amendments to the 1995 respirator certification update affected only non-powered particulate air-purifying respirators. The old approval number sequence under 30 CFR 11 for particulate filters was TC-21C. Particulate respirators approved under 42 CFR 84 have the approval number sequence of TC-84A. In most cases, the particulate respirators in use before 1995 continued in service because most filters certified under 42 CFR 84 were designed to be “drop-in” replacement products for old filters certified under 30 CFR 11.

3. The Bureau of Mines was the first agency to test and certify respirators. The approval schedules for Bureau of Mines respirators have expired and are not considered valid except in the following two cases (although it is doubtful that any of these respirators are still in use):

- a. Gasmasks approved by the U.S. Bureau of Mines (Schedule 14F) are approved until further notice.
- b. Self contained breathing apparatus (SCBA) approved under Schedule 13E which have a low air warning device and which were purchased before June 30, 1975 are still valid.

4. A historical summary of respirator approval schedules is provided in Table 1.

TABLE 1 APPROVAL SCHEDULES					
Respirator Certification Regulatory Authority	Gasmask	Airline	SCBA	Particulate	Chemical Cartridge
Original BM	BM-14	BM-19	BM-13	BM-21	BM-23
30 CFR 11	TC-14G	TC-19C	TC-13F	TC-21C	TC-23C
42 CFR 84	TC-14G	TC-19C	TC-13F	TC-84A	TC-23C

5. Combination respirators are not addressed in Table 1. Per paragraph 84.64.b of reference 2, combination respirators, such as air purifying/airline, are approved under the approval schedule of the respirator component having the least protection to the respirator wearer. For example, combination airline respirators with chemical cartridge/particulate filters have approval labels indicating the particulate filter classification TC-84A because the particulate filter is the least protective component of this combination respirator. The one exception is combination SCBA/airline respirators, which are approved under TC-13F because this combined respirator configuration is considered as protective as the SCBA.

II. RESPIRATOR ASSIGNED PROTECTION FACTORS

A. The thousands of respirators approved under NIOSH respirator certification schedules are classified by their modes of operation, types of respiratory inlet covering, and their capabilities & limitations into respirator classes, which are discussed in Sections III., IV., V., VI., and VII.

B. Each class of respirator is identified as providing a specific level of protection, which is called the assigned protection factors (APF). APFs are determined by statistical analysis of workplace protection factor (WPF) studies and simulated workplace protection factor (SWPF) studies, which evaluate the amount of leakage into the respiratory inlet coverings (e.g., facepieces) at sealing surfaces, leakage around valves, and leakage through or around cartridges or canisters. By considering and measuring the effect of these variables during WPF studies and SWPF studies the degree of protection may be estimated and combined with a safety factor to assign a protection factor.

1. WPFs measure the level of protection expected to be provided by respirators in the workplace by dividing the measured workplace contaminant concentration outside the respirator (C_{out}) by its concentration inside the respirator (C_{in}). SWPF studies are similar to WPF but are measured in a simulated laboratory environment instead of in the workplace.

2. APFs represent the minimum ratio of C_{out} to C_{in} and only apply when respirators are used within the context of a comprehensive respirator program. Therefore, APFs are defined as the minimum levels of respiratory protection provided by properly functioning and properly used respirators or class of respirators when all elements of an effective respiratory protection program are established and are being enforced. Appendix A contains the table of assigned protection factors.

III. RESPIRATORY INLET COVERINGS

A. Respiratory inlet coverings are the respirator components connecting the wearer's respiratory tract to an air-purifying or an atmosphere-supplying respirator. Respiratory inlet coverings can be either tight fitting or loose fitting. Types of respiratory inlet coverings include the following designs:

1. Tight fitting respiratory inlet coverings seal tightly to the face or tightly around the neck via neck dams and are referred to as facepieces and tight fitting or tight sealing hoods, respectively.

a. Facepieces are held in place with straps and have a sealing surface where the facepiece surface seals against the face to ensure that air entering the respirator passes only through the respirator filters or the breathing air hoses.

i. Filtering facepiece respirators are half masks in which the filter is an integral part of the respirator. The Navy APF for this type of respirator, shown in Figure 1, is five (protects up to five times the occupational exposure limit (OEL)).

ii. Elastomeric facepieces are usually made of rubber, silicone, or neoprene. Types of elastomeric facepieces include quarter masks, half masks, full facepieces and mouthpiece respirators, which are illustrated in Figure 2. Half mask and full facepieces can be respiratory inlet coverings for both air-purifying and atmosphere-supplying respirators.



Figure 1
Filtering Facepiece Respirator

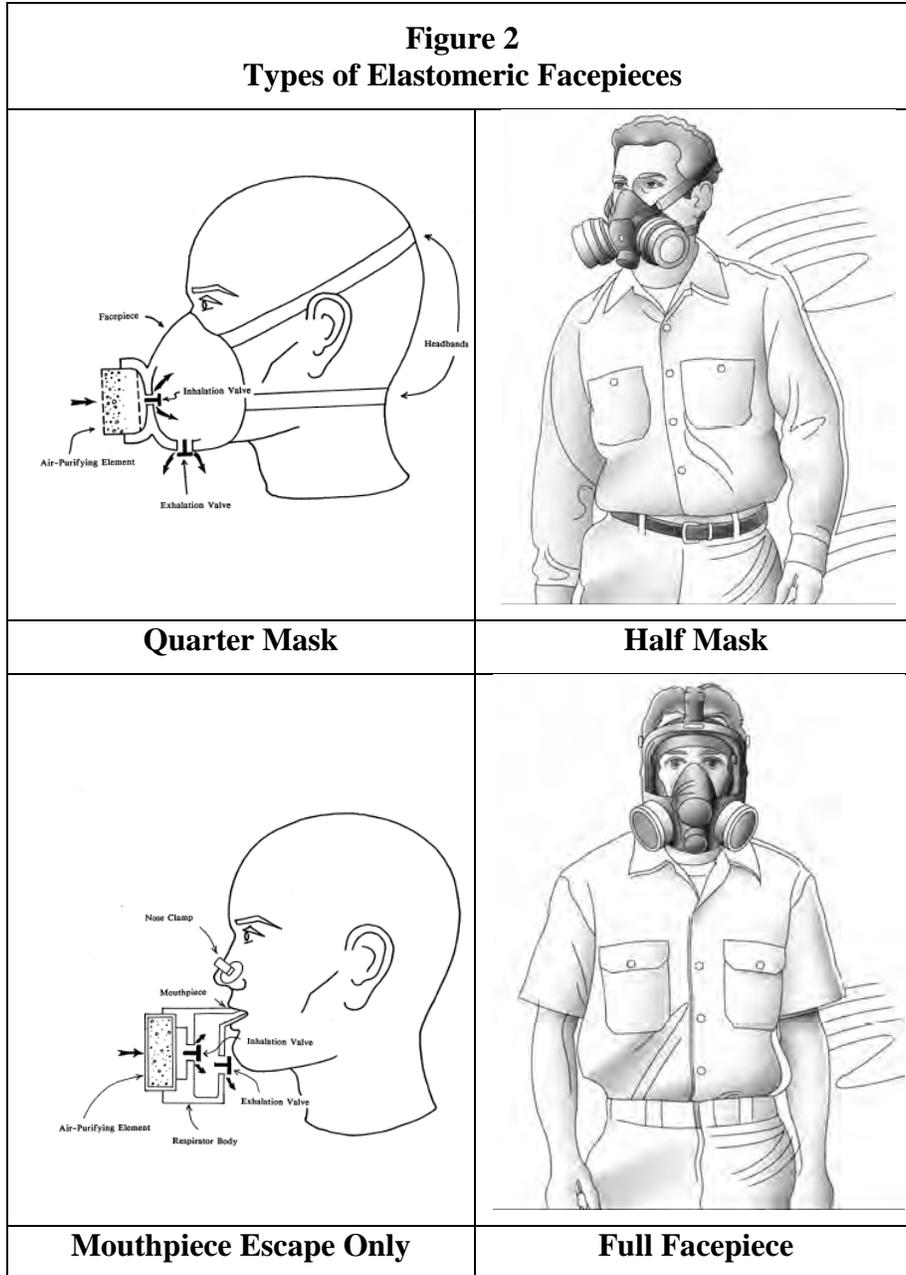
(i) Quarter masks fit from between the lower lip and the chin to the bridge of the nose and have a very small sealing surface; therefore, they are prone to leakage and are easily dislodged. However, quarter masks can be the best fitting respirator for some people with small facial features. There are only negative pressure air-purifying quarter masks. The Navy APF for air-purifying quarter masks is five (protects up to five times the occupational exposure limit (OEL)).

(ii) Half mask elastomeric respirators fit from bridge of nose to under the chin and are the most common respirator found in the workplace today. Half masks are designed to seal more reliably than quarter masks because they have a larger sealing surface. Navy APF for half mask negative pressure air-purifying respirators is 10 (protects up to ten times the OEL).

(iii) Full facepiece respiratory inlet coverings enclose the face from hairline to underneath the chin, have the greatest sealing surface, and are the hardest types of facepieces to dislodge; therefore, they provide the most reliable fit. Full face respirators provide eye protection. Navy APF for full face negative pressure air-purifying respirators is 50 (protects up to 50 times the OEL). See Appendix A for the APFs of other respirator classes with full facepiece respiratory inlet coverings. Gas masks are full facepiece air-purifying respirators that are approved with a canister worn on the facepiece, chest, or back.

(iv) Mouthpiece respirators are held by the teeth and sealed with closed lips. Wearing this type of respirator can be tiring and makes verbal communication very difficult. A nose clip is required so contaminated

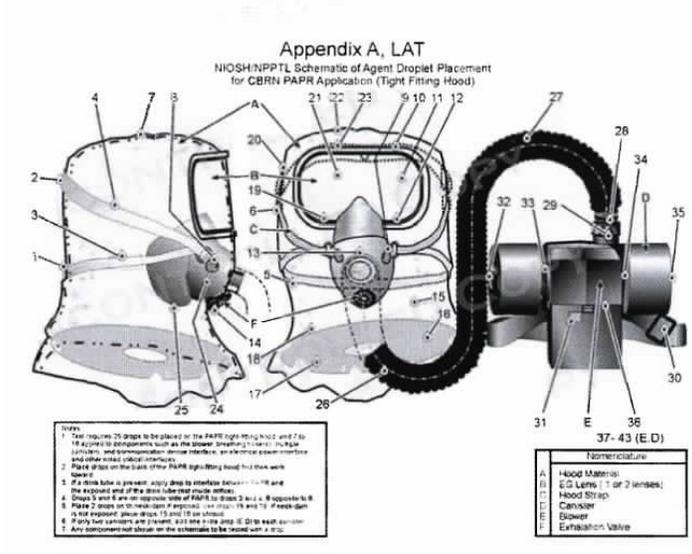
air is not inhaled through the nose. Mouthpiece inlet coverings are exclusively approved for escape only respirators, which are not assigned APFs.



b. Tight fitting hoods are designed with tight sealing neck dams that seal tightly around the neck. Tight sealing hooded chemical/ biological/ radiological/ nuclear (CBRN) powered air-purifying respirators (PAPRs), as shown in Figure 3, are examples of hooded respirators that seal tightly around the neck and have an APF of 1,000.

Figure 3
Tight sealing hooded CBRN PAPRs seal tightly around the neck

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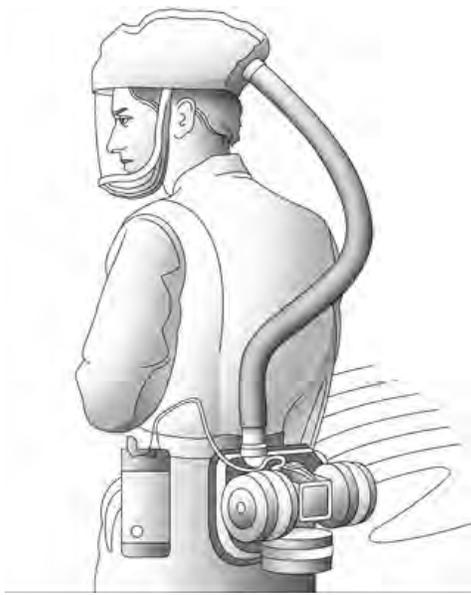
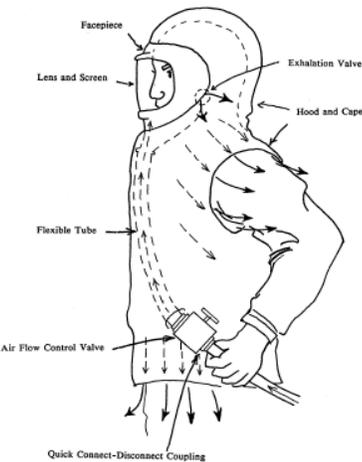
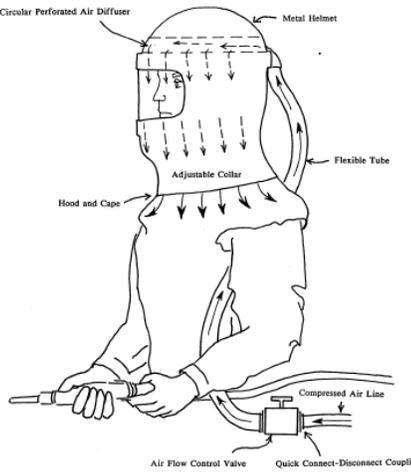


2. Loose fitting hoods and helmets have no sealing surfaces and are respiratory inlet coverings for certain types of PAPRs, and continuous-flow supplied-air respirators. See Figure 4.

- a. Loose fitting hoods are respiratory inlet coverings that completely cover the head and neck and may cover portions of the shoulders.
- b. Helmets loosely cover about the same area as hoods, but are hard or rigid and may be approved for abrasive blasting operations if equipped with impact-resistant viewing lenses and protective exterior designed for deflecting rebounding particles. A protective shroud is an integral part of abrasive blasting respirators.
- c. Loose fitting facepieces are designed to form a partial seal with the face and do not cover the neck and shoulders. Loose fitting facepieces can be the respiratory inlet covering for supplied-air respirators (SARs) also known as airline respirators and PAPRs.

Note: Tight Fitting respirators cannot be worn by people with beards or facial features, such as deep scars because of interference with the respirator seal. Only continuous flow supplied-air respirators or PAPRs with loose fitting hoods, helmets, and facepieces can be worn by these individuals if the loose fitting hooded respirator APF is sufficiently high for the exposure (See *Appendix A, Assigned Protection Factors*).

Figure 4
Types of Loose Fitting Respiratory Inlet Coverings

	
<p align="center">Loose Fitting Facepiece PAPR</p>	<p align="center">Hooded PAPR</p>
	
<p align="center">Hooded Airline</p>	<p align="center">Abrasive Blasting Helmet Airline</p>

IV. MODES OF RESPIRATOR OPERATION

A. Respirators operate either in negative or positive pressure mode. Each mode of operation is described in the following discussions.

1. Negative pressure respirators are respirators in which the air pressure inside of the respirator is positive during exhalation, but negative during inhalation, with

respect to the ambient air pressure. Examples of negative pressure respirators include, non-powered air-purifying and demand atmosphere-supplying respirators. Any break in the seal of negative pressure respirators causes the surrounding atmosphere and contaminants to flow into the respiratory inlet covering and be inhaled by the wearer.

2. Positive pressure respirators are respirators in which the air pressure inside the respirator is normally positive with respect to the ambient air pressure during inhalation and exhalation. Examples include pressure demand SCBA, continuous flow airline respirators, and powered air-purifying respirators (PAPRs).

a. A break in the face seal of positive pressure respirators produces an outward flow of air, forcing contaminants away from the face. However, a continuous outward leakage of air is believed to cause an eddy current or venturi effect, which may cause contaminated air to be siphoned back into the respiratory inlet covering. The larger the leak – the larger the venturi effect.

b. This means that a break in the seal would require delivery of an additional amount of air to the facepiece to compensate for the leak, which could make SCBA air cylinders run to of air sooner. This is a good reason to fit test positive pressure respirators.

V. CLASSES OF RESPIRATORS

A. The two main categories of respirators are air-purifying respirators and atmosphere-supplying respirators. The following classes of respirators are listed below for quick reference. Descriptions of respirator design, function, capabilities, and limitations are provided in Sections VI. for air-purifying respirators and in Section VII. for atmosphere-supplying respirators.

1. Air-purifying respirators (APR) – Respirators that purify ambient air by drawing it through an air-purifying element, which removes aerosols, vapors, gases, or a combination of these contaminants.

a. Non-powered APR – Half mask or full face APR in which the wearer’s breathing draws air through the air-purifying element.

i. Gas and vapor removing

ii. Particulate removing

iii. Combination of gas/vapor removing and particulate removing

b. Powered air-purifying respirators (PAPR) – PAPRs operate by a blower drawing ambient air through an air-purifying element, which removes aerosols, vapors, gases, or a combination of these contaminants. PAPR are normally under positive pressure and equipped with a hood or helmet, loose fitting facepiece, tight-fitting facepiece, or tight-fitting hood sealing around the neck.

i. Gas and vapor removing

ii. Particulate removing

iii. Combination of gas/vapor removing and particulate removing

- c. Multifunctional¹ (combination of an APR and PAPR) – A PAPR that is also approved to operate in negative pressure mode in case the motor fails or for clandestine operations.
 - i. Gas and vapor removing
 - ii. Particulate removing
 - iii. Combination of gas/vapor removing and particulate removing
 - d. Combination atmosphere-supplying and air-purifying respirator - Respirators that can be used in either an atmosphere-supplying or air-purifying mode. According to paragraph (d)(3)(i)(A) of reference 1, when using combination respirators the APF is appropriate to the mode of operation in which the respirator is being used.
2. Atmosphere-supplying respirators – Respirators that provide Grade D breathing air to the wearer.
- a. Self-contained breathing apparatus (SCBA) – Respirators in which the supply of breathing air is carried by the wearer.
 - i. Closed-circuit – SCBA in which the breathing air is recirculated and require tight-fitting facepieces.
 - (i) Demand – Closed-circuit SCBA that is under negative pressure during inhalation.
 - (ii) Pressure demand – Closed-circuit SCBA that is normally under positive pressure.
 - ii. Open-circuit – SCBA in which the breath is exhaled to the atmosphere and are equipped with a full-facepiece or tight-fitting hood sealing around the neck.
 - (i) Demand – Open-circuit SCBA that is under negative pressure during inhalation.
 - (ii) Pressure demand – Open-circuit SCBA that is normally under positive pressure.
 - b. Supplied air respirators (SAR) – Respirators that provide breathing air that is supplied by a hose, usually connected to an air supply (e.g., air compressor).

¹ OSHA and NIOSH use the term “combination respirator” to describe respirators that combine the technology, capabilities, and functions of two or more types of respirators. The European Standard *ISO 16972:2010 Respiratory protective devices - Terms, definitions, graphical symbols and units of measurement* coined the term “multifunctional respirator” to refer to respirators capable of operating within their primary mode of operation (either atmosphere-supplying mode or air-purifying mode) but by different operational technologies, such as combination of two types of atmosphere-supplying respirators (e.g., SCBA/airline) or the combination of two types of air-purifying respirators (e.g., CBRN gas mask/CBRN PAPR) into a single respirator. This ISO Standard defines the term “combination respirator” as respirators capable of operating in either the filtering mode or the atmosphere-supplying mode (e.g., airline/gas mask). This new terminology is expected to be found in the next version of *ANSI Z88.2 Respirator Standard*.

- i. Type B supplied-air (hose mask) respirator – No longer used – Negative pressure SAR in which air is drawn into lungs by lung power and require tight-fitting facepieces.
- ii. Type A supplied-air (hose mask with blower) respirator - No longer used – Negative pressure SAR, similar to hose mask, but breathing is assisted by a hand-cranked or mechanical blower.
- iii. Type C supplied-air (airline) respirator – An airline respirator, which delivers Grade D air from a source (e.g., air compressor) through an air hose.
 - (i) Continuous flow – Airline respirator that is normally under positive pressure and equipped with a hood or helmet, loose fitting facepiece, tight-fitting facepiece, or tight-fitting hood sealing around the neck.
 - (ii) Demand – Airline respirator that is normally under negative pressure during inhalation and requires a tight-fitting facepiece.
 - (iii) Pressure demand – Airline respirator that is normally under positive pressure and requires a tight-fitting facepiece.
- c. Multi-functional atmosphere-supplying respirator (a combination of SAR and SCBA).

VI. AIR-PURIFYING RESPIRATORS

Air-purifying respirators remove air contaminants by filtering out particles or removing gases and vapors, or by removing both gases/vapors and particulates. Please see Sections III. and IV. for discussions on the types air-purifying respirator respiratory inlet coverings and modes of operation, respectively. Air-purifying respirators are not allowed to be worn in oxygen deficient or immediately dangerous to life or health (IDLH)² atmospheres. The mentioned above, the three types of air-purifying respirators are: (1) particulate filtering respirators; (2) gas and vapor removing respirators; and (3) combination gas and vapor removing/particulate filtering respirators.

A. Particulate filtering respirators. Classes of negative pressure (non-powered) air-purifying respirator particulate respirator filters are discussed in this Section. See Section VI.D. for a discussion of industrial PAPR high efficiency particulate air (HEPA) filters (which must not to be confused with the particulate filter component of CBRN PAPR canisters, which is a true P100 filter).

1. There are nine 42 CFR 84 classifications of non-powered particulate air-purifying respirator filters certified under three classes: N, R, and P. Each class has three levels of filter efficiency: 95%, 99%, and 99.97% (designated 100 in this system). N, R, and P 100 filters are high efficiency (HE) filters.

a. However, according to Navy policy for shore-based commands (Chapters 17 and 21 of reference 3), P 100 filters are the only HE filters allowed for negative pressure air-purifying respirators worn for protection against asbestos

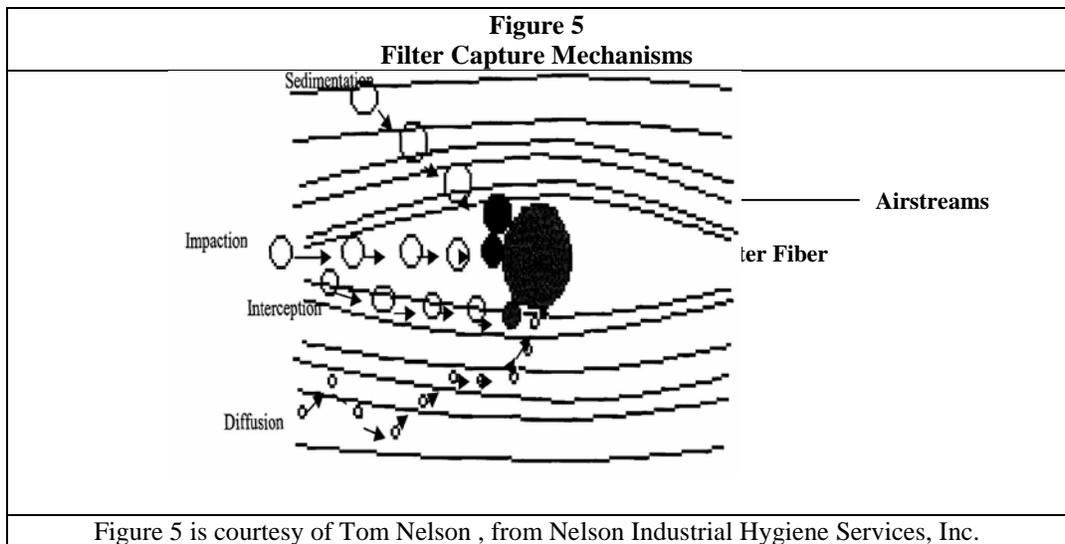
² Per ANSI Z88.2, IDLH is any atmosphere that poses an immediate hazard to life or poses immediate irreversible debilitating effects on health.

and lead because they are the only HE filters approved for negative pressure, air-purifying respirators that are magenta (purple) in color.

b. Lead and asbestos workers were accustomed to using magenta colored HEPA filters under 30 CFR 11. Additionally, supervisors can easily observe the magenta color, indicating that the correct filters are being worn, which is an important factor in the operation of large facilities, such as shipyards.

2. According to NIOSH, all nine filter classes can be used as protection against tuberculosis in healthcare facilities (reference 4). Filters are very efficient at filtering very large particles by sedimentation, impaction, and interception and very small particles are captured by diffusion. These removal mechanisms are illustrated in figure 5 and are discussed below.

a. **Impaction.** Particles cannot bend with the airstreams as air goes around the fiber, so the particles impact onto the fiber. Impaction is primarily a function of the particles' momentum and usually occurs when the velocity of airstreams is high, the particles are large (>1 micron), and heavy. Since particles with high mass and velocity have more momentum, it is unlikely that they can turn with the airstreams around the fiber.



b. **Interception.** Particles stay in the airstreams but are pulled onto the fiber by van der Waal's and electrostatic forces. Interception affects particles lighter in weight and size (0.5 – 1 micron) than affected by impaction. Generally, particles passing the fiber within a distance of half of the particle diameter will be captured. Filtration efficiency is enhanced by high relative humidity because the moisture forms a liquid meniscus between the particles and fibers, which assures adhesion.

c. **Sedimentation.** Only large particles (2 microns and above) are affected by sedimentation. Sedimentation works only at low air flow rates. As particles fall through the airstreams by the force of gravity, they are captured by the fiber.

d. **Diffusion.** Smaller particles (less than 0.2 microns diameter) with slower velocities are captured by diffusion. Small particles are subject to Brownian

movement (the random movement or bouncing motion of small molecules, almost like vibration, which increases the probability that particles will contact another object). Slower velocity means particles remain near filter fibers for a longer time, which increases the probability that particles will contact the fibers and be captured. This is the main mechanism in high-efficiency particulate air filters.

e. **Electrostatic Attraction.** Charged particles in the airstreams are attracted by oppositely charged fibers. Electrostatic attraction is often used to increase filter efficiency. There are two basic methods of establishing electrostatic attraction in filters.

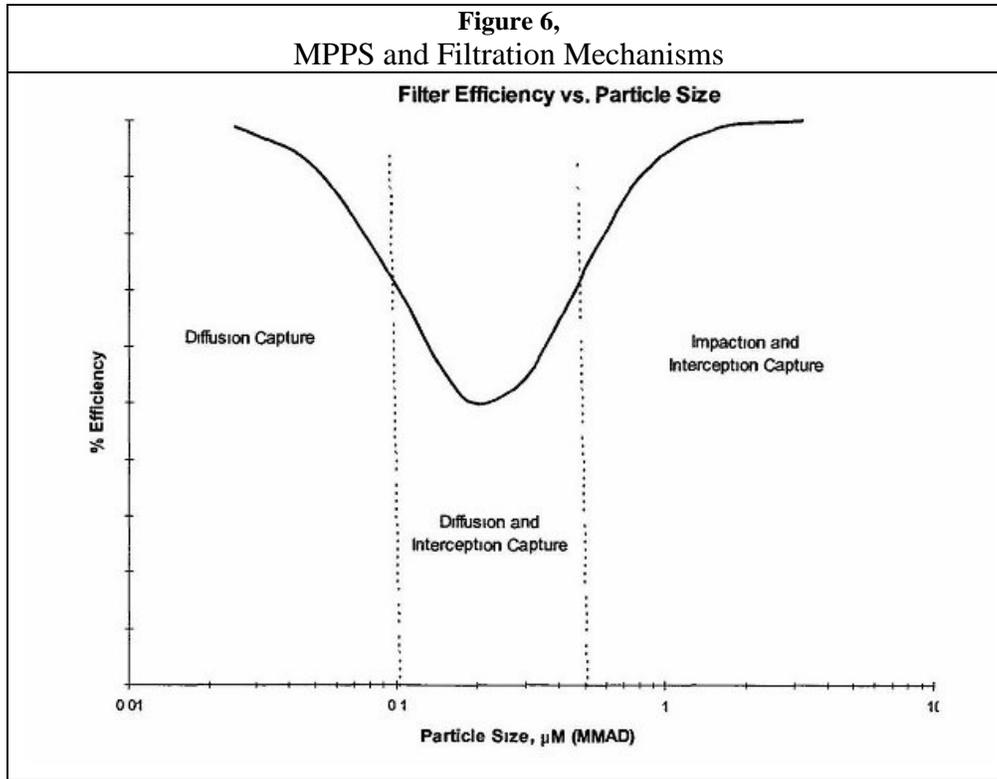
i. The original method consisted of impregnating a blend of wool and synthetic fibers with wood resin, which is then dried and energized by a mechanical needling process. This creates a positive charge on the fibers and a negative charge on the resin. Unfortunately, this mechanism is not effective for oil mist or atmospheres with high humidity, which dissipate the electrostatic charge.

ii. In the newer method, electret fibers have permanent, strong electrostatic charges embedded inside plastic fibers during processing. Fibers maintain a positive charge on one side and an equally negative charge on the other side. Besides attracting oppositely charged particles to them, electret fibers polarize neutral particles by attracting the oppositely charged dipole to the fiber. They are less affected by high humidity, heat, and oily particles. Also, see Section VI.A.5. concerning nanoparticles.

f. Figure 6, illustrates filter efficiency of 95% filters. According to the “single fiber filtration theory,” the most penetrating particle size (MPPS) is in the range of 0.1 to 0.4 microns with 0.3 micron particles producing the worst filter efficiency.

i. The MPPS is illustrated in figure 6 (Figure 6 is courtesy of Tom Nelson, from Nelson Industrial Hygiene Services, Inc.) as the lowest point on the filter efficiency curve. In this size range, none of the filtration mechanisms dominate particle capture. However, for particles of this size the filters are still 95% efficient. Particles larger and smaller than 0.3 microns are very efficiently filtered by N95 filter media. The filters are more than 99% efficient on either side of the 0.3 micron dip in efficiency.

ii. Field industrial hygienists often have to decide between selecting a 95% versus a 100% efficient filter especially when the particulate contaminant is in the most penetrating particle size range. Appendix B provides guidance on selecting the appropriate filter efficiency for 0.1 to 0.4 micron sized particles.



3. 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. A partial list of filter degrading oils includes mist from the following oils: alboline; white mineral oil; bayol F; blandlube; drakeol; paraffin oil; liquid petrolatum; water-insoluble petroleum-based cutting oils; hydraulic oil; lubricating oil; drawing oil; crystal 325; cable oil; drawing oil; engine oil; heat-treating oils; dioctyl phthalate; corn oil; and transformer oil.

a. N-series (i.e., Not resistant to 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:

- i. Extended use will not degrade the filter efficiency below the efficiency level specified in 42 CFR 84, or
- ii. 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).

iii. 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., Resistant to oil), like N-series filters, should in general be used and reused subject only to considerations of hygiene, damage, and increased breathing resistance. However, R-series 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 with N-series filters, 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.

i. NIOSH guidance concerning 42 CFR 84 particulate respirators is provided in reference 4, which may be downloaded from this [website link](#).

ii. Additional guidance on these particulate respirators is available in reference 5, which may be downloaded from [NIOSH Respirator User Notice of 2 May 1997](#). Other NIOSH documents can be ordered from the [NIOSH publication web site](#).

4. Change schedules for particulate respirators. OSHA does not require establishing change schedules for particulate respirators. However, since N and R filters must be replaced before 200 mg loading is reached, change schedules can be calculated if we know the workplace concentration and the daily breathing volume. NIOSH estimates that a typical worker inhales 10 m³ air per day. This equates to a 20 lpm breathing or work rate. This information can be used to determine when N and R filters will become loaded with 200 mg. For example: What is the estimated filter change schedule for an operation in which the Upper Tolerance Limit (UTL_{95%, 95%}), was 8 mg/ m³ for total dust ([Particulates not otherwise regulated](#))? The UTL_{95%, 95%} is the concentration below which we are 95 percent confident that 95 percent of exposures occur. Since no oil is present, a half mask respirator equipped with N95 filters was selected for protection.

a. Example: Calculate daily filter loading by multiplying 8 mg/m³ exposure by the 10 m³ air/day breathing volume. This equals 80 mg/day. Next, calculate how many days it takes to load 200 mg on the filters by dividing 200 mg by 80 mg/day. This equals 2.5 days, therefore, change filters every 2.5 days or earlier if breathing starts to be difficult or filters become damaged or unsanitary. This same logic can also be applied to R filters to estimate service life and establish filter change schedules. If P filters are used, replace them according to respirator manufacture's recommendations.

5. Respiratory Protection Against Nanoparticles. Nanoparticles are defined as having at least one dimension between 1 and 100 nanometers (nm). Because of their small size and large surface area, they may be more biologically reactive than larger particles of similar chemical composition.
- Reference 6 confirms that NIOSH-approved N95 filtering facepiece respirators provide filtration performance greater than 95% against 4 - 30 nm size particles and that P100 filtering facepiece respirators provide filtration performance greater than 99.97% against 4 - 30 nm size particles.
 - However, when a large percentage of the nanoparticles are in the 50 to 100 nm range, the [NIOSH Science Blog, of 7 December 2011](#) recommends wearing respirators with 99 or 100-class filters.
 - Detailed information about respirator performance against nanoparticles is in the “Respirator Toolbox” under the NMCPHC [Industrial Hygiene](#) homepage.
6. Welding Spark Resistant Filters. There is special matter that must be taken into consideration during the process of respirator selection for welding operations, which is the sparks produced during welding can enter filters and set the filtering media on fire (Figure 9). Respirator manufacturers make specially designed filters that are shielded to prevent sparks from entering into the filter media. There are also plenum respirators with the filters worn on the back to avoid sparks.

Figure 9
Burned Filters From Welding Sparks



B. Gas and vapor removing air-purifying respirators. Gas and vapor removing air-purifying respirators, remove specific individual contaminants or a combination of contaminants by catalytic reaction or sorption.

1. 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.

a. 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.

b. 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.

2. Sorption is the process in which one substance takes up or holds another. In respirator chemical cartridges, sorption occurs by vapors being incorporated into a sorbent material or adhering to the sorbent surface. The sorbent in respirator cartridges or canisters (e.g., activated charcoal) is the material doing the sorption. The sorbate is the vapor contaminant being captured. Types of sorption include adsorption and absorption.

a. In adsorption, the contaminant adheres to the surface of the sorbent. Therefore, 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 (one teaspoon of activated charcoal has a surface area approximately equal to the surface area of a football field). 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 (like a bath sponge). 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. There are two types of adsorption, physisorption and chemisorption.

i. Physisorption is a reversible surface attraction, resulting from physical force interactions between sorbent and sorbate. The bonding is by weak [Van der Waals - type forces](#) and it is easy to separate the sorbent and sorbate especially for organic compounds with low boiling points. For example, heating will drive the gas or vapor off the sorbent. Another mechanism is preferential physisorption, 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. That is why the service life of chemical

cartridges is shorter in humid environments. Physisorption is the main mechanism for capturing organic vapors on pure activated charcoal.

ii. Chemisorption is similar to physisorption and is used to capture volatile inorganic substances (e.g., acid gases and ammonia) but results from chemical bonding between the sorbent and the sorbate. The bonds can be either ionic or covalent. The sorbent surface is 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.

(i) It is interesting to note that since mercury has no warning properties original mercury vapor cartridges had end-of-service life indicators (ESLIs) that changed color as the sorbent became saturated.

(ii) Since ESLIs were located on the front of the cartridges, the cartridges had to be worn in a plenum mounted on the belt so that the user could observe the ESLIs. More recently, however, ESLIs have been located on the upper edges of cartridges so that they are visible to the respirator wearer while cartridges are worn on the facepiece.

b. In absorption, the absorbed vapor is held in the bulk of the solid rather than on its surface. The contaminant actually penetrates into the sorbent where it is held there chemically. Absorption is a slower vapor removal mechanism than adsorption because it involves a chemical reaction between the sorbent and the sorbate. 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[®]. However, [Whetlerite[®] contained chromates](#) that could leach out of the sorbent and on 1 September 1990, NIOSH rescinded the approval of chromium-impregnated cartridges.

3. The sorbent material of chemical cartridge respirators is available in a variety of sizes, including face mounted cartridges, chin mounted canisters, and front or back mounted industrial gas mask canisters. Although these sorbent containers vary considerably in the amount of sorbent material that they hold, the maximum use concentration of all chemical cartridge respirators is determined by the lesser of either the calculated maximum use concentration (MUC) or a MUC established by respirator manufacturers. The MUC is calculated as follows: $MUC = APF \times OEL$. The IDLH concentration always takes precedence over the calculated MUC.

4. Reference 1 requires establishing a change schedule for chemical canisters and cartridges based on objective information that will ensure that they 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 written respirator program for each operation. 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.

- a. Alternatively, either atmosphere-supplying respirators, or, where they are available and appropriate for the workplace, air-purifying respirators equipped with ESLIs can be worn as protection against gases and vapors.
- b. The article entitled *Chemical Cartridge Change Schedules* includes a method for establishing and implementing respirator cartridge change schedules for mixtures of chemicals that incorporates those factors, which are problematic to mathematical modeling (i.e., humidity, temperature, atmospheric pressure, breathing rate, and varying concentrations of multiple contaminants) and is provided under the NMCPHC [Industrial Hygiene](#) homepage.

C. In combination particulate, vapor, and gas-removing respirators, the filter may be permanently attached as part of the cartridge/canister or may be a separate replaceable filter used with the sorbent containing component of the cartridge. Combination particulate/gas and vapor removing respirators combine the respirator characteristics of both particulate and gas/vapor removing air-purifying respirators and are approved under 42 CFR 84 (reference 2) under approval schedule TC-84A because the particulate filter is the cartridge component providing the least protection for the respirator wearer. Unlike respirators approval schedules in 30 CFR 11, 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 used.

1. CBRN air-purifying respirators have combination particulate/gas and vapor removing canisters. Canisters of CBRN non-powered full face, air-purifying respirators and CBRN PAPRs are both tested against the same representative test agents and at the same concentrations. To reduce the number of CBRN certification tests, NIOSH has grouped the respiratory hazards into seven families of chemicals. NIOSH research determined which representative chemical(s) from each family to test canisters against during the CBRN certification process. Thus by testing respirator canister filtration media against 11 representative test agents, respirators can be approved as protection against a total of 139 chemical warfare agents and TICs/TIMs.

2. CBRN canisters are tested at laboratory service life challenge concentrations that are normally 2, 3, or 10 times greater than the IDLH concentrations. This ensures the escape protection against atmospheres at or greater than IDLH. The particulate filtering component of CBRN combination canisters are per 42 CFR 84 criteria for class P-100 filters. For a detailed discussion of CBRN respirators and certification testing, see the article on this topic in the “Respirator Toolbox” under the NMCPHC [Industrial Hygiene](#) homepage.

D. Powered Air-purifying Respirators (PAPRs). PAPRs 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 temperatures³. PAPRs are manufactured with either tight-fitting or loose fitting respiratory inlet coverings. Tight fitting PAPRs include

³ However, according to the [OSHA Technical Manual on Heat Stress](#) “Air flowing past the body can cool the body if the air temperature is cool. On the other hand, air that exceeds 35°C (95°F) can increase the heat load on the body.” This is also the case when wearing a PAPR.

facepieces (half-face and full-face) or tight fitting hoods that seal tightly at the neck. Loose fitting PAPRs include hoods and helmets that do not seal tightly at the neck, along with loose fitting facepieces, which form a partial seal with the face and do not cover the neck and shoulders. Tight-fitting PAPRs supply a minimum of 4 cubic feet per minute (CFM) [equal to 115 liter per minute] of air to the user. Loose fitting PAPRs supply a minimum of 6 CFM [equal to 170 liter per minute]. NIOSH is in the process of developing new certification testing criteria for approval of industrial use PAPRs. Details can be found at the following [NIOSH website](#). PAPRs with loose fitting hoods and helmets may be worn by individuals when conditions like facial hair prevent a good facepiece to face seal as long as these PAPRs provide the required level of protection. PAPRs with “loose fitting facepieces” have partial sealing surfaces at the temple, cheek, or chin that help maintain positive pressure inside the facepiece. Reference 7 states that PAPRs with loose fitting facepieces can be worn with facial hair as long as facial hair does not interfere with valve or function of the respirator.

1. Currently, NIOSH requires 42 CFR 84 magenta (purple) approval labeling for P100 filters and industrial PAPR HE (HEPA) filters, both of which can be mechanical or electrostatic filters. P100 and industrial PAPR HE filters are tested against an oil aerosol.
 - a. However, unlike negative pressure air-purifying respirator P100 filters, which are tested against 42 CFR 84 filter criteria to ensure that they are protective against **charge-neutralized** oil aerosols with loading of 200 mg; PAPRs for industrial use must be equipped with HE filters meeting 30 CFR 11 HEPA filter testing criteria, which was transferred unchanged to 42 CFR 84. The equipment that NIOSH used to certify the high-efficiency PAPR filters under 30 CFR 11 did **not contain an aerosol neutralizer**; therefore, the challenge aerosol was electrically charged.
 - b. Reference 8 showed that mechanical industrial PAPR filters showed no significant difference in performance from the charged and uncharged DOP aerosol when loaded with 2,000 mg or more of DOP aerosol. However, electrostatic industrial PAPR filters showed significantly decreased performance against the neutralized DOP compared with the charged DOP aerosol when loaded with 2,000+ mg of DOP.
2. Since all high-efficiency industrial HE PAPR filters are required to be a magenta (purple) color, industrial PAPR users cannot tell by visual inspection if their PAPR is equipped with electrostatic filters. Also, currently, NIOSH does not limit electrostatic high-efficiency HE PAPR filters for use only against non-oil aerosols. NIOSH is [developing a PAPR standard](#) that will resolve this issue. Until the PAPR standard is promulgated, RPPMs should restrict the use of electrostatic HE industrial PAPR filters in oil aerosol atmospheres based on filter loading tests and recommendations of PAPR filter manufacturers.

Note: Replace PAPR high efficiency filters when the PAPR the airflow indicator shows that the minimum airflow cannot be maintained.

E. CBRN PAPRs. Paragraph 2606.c.1.(d) of reference 3 states that until NIOSH CBRN approved PAPRs are available, personnel assigned to secondary decontamination stations at MTFs and military security personnel stationed at the decontamination corridor will wear full-face rubber PAPRs equipped with combination organic vapor, acid gas, and HEPA filters. Full face PAPRs were chosen because at that time, the *Draft OSHA APF Standard* granted full face PAPRs an APF of 1,000. Paragraph 2606.c.1.(d) further states that once NIOSH CBRN approved PAPRs are available, they will be the only air-purifying respirators permitted for use during these operations. MSA now has a full face NIOSH CBRN approved PAPR called the MSA Responder CBRN PAPR (Figure 10). This PAPR is approved with both



Figure 10
MSA Responder CBRN PAPR

the MSA Millennium and the MSA Ultra Elite tight-fitting facepieces. Because of its similarity to the Navy military gasmask (MCU-2/P), the Navy issues the MSA Millennium as the respirator component of Level C first responder protective ensembles. Personnel who are already fit tested with MSA Millennium gasmasks or the MSA Ultra Elite facepiece will not have to be fit tested for the MSA Responder CBRN PAPR equipped with the same facepiece. Please see the following website for more information on the [MSA Responder CBRN PAPR](#). Also, see the following website for a list of [NIOSH CBRN approved PAPRs](#). The following discussion describes why “full face” CBRN PAPRs are the respirators of choice for MTF secondary decontamination stations and decontamination corridor security personnel.

1. The [NIOSH CBRN PAPR approval standard](#) sets forth CBRN approval criteria for both tight-fitting PAPRs and loose fitting PAPRs. NIOSH classifies both full face CBRN PAPRs and tight neck-sealing hooded CBRN PAPRs as tight-fitting PAPRs. The NIOSH CBRN PAPR approval standard has provisions for granting CBRN approval to loose fitting PAPRs, which must not to be confused with industrial loose fitting facepiece PAPRs. Under the CBRN PAPR approval standard, loose fitting PAPRs can be hooded devices. Tight sealing hooded CBRN PAPRs seal tightly around the neck (see Figure 3); but loose fitting CBRN PAPRS do not have any tight sealing surface.
2. Loose fitting CBRN PAPRs are not tested as stringently as tight-fitting CBRN PAPRs. Loose fitting PAPRs are not subjected to liquid mustard agent permeation testing as is required for the tight fitting CBRN PAPRs. Also, the canisters of tight fitting CBRN PAPRs are tested at twice the challenge concentrations as are the loose fitting CBRN PAPRs. Another distinction is that the Laboratory Respiratory Protection Level (LRPL) [NIOSH quantitative fit testing certification criteria]. The tight fitting CBRN PAPRs are tested both with the blower running and then again with the blower off. In contrast, the loose fitting CBRN PAPRs are only tested with the blower running. If power is lost to loose fitting PAPRs the wearer cannot draw

contaminated air through the filters; but if power is lost to tight fitting full face PAPRs the wearers' negative pressure created during their inhalation will still draw contaminated air through the air-purifying filters.

3. Also, hooded PAPRs only have an APF of 25 unless proven by empirical testing as having a higher APF. In contrast, every tight-fitting full face PAPR that has received NIOSH CBRN approval is awarded an APF of 1,000 - in other words, it can be worn into atmospheres up to 1,000 times the OEL.

F. Multi-functional air-purifying respirators. These are respirators are a combination of a negative pressure air-purifying respirator and a PAPR. Basically, these are tight-sealing PAPRs that are also approved to operate in negative pressure mode in case the motor fails. The tight seal allows the wearer to draw air through the filters when the motor is not running by producing a negative pressure inside the respiratory inlet covering during inhalation. They are also used in law enforcement for clandestine operations, when the sound of the PAPR motor is undesirable during stealthy movement.

G. COLOR CODING. ANSI Z88.7-2001 replaced ANSI K13.1-1973 as the color coding standard for air-purifying respirator canisters, cartridges, and filters. ANSI Z88.7 was revised in 2010 (reference 9)) and the new color codes are listed in Table 2. Although the color coding scheme of ANSI Z88.7 provides a rapid means of respirator cartridge identification, make the final decision on respirator cartridge selection by consulting the approval information provided on the NIOSH certification labels.

**TABLE 2
RESPIRATOR FILTER COLOR CODING ^A**

CONTAMINANT(s)	COLOR CODE ^B	CONTAMINANT EXAMPLES ^C
Acid gases	White	chlorine (Cl), chlorine dioxide (ClO ₂), hydrogen sulfide (H ₂ S), hydrogen chloride (HCl), sulfur dioxide (SO ₂), hydrogen fluoride (HF)
Organic vapors	Brown	most organic vapors [e.g., xylene (C ₆ H ₄ (CH ₃) ₂), toluene (C ₆ H ₅ (CH ₃))]
Basic gases	Green	ammonia (NH ₃), methylamine (CH ₃ NH ₂)
Formaldehyde	Tan	formaldehyde (HCHO)
Carbon monoxide	Blue	carbon monoxide (CO)
Mercury Vapors	Orange	mercury (Hg)
Other vapors and gases or combinations not listed above	Olive	nitrogen oxides (NO _x), hydrogen cyanide (HCN), methyl bromide (CH ₃ Br), ethylene oxide ((CH ₂) ₂ O), arsine (AsH ₃)
All aerosols (High Efficiency filter)	Purple	dusts, mists, fumes, droplets, bacteria, viruses, radionuclides
CBRN	Black	See note D.

^A Adapted from ANSI Z88.7-2010
^B Multiple contaminant filtering elements, except for CBRN, have all applicable colors.
^C Not all cartridges or canisters are suitable for all contaminants within the contaminant class. See the filter labels for specific contaminant designations for which the filtering element is suitable.
^D CBRN canisters are suitable for many of the contaminants within all of the classes listed.

Note: NIOSH is not required to use or accept ANSI Z88.7. The NIOSH color coding requirements for canister and cartridge labels are in paragraphs 84.113 and 84.193 of 42 CFR 84, respectively, which are based on ANSI K-13-1973. See the [NIOSH 17 January 2008 letter](#) for the NIOSH latest color coding requirements.

VII. ATMOSPHERE-SUPPLYING RESPIRATORS

Atmosphere-supplying respirators provide a respirable atmosphere to the respirator wearer that is independent of the ambient air. Atmosphere-supplying respirators include supplied-air respirators and self contained breathing apparatus.

The respirable atmosphere provided by these respirators must be of at least Grade D quality described in reference 10. Fatalities have resulted from accidentally using nitrogen or another inert gas (e.g., argon, helium, neon) in atmosphere-supplying respirators. The fatalities are due to asphyxiation of the wearer caused by the inert gas depleting arterial carbon dioxide, which is the primary trigger for stimulating inhalation.

A. Supplied-air respirators. Supplied-air respirators, also called airline respirators, provide breathing air independent of the environment via air hoses. Airline respirators must not be worn in IDLH environments. Because air supply from the hose can be interrupted (e.g., severed, pinched, or disconnected hose), airline respirators are limited to operations in which the wearer can safely escape without the respirator. Also, airline hoses restrict the wearers' movement. Airline respirators are used in place of chemical cartridge, air-purifying respirators when a cartridge change schedule has not been established and implemented or there are no appropriate end-of-service-life indicator respirators. Supplied-air respirators are classified into the following subgroups: Type A and AE, Type B and BE, Type C and CE.

1. Type A and AE, Type B and BE supplied-air respirators are obsolete but are included here because they are still encountered in industrial workplaces and even aboard Navy ships. According to [NIOSH Certified Equipment List](#), "*Any "obsolete" respirator in use that carries NIOSH/MSHA or NIOSH approval and has been maintained in accordance with approved designs and specifications, continues to be approved until discarded or scrapped due to physical damage, lack of maintenance, or unavailable repair parts.*"

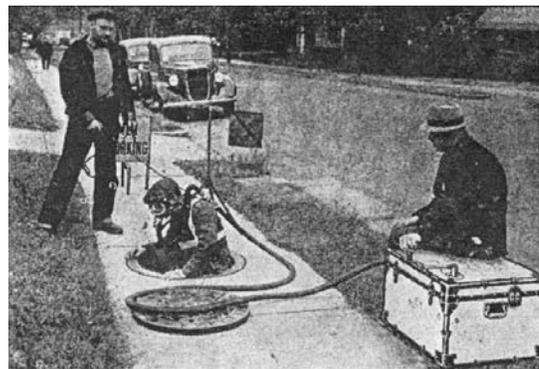


Figure 11

MSA Type A Hose Mask & Blower

a. Type A has a tight fitting facepiece with a large diameter hose (7/8" ID), and a blower that can be operated either electrically or hand cranked. The blower takes fresh air from a source outside the contaminated atmosphere and blows it into the user's facepiece. The hose length is limited to 300 feet and is only approved for non-IDLH atmospheres. Figure 11 from the [Sewer History Through the Ages](#) website photo collection is a picture of circa 1930, MSA hose mask with a hand cranked blower being used for sewer entry.

i. Type AE is the same as Type A, but also has abrasive blasting approval.

ii. Per reference 11, the Type A respirator lost approval for entry into IDLH atmospheres in 1977.

b. 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 hose. Note the metal spike in Figure 12 used to anchor the air inlet funnel in an area with respirable atmosphere. Fine wire mesh covered the air inlet funnel to prevent large particles and insects from entering the hose.



Figure 12
MSA Type B Hose Mask

i. Type BE is the same as Type B, but also has abrasive blasting approval.

ii. The NMCPHC wrote to NIOSH requesting that they revoke the hose mask and hose mask with blower certifications since, based on their antiquated technology, their mode of operation provides inadequate protection. [NIOSH Docket 083 – A Supplied Air Respirator](#) initiated a program to update portions of 42 CFR 84, which include eliminating Type A, AE, B, and BE hose mask respirators along with eliminating demand-type airline respirators. This docket will initiate rulemaking to re-designate the nomenclature of Type C and Type CE supplied-air respirators as “Airline Type” respirators.

2. Type C airline 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 air supply hoses and quick disconnect fittings are parts of the approved respirator assembly and substituting other hoses voids the NIOSH approval. The operating pressure and hose lengths are specified by the respirator manufacturer. Care must be taken not to allow contamination of airline hoses with materials used in the workplace because these chemicals can permeate through the wall of airline hoses. This condition could allow the permeated chemical to evaporate inside the airline hose and then be inhaled by the respirator wearer. Type C respirators operate either in continuous flow, demand, or pressure-demand modes. Type CE has abrasive blasting approval and is equipped with additional protection for the wearer against impact of rebounding abrasive material.



Figure 13
Continuous Flow Airline

a. In continuous flow Type C respirators (Figure 13), 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 hoods, helmets, and loose fitting facepieces, minimum flow rate is 6 CFM and the maximum flow rate is 15 CFM. NIOSH can approve continuous flow airline respirators with vortex tubes for heating or cooling supplied air flowing into the facepiece. Some airline respirators are designed to be worn inside of encapsulating suits.

Note: In many of their publications, NIOSH and OSHA use the term “*other positive pressure mode*” to describe certain types of airline respirators and closed-circuit SCBA. According to reference 12, this term is used to describe continuous flow airline respirators, which meet NIOSH pressure demand certification requirements and for which NIOSH approves as pressure demand SAR.

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.

i. Demand regulators (Figure 14) consist of the regulator housing, diaphragm, inlet port, outlet port to the facepiece, admission valve, and lever 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 lever arms up against the admission valve.

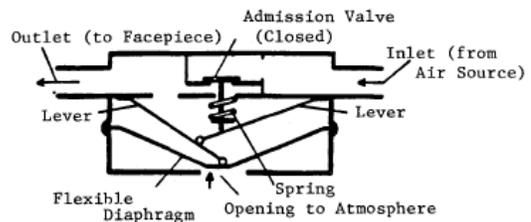


Figure 14
Demand Airline Regulator

ii. As the admission valve is pushed up, air flows from the air source through the regulator to the facepiece. Air flow stops when the user exhales.

iii. Figure 14, shows the demand regulator during exhalation, which causes the admission valve to close. When the user exhales, positive pressure builds up in the regulator. This causes the diaphragm and the lever arms to fall down, relieving pressure on the admission valve. The admission valve closes and cuts off air flow to the facepiece. The cycle repeats when the user inhales again.

iv. Demand airline respirators are no longer manufactured but are still available. Along with hose masks and hose masks with blowers, demand airline respirators should not be worn because of the low level of protection provided to the wearer.

c. The pressure demand Type C regulator maintains positive pressure inside the facepiece at all times. The pressure demand regulator housing consists of a diaphragm, air inlet port from the air supply, air outlet port to the facepiece, admission valve, and lever arms.

i. There is usually a spring located between the diaphragm and the regulator case (See the gold-colored, dome-shaped regulator case in Figure 15, housing this spring.). This spring holds the admission valve slightly open, allowing for continual air flow into the facepiece. When this positive pressure is reduced by inhalation, breathing air is admitted to the facepiece at higher pressure.

ii. Air would continually flow into the facepiece except that all pressure demand respirators have a spring located in the special facepiece exhalation valve that maintains approximately 1.5 to 3 inches of WG (1 inch water gauge = 0.036 psi) positive pressure in the facepiece at all times. This spring releases any excess pressure in the facepiece through the exhalation valve instead of allowing the excess pressure to escape through the facepiece sealing surface.



Figure 15
Pressure Demand Airline

B. Self-Contained Breathing Apparatus (SCBA). SCBA provide the wearer with a large independent supply of breathable air that is carried by the wearer. Full face pressure-demand SCBAs are approved for IDLH atmospheres. SCBA 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 CO₂ is removed and O₂ 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). In general, closed-circuit SCBA produce more heat, resulting in inspired air being hotter than open-circuit SCBAs.

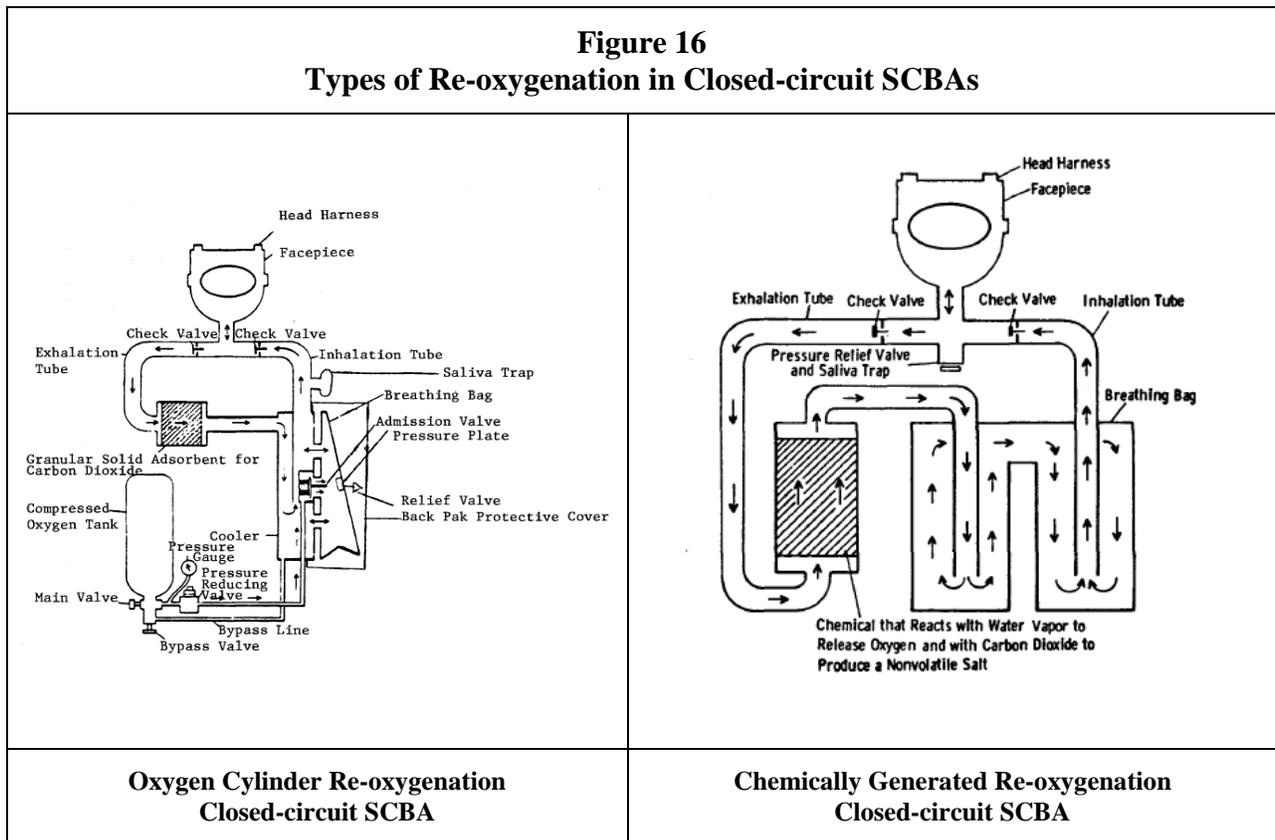
a. Most closed-circuit SCBAs are negative pressure respirators because they operate in the demand mode. However, there are positive pressure units. Per reference 12, NIOSH has approved several closed-circuit SCBA as pressure-

demand SCBA using the same testing criteria as used for certifying open-circuit pressure-demand SCBA. OSHA and NIOSH often use the term “*other positive pressure mode*” to describe pressure demand closed-circuit SCBA. The confusion appears to have started for closed-circuit SCBA in the 1985 Federal Register (reference 13), which stated,

“*Unlike the certification of open-circuit breathing apparatus under the requirements of 30 CFR 11 (Subpart H), which may be for demand (negative pressure) or pressure-demand (positive pressure) apparatus, the closed circuit certifications are classified as to whether they are negative or positive pressure.*”

b. Reference 12 clarifies this issue by stating, “*While some of the approval letters issued for closed-circuit SCBAs have included the "positive pressure" terminology identified in the Federal Register Notice, that is not a protection listed on the approval label for which the NIOSH approval is granted. The criteria that we use to evaluate "positive pressure" operation are the performance requirements for Pressure Demand operation. Both open-circuit and closed circuit devices meeting these criteria should be approved and labeled as Pressure Demand SCBA.*”

c. As shown in Figure 16, re-oxygenation is accomplished by either a cylinder of compressed oxygen or by chemical reaction. In general, the breathing air from closed-circuit SCBA is hotter than open circuit SCBA breathing air.



d. According to the [Positive-Pressure Closed Circuit Self-Contained Breathing Apparatus Docket](#), NIOSH limits using positive-pressure closed-circuit self-contained breathing apparatus, which use pure oxygen to atmospheres, which do not involve exposure to open flames or high radiant heat.

i. With compressed oxygen, the breathing air is supplied from an inflatable bag. Exhaled air passes through a scrubber where CO₂ is removed using either sodium hydroxide or potassium hydroxide sorbent media. Removal of the CO₂ 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 re-inflated. The re-oxygenated air is sent back to the facepiece. Only the oxygen is replenished. Other air constituents, except CO₂, are recirculated.

ii. With chemically generated oxygen, potassium superoxide reacts with water vapor in the exhaled breath to generate oxygen ($4 \text{ KO}_2 + 2 \text{ H}_2\text{O} \rightarrow 4 \text{ KOH} + 3 \text{ O}_2$). CO₂ is removed through reaction with potassium hydroxide ($2 \text{ KOH} + \text{ CO}_2 \rightarrow \text{ K}_2\text{CO}_3 + \text{ H}_2\text{O}$) and with potassium carbonate ($\text{ K}_2\text{CO}_3 + \text{ CO}_2 + \text{ H}_2\text{O} \rightarrow 2 \text{ KHCO}_3$). 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 Navy's OBA works this way. Per reference 3:

- (i) OBAs are used only for damage control and firefighting aboard ships and for training fire fighters. It is a military-unique item, and is not approved by NIOSH/MSHA for industrial use.
- (ii) OBAs are being replaced by NIOSH approved full face pressure demand SCBAs, which are compliant with NFPA 1981 for firefighting and NIOSH CBRN approval.

2. In open-circuit SCBAs (Figure 17), 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 Grade D quality air that is carried on the back. NIOSH weight restrictions limit the maximum service life. SCBA service times vary and are available in durations over an hour. The actual service life is usually less than the NIOSH rated service time. 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. Per reference 1, full



Figure 17
Pressure Demand Airline

facepiece pressure-demand SCBAs have an assigned protection factor of 10,000. In contrast, full facepiece demand SCBAs have a protection factor of only 50. According to paragraph 1507 of reference 3, respirators used for firefighting shall be NIOSH approved, full facepiece, pressure demand SCBA equipped with air cylinders rated for at least 30 minutes and meeting NFPA 1981 compliance (see Section XII.B.3.a.).

- a. There are no half mask SCBAs approved for entry into hazardous atmospheres. Almost all SCBAs are equipped with full facepieces. However, there is a hooded demand SCBA and a hooded pressure demand SCBA on the market, both of which have tight-fitting neck seals. Neither can be worn for firefighting and only the pressure demand model can be worn into IDLH atmospheres.
- b. Both require fit testing by converting them into the air-purifying respirator mode. Even though they are hooded devices, neither can be worn with facial hair that interferes with the nose cup or tight-fitting neck seal. Please see the following website for [NIOSH policy](#) on this issue.

3. NIOSH CBRN SCBA. The following website link lists [NIOSH CBRN approved SCBAs](#). Paragraph 2606.c.(1)(a) of reference 3 requires using NIOSH CBRN approved SCBAs with 60 minute service life.

NIOSH CBRN SCBA certification requires NFPA 1981 compliance as a component of NIOSH CBRN SCBA approval. Likewise, changes to the 2007 edition of *NFPA 1981, Standard on Open-Circuit SCBA for Emergency Services* require NIOSH CBRN SCBA approval as a component of NFPA 1981 compliance. The combined effect of these two standards is that NFPA 1981 compliance and NIOSH CBRN approval shall be issued jointly. Now, both NFPA 1981 compliant SCBA and NIOSH CBRN approved SCBA shall pass a three tiered approval, which includes initial NIOSH 42 CFR Part 84 approval, followed by joint issuance of NFPA 1981 compliance certification, and NIOSH CBRN approval. One solution is for NIOSH CBRN SCBA approval applications and NFPA 1981 SCBA compliance certification applications to be accepted at the same time as 42 CFR Part 84 approvals. Please see the following website for more information on [NFPA 1981 compliance certification and NIOSH CBRN SCBA approval](#).

Note: NIOSH 42 CFR Part 84 approval requires testing SCBA at 40 lpm. In contrast, NIOSH approved/NFPA 1981 compliant SCBA must pass testing at 100

4. Escape-only SCBA. 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 have half mask, full face, hooded, or mouthpiece respiratory inlet coverings. NIOSH approval requires mouthpiece respirators to be equipped with noise clips to prevent inhaling hazardous atmospheres. The Scott emergency escape breathing device (EEBD P/N 802300-14) is a closed-circuit, oxygen generating SCBA especially developed for the Navy. This respirator was designed to be used

only aboard ship for escape from a hazardous atmosphere. **It must never be used for entry into a hazardous atmosphere.** The Scott EEBD has been phased out and replaced by the NIOSH approved (TC-13F-386) [OCENCO M-20.2 Self Contained Self Rescuer](#) (Figure 18), which is a 10 minute closed-circuit, demand, mouthpiece respirator using compressed oxygen for oxygen replenishment.



Figure 18
OCENCO M-20.2

a. NIOSH CBRN Escape-Only Respirators. Currently, all NIOSH CBRN approved escape respirators are air-purifying devices and do not provide oxygen and therefore will not provide protection against oxygen deficient atmospheres.

b. Hooded CBRN approved escape-only respirators are not fit tested. See the following website for a list of [NIOSH CBRN approved escape respirators](#).

C. Multi-functional atmosphere-supplying respirators. Combination Type C/SCBA (Figure 19) are Type C supplied-air respirators, either demand or pressure-demand, in combination with an SCBA cylinder as an auxiliary air supply. Continuous flow supplied-air respirators are not compatible for use with an auxiliary SCBA. If SCBA breathing air were delivered to the facepiece in the continuous flow mode, then the auxiliary air supply would be depleted too rapidly for escape. Pressure demand, multi-functional Type C/SCBAs are approved for entry into IDLH atmospheres. 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 shall 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. To escape from an IDLH atmosphere if the airline function fails, the respirator wearer must switch to the self-contained air supply, disconnect the air supply hose, and leave the area.



Figure 19
Combination Airline/SCBA

D. Combination Type C/air-purifying respirators (Figure 20 [*Note the dome shaped pressure demand regulator spring housing*]). These respirators are approved as air-purifying cartridge respirators. They can be particulate filter, 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 approved for:

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

VIII. NULLIFICATION OF RESPIRATOR APPROVAL.

A. NIOSH approval is issued only to specific and complete respirator assemblages after NIOSH tests the respirator assemblage and it is found to comply with the requirements under 42 CFR 84 and after the manufacturer's quality assurance and control plan is determined to be satisfactory (Please see following [NIOSH website link](#)). A respirator's approval is nullified when:

1. Unapproved components are used (e.g., components between different types or makes of respirators are mixed, such as brand X cartridges on brand Y respirators or brand X supplied-air hose on brand Y airline respirator).
2. Non-NIOSH authorized additions or changes to the respirator void the approval. Further clarification on this important issue is found in the NIOSH [Respirator User Notice of May 4, 2007](#), which states:

"...users of NIOSH approved respirators are cautioned against interchanging subassemblies or making unapproved modifications to their respirators. Respirators which have been modified by the interchanging of subassemblies or other deviations using parts not produced and distributed under the respirator manufacturer's controlled system, no longer meet the definition of being approved as a NIOSH certified respirator and the use of the NIOSH approval label is not authorized for that unit."

3. A respirator is used in atmospheric concentrations for which it is not approved. An example is airborne concentrations exceeding either the calculated maximum use concentration (MUC) or the MUC established by the manufacturer.
4. A 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.

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Figure 20
Combination Airline/Air purifying

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Appendix A					
Assigned Protection Factors^D					
Type of respirator ^{A, B}	Quarter mask	Half mask	Full facepiece	Helmet/hood	Loose fitting facepiece
Air-purifying Respirator	5	10	10/50 ^G	————	————
Filtering Facepiece Respirators	————	5	————	————	————
Powered Air-purifying Respirator (PAPR)	————	50	1,000	25/1,000 ^C	25
Supplied-Air Respirator (SAR) [Airline Respirator]^E					
Demand mode	————	10	10/50 ^G	————	————
Continuous flow mode	————	50	1,000	25/1,000 ^C	25
Pressure-demand or other positive-pressure mode (i.e., Continuous flow SAR meeting NIOSH pressure demand requirements are approved as pressure demand SAR.)	————	50	1,000 ^F	————	————
Self-Contained Breathing Apparatus (Open & Closed Circuit SCBA)					
Demand	————	10	10/50 ^G	50	————
Pressure-demand	————	————	10,000	10,000	————
<p>^A Employers may select respirators with greater protection factors than what is required by the hazard.</p> <p>^B APFs are only applicable if all elements of an effective respirator program are established and enforced in accordance with the Respirator Chapter of OPNAVINST 5100.23 Series.</p> <p>^C The employer must have evidence that testing of these respirators demonstrates performance at a level of protection of 1,000 or greater to receive an APF of 1,000. OSHA accepts respirator manufacturers' empirical test data demonstrating that hooded respirators provide an APF of 1,000. In the absence of such testing, these respirators are to be treated as loose-fitting facepiece respirators, and receive an APF of 25.</p> <p>^D These APFs do not apply to respirators used solely for escape. For escape respirators used in association with contaminants that are regulated by OSHA substance specific standards (e.g., acrylonitrile, formaldehyde, benzene), refer to the appropriate substance-specific standards. Paragraph (d)(2)(ii) of 29 CFR 1910.134 states that <i>“Respirators provided only for escape from IDLH atmospheres shall be NIOSH certified for escape from the atmosphere in which they will be used.”</i></p> <p>^E When using a combination respirator ensure that the APF is appropriate to the mode of operation in which the respirator is being used. For example, a combination full facepiece pressure-demand SAR with an air-purifying canister would have an APF of 1,000 in the pressure-demand mode; but would have an APF of 50 in the negative pressure air-purifying mode.</p> <p>^F The protection provided by combination, full facepiece pressure-demand SARs with auxiliary SCBA is equivalent to the protection provided by full facepiece pressure-demand SCBA; therefore, the APF of 10,000 for pressure-demand SCBA applies.</p> <p>^G APF is 10 when qualitatively fit tested and 50 when quantitatively fit tested.</p>					

Appendix A

SELECTION BETWEEN 95% VERSUS 100% PARTICULATE FILTER

I. GUIDANCE FOR SELECTING BETWEEN A 95% FILTER VERSUS A 100% FILTER.

A. This guidance is for **0.1 to 0.4 micron sized particles**, which historically are the most filter penetrating sized particles⁴ in typical workplaces. Section II. of this appendix explains why higher efficiency filters don't necessarily provide increased protection.

B. This guidance requires introducing the concepts of respirator protection factor (PF) and assigned protection factors (APFs).

1. The protection factor is an expression of respirator performance based on the ratio of two measured variables, the challenge agent concentration outside the respirator (C(out)) to the challenge agent inside the respirator facepiece (C(in)), (i.e., $PF = C(out) / C(in)$).

2. APFs are defined as the workplace levels of respiratory protection provided by properly functioning and properly worn respirators or class of respirators when all elements of an effective respiratory protection program are established and are being enforced. APFs indicate the protection level of a respirator or a class of respirators. For example, the APF of 10 for half mask respirators correlates to the workplace contaminant concentration being ten times lower inside the respirator than outside – protects up to 10 times the occupational exposure limit.

3. The PF equals 100 divided by % respirator leakage ($PF = 100 / \% \text{ leakage}$). Half mask and full face, negative pressure air-purifying respirators have an assigned protection factor (APF) of 10 and 50, respectively. As shown below, these APFs equate to **10% leakage for half masks** and **2% leakage for full face respirators, assuming that there is 0% filter leakage**. To determine the filter efficiency needed, filter efficiency must also be considered as shown below:

a. First calculate the hazard ratio (HR) to determine what APF is required and therefore what class of respirator is needed ($HR = [Exposure] / OEL$);

b. Next rearrange PF equation and calculate leakage for the class of respirator:

$$(\% \text{ leakage} = 100 / APF)$$

$$(\% \text{ leakage}_{\text{(half mask)}} = 100 / 10 = 10\%)$$

$$(\% \text{ leakage}_{\text{(full face)}} = 100 / 50 = 2\%)$$

c. Then calculate total leakage by adding filter leakage and respirator class leakage. For example:

$$95\% \text{ filters have } 5\% \text{ leakage, so } (\% \text{ leakage}_{\text{(total)}} = \% \text{ leakage}_{\text{(respirator class)}} + 5\%_{\text{(filter leakage)}})$$

⁴ See Section IV.b.6. for guidance on selecting respirators for protection against nanoparticle inhalation.

d. Finally, calculate protection factor using the total % leakage

$$(PF = 100 / \% \text{ leakage}_{(total)})$$

If PF > HR then a 95% filter is sufficient;

If PF < HR then a 100% filter is required;

Examples For Selection of 95% Versus 100% Filter	
100% Filter is Required	95% Filter is Sufficient
Exposure = 250 ppm; OEL = 15 ppm	Exposure = 50 ppm; OEL = 20 ppm
HR = 250 ppm / 15 ppm = 16.7	HR = 50 ppm / 20 ppm = 2.5
Must use full face: APF = 50; Leakage = 2% % leakage = 100 / APF % leakage = 100 / 50 = 2%	Can use half mask: APF = 10; Leakage = 10% % leakage = 100 / APF % leakage = 100 / 10 = 10%
Total leakage % % leakage _(total) = % leakage _(respirator class) + 5% _(filter leakage) % leakage _(total) = 2% + 5% = 7%	Total leakage % leakage _(total) = % leakage _(respirator class) + 5% _(filter leakage) % leakage _(total) = 10% + 5% = 15%
Recalculate PF (PF = 100 / % leakage _(total)) PF = 100 / 7% = 14.3	Recalculate PF (PF = 100 / % leakage _(total)) PF = 100 / 15% = 6.7
Since PF (14.3) < HR (16.7) use a 100% filter.	Since PF (6.7) > HR (2.5) use a 95% filter.

II. HIGHER EFFICIENCY FILTERS DON'T NECESSARILY INCREASE PROTECTION.

A. NIOSH tests filters under worst case conditions of the most penetrating particle sizes and at a very high flow rate simulating very heavy work that could not be sustained more than brief periods of time. As shown in Figure 6 of Section VI. and explained above, the worst filter efficiency is around 0.2 micron sized particles. However, for particles of this size the filters are still 95% efficient. On either side of the 0.2 micron dip, the filters are more than 99% efficient.

1. Increasing filter efficiency also increases inhalation pressure. The data in Figure B-1 was collected using a controlled negative pressure fit test apparatus in an unpublished study by Tom Nelson, from Nelson Industrial Hygiene Services, Inc. and figures B-1 through B-2 are courtesy of Tom Nelson. This data shows that leakage around the facepiece seal increases with increased inhalation pressure. All classes of 95 percent filters must be 95 percent efficient to pass NIOSH certification testing at 85 liters per minute (42.5 lpm per filter for pairs of filters). Work rates

realistically expected in the workplace are 20 to 30 lpm. At these workplace breathing rates, Figure B-2 shows that 95 percent filters are between 98 to 99% efficient. According to reference 1, typical particle size in industry is much larger than the 0.2 micron size that penetrates filters most effectively. These large particles are filtered out with greater than 99% efficiency by 95% filters.

2. Because particle sizes in much of industry are large and the work rates commonly encountered in industry are relatively low, 95% filters that pass NIOSH certification testing will be essentially 100% efficient in most workplaces. Using a higher efficiency filter where it is not needed potentially increases exposure by increasing breathing resistance pressure and causing more leakage around the sealing surface by the increased negative pressure inside the facepiece. Therefore, carcinogens do not always require HEPA filters.

3. However, there are scenarios where 100% efficient filters are necessary. Examples include:

- a. Workplace operations where the contaminant particle size is the most penetrating; the hazard ratio (concentration of contaminant divided by its occupational exposure limit) is close to the assigned protection factor of the respirator; and the breathing rate is very high. In these scenarios, follow the guidance in Section 1. of this appendix.
- b. Respiratory protection against nanoparticles when a large percentage of the nanoparticles in workplaces are in the 50 to 100 nm range: In these cases, the [NIOSH Science Blog, of 7 December 2011](#) recommends wearing respirators with 99 or 100-class filters.
- c. OSHA substance specific standards such as lead, asbestos, and cadmium, which require HEPA filters.

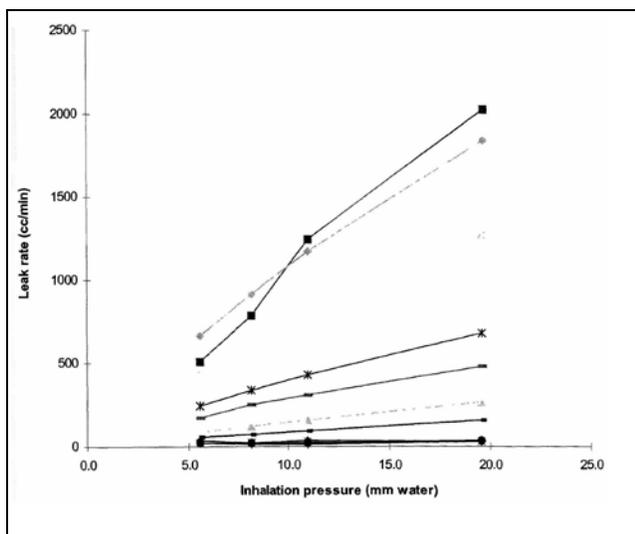


Figure B-1
Leakage around the facepiece seal increases with increased inhalation pressure.

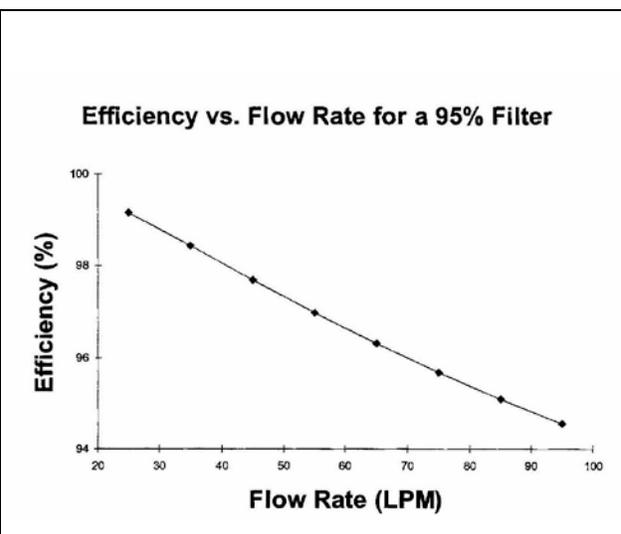


Figure B-2
95% filters are essentially 100% efficient in filtering most typical particle size (>0.2 micron) in industrial workplaces

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RESPIRATORY PROTECTION AGAINST PANDEMIC INFLUENZA AND OTHER MICROORGANISMS

I. PARTICULATE FILTERS APPROVED FOR PROTECTION

A. All nine classes of NIOSH approved particulate respirator filters can be used as protection against microorganisms (e.g., anthrax, tuberculosis, and avian influenza H5N1 viruses).

1. According to reference 1, a sneeze generates nearly 2 million droplets, which can be expelled at nearly 200 miles per hour and a cough produces approximately 100,000 droplets. Reference 2 measured the size and amount of aerosol produced by influenza patients during coughing and determined that patients produced an average 75,400 particles/cough. Of these particles, 63% were of respirable size (Per ACGIH, the aerodynamic cutoff diameter for respirable particles is 4 μm .) and can be easily inhaled and drawn down into the deepest parts of the lungs where they may be more likely to cause an infection. The authors explained that:

“... at close range, larger drops can be important because of their greater volume and subsequent pathogen content, but as one moves farther away from an infected person, smaller particles may gradually become more important because they are able to stay airborne longer, reach more people, and are more easily inhaled.”

2. In reference 3, the authors used an environmental chamber equipped with a collision nebulizer to simulate a patient coughing in a medical examination room and three breathing simulators representing health care workers exposed to inhaling infectious particles at three locations in the room. Their study showed that aerosol particles from a coughing patient are carried rapidly in the direction of the cough, resulting in an almost immediate exposure to a high concentration of particles for anyone in the path of the cough plume. However, their results also show that the room air currents generated by the coughing of the patient and breathing of the workers disperse the cough particles throughout the room, and that within several minutes anyone in the room would be exposed to these particles regardless of their location. Even at a relatively high ventilation rate of 12 air changes/hour, with the air blowing diagonally and downward across the room, some exposure to cough aerosols still occurred for several minutes after a cough both directly in front of the coughing simulator and away from the initial cough aerosol plume, suggesting that exposure to the cough aerosol would occur anywhere in the room.

a. Per reference 3, N95 filtering facepiece respirators with no face seal leakage consistently protected the breathing simulators from cough aerosol particles of all sizes even when the influenza infectious aerosol plume impinged directly on the face of the breathing simulator.

b. On the other hand, surgical masks did not provide adequate protection from small particles in cough aerosols even when sealed to the head of the breathing simulator. Surgical masks admitted aerosol particles of all sizes at concentrations 22 times higher than the concentrations seen with the N95 and N95/surgical masks at 32 L/min, and 32 times higher at 85 L/min. **The authors urgently reinforce the message to the health care community that surgical**

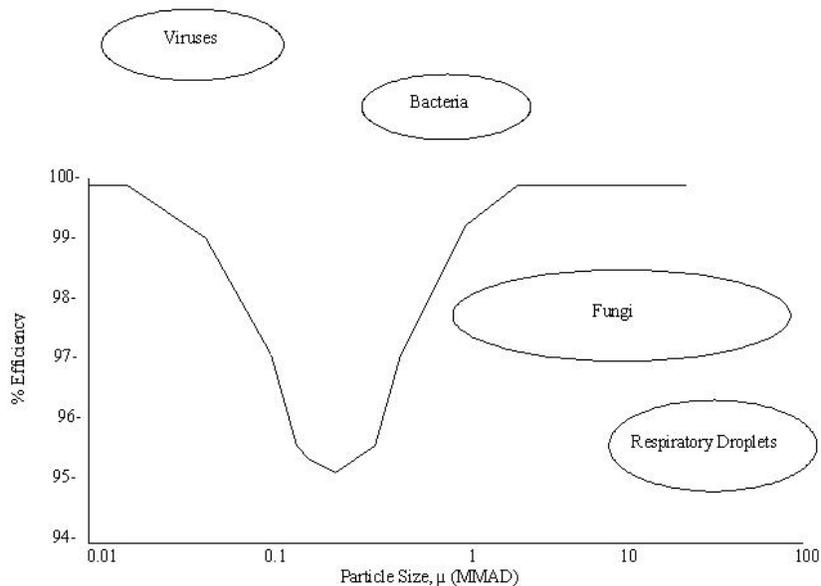
masks do not provide protection against small airborne particles and a properly fitted respirator is needed when exposed to infectious bioaerosols.

3. At the breathing rates found in the workplace, 95% efficient filters filter out more than 99.5% of these microorganisms. Figure 7 shows the efficiency of N95 filters at removing microorganisms of various size ranges. N95 filter media is the minimal protective filter recommended for protection against pandemic influenza. N95 filter media will effectively filter out 10 to 100 micron sized virus laden droplets produced by the respiratory tract and also viruses, which are much smaller in size (0.08 to 0.12 microns). N95 filter media is available both as replaceable filters for elastomeric respirators and as the integral part of filtering facepiece respirators.

4. Although N95 filtering media is an effective filter, protection against inhaling influenza aerosols is also dependent on how well the respirator seals to the face to prevent leakage. Lawrence, et al., (reference 4) compared the performance of surgical masks, N95 filtering facepiece respirators, and elastomeric half mask respirators equipped with N95 filtering media. They determined that surgical masks both as a class and individually provided very little protection and that filtering facepiece respirators do not perform as well as elastomeric half masks. They also determined that passing fit-testing resulted in a higher level of protection when compared with no fit testing for both filtering facepiece and elastomeric respirators.

Figure 7

N95 FILTER EFFICIENCY VERSUS SIZE DISTRIBUTIONS OF MICROORGANISMS & RESPIRATORY GENERATED DROPLETS



5. Lawrence, et al., stated that differences in design features could be the reason elastomeric half-facepiece respirators as a whole provided a higher level of protection than the filtering-facepiece respirators. They explained that all of the elastomeric respirators were equipped with adjustable head straps, whereas some of the filtering-facepiece respirators had only elastic, nonadjustable straps.

6. The minimum respiratory protection required for protection against Pandemic Influenza is a properly fitting N95 filtering facepiece respirator. There is a wide spectrum of filtering facepiece designs. Many are poorly designed and do not fit the wearer very well. In some cases, the whole facepiece consists of filter media. However, many are designed very well and some even include a sealing surface to ensure a tight seal with the face. See Figure 8 (courtesy of Dr. James Johnson, ANSI Z88 Secretariat), which illustrates the wide spectrum of filtering facepiece designs (Note that four of the respirators are probed for quantitative fit testing.). Also, if filtering facepiece respirators are selected for use, select cup shaped filtering facepieces with good sealing surfaces that can pass fit testing and meaningful user seal checks. The Navy and Marine Corps Public Health Center (NMCPHC) developed the *NAVY POCKET GUIDE FOR HEALTHCARE PROVIDERS - PANDEMIC INFLUENZA PROTECTION PROCEDURES* based on the best practices prescribed in the plethora of information on pandemic influenza and control of tuberculosis and other infectious diseases and is posted on the NMCPHC [Industrial Hygiene](#) homepage.

Filtering Facepiece Respirators Sealing Surfaces



Figure 8

7. It is critically important to store an adequate amount of sizes and numbers of respirators to ensure that when needed, there will be sufficient quantities on hand for

personnel required to wear them and that they will correctly fit. As with all respirators, stockpiles of stored respirators must be maintained in pristine condition.

8. The following discussion explains how to estimate the amounts of sizes and numbers of respirators to stockpile in anticipation of Pandemic Influenza.

a. NIOSH created the largest anthropometric database in U.S. history and used this data to develop new respirator fit test panels that will both maximize respirator design and NIOSH certification testing for new respirators. NIOSH required that the database must represent the demographic variability in the United States and include respirator users from all sectors of the American workforce, including the healthcare and the emergency response sectors. Male and female healthcare workers made up the largest population of respirator users measured (37.1 %).

b. NIOSH conducted experiments to determine if respirator fit testing results for half mask respirators correlated with facial sizes in the fit test panel. Using this information, the following observations and recommendations can be made regarding stockpiling half mask respirators for pandemic influenza.

i. Based on the NIOSH research, recommend stockpiling 17% large facepieces, 59% medium facepieces, and 21% small facepieces. Since these percentages add up to 97%, add one % to each respirator size to bring the total to 100%.

ii. For more information, see the website article entitled *Stockpiling Respirators for Pandemic Influenza Based on NIOSH Respirator Fit Test Panels* on NMCPHC [Industrial Hygiene](#) homepage.

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