Chapter 5

Personal Protective Equipment

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Objectives

After completing this chapter, participants should be able to:

1. Define the terms *assigned protection factor* (APF) and *maximum use concentration* (MUC) and explain how they are calculated and why they are important.
2. Describe the following three air-purifying respirators (APR) and list the APF for each:
    - Half-face air-purifying respirator (Half-Face APR)
    - Full-face air-purifying respirator (FFAPR)
    - Powered air-purifying respirator (PAPR)
3. Explain the difference between an air-purifying respirator and an atmosphere-supplying respirator.
4. Describe and list the limitations of a half-face APR, full-face APR and a PAPR.
5. List and explain the different filters and canisters that are used with APRs.
6. Explain the requirements of a Respiratory Protection Program.
7. Describe the difference between a qualitative and quantitative fit-test.
8. Explain what a positive and negative user seal check is and when they need to be done.
9. Describe and demonstrate the proper inspection, donning, and doffing of an APR.
10. Describe and demonstrate the proper use and storage of an APR.
11. Explain the use of PPE for infectious diseases in both high-risk and low-risk environments.
12. Describe the proper inspection, donning, and doffing of PPE.
13. Describe the proper decontamination and/or disposal of PPE.
14. Demonstrate the proper technique for doffing inner gloves.

Chapter 5: Personal Protective Equipment

Introduction

Personal protective equipment (PPE) is any type of protective clothing or device worn to protect you against exposure to certain types of hazards. PPE is the key to performing all types of work safely, including working with or around infectious diseases. Therefore, you need to develop a good understanding of the types of PPE worn when doing this work, when and how to wear it, how it is selected, and its limitations (when and where it can't be worn).

The use of PPE is can be even more complicated when dealing with infectious disease scenarios because there is no one type of PPE that protects us against all situations. Therefore, the person on site responsible for selecting the correct type of PPE – the site safety and health officer, company safety manager, industrial hygienist, infectious disease specialist, and so on – must have a detailed knowledge of all the hazardous exposures that are present. As a result, there are many types of PPE that you need to become familiar with.

As we covered in Chapter 4, the OSHA PPE standard requires that employers assess the workplace, determine the presence of hazards, and then choose appropriate PPE to protect workers. Employers must select PPE that protects workers against infectious substances and other hazards to which they may be exposed. Depending on the route(s) of transmission of the pathogen of concern and the types of potential exposures associated with a worker's job tasks, workers must wear PPE to help minimize exposure to pathogens via mucous membranes, broken skin, or through inhalation of bio-aerosols or airborne particles. For additional information about PPE, see the OSHA PPE standards at 29 CFR part 1910 subpart I.

Employers and workers should also follow manufacturer instructions on product labels and Safety Data Sheets for EPA-registered disinfectants and other chemicals involved in waste management operations when selecting PPE for their workers (that is, to ensure that PPE protects workers from chemical hazards posed by such disinfectants).

When workers may be exposed to infectious particles or droplets, employers must implement a respiratory protection program that complies with the OSHA Respiratory Protection standard. A comprehensive respiratory protection program includes properly selected respirators approved by the National Institute for Occupational Safety and Health (NIOSH), fit-testing, and medical exams for workers who will use such equipment. Note that not all respirators or respirator cartridges used to protect workers against inhalation of infectious

particles effectively protect them from exposure to certain chemicals used in waste packaging procedures or for cleaning and decontaminating equipment and surfaces.

Workers must don (put on) and use PPE properly in order to achieve the intended protection and minimize the risk of infection. Workers should doff (remove) PPE in a way that avoids self-contamination. For example, avoid skin and mucous membrane contact with potentially infectious materials contaminated with contact- and droplet-transmissible agents; only remove respirators after leaving work areas where air contaminants (e.g., airborne-transmissible agents) may be present. The order of PPE donning and doffing may vary depending on the infectious agent(s) of concern in the waste, the type of PPE a worker uses, the nature of the work tasks being performed, and which devices or garments are contaminated, among other factors. Refer to updated guidance from OSHA and CDC for the most current information about particular Category A infectious agents.

Personal Protective Equipment

RESPIRATORY PROTECTION

A respirator is a piece of protective equipment that is designed to protect you from exposures through inhalation, which is the most common route of entry to hazardous chemicals and other materials such as infectious diseases.

While inhalation is the most common route of exposure, you should not ignore exposures to hazardous chemicals or materials that can result from skin absorption or ingestion.

Although a respirator may consist of many parts, all respirators must be designed with two essential components:

1. A face-piece that attempts to seal out contamination.
2. A way that allows you to breathe safe air.

Even a simple filtering facepiece (e.g., N95) respirator has both of these components in a limited way. There are many different types of respirators found in the workplace today – all useful in specific situations. But why is one type of respirator more effective than another? Why can a certain respirator be used in one situation and not another? Why does one respirator cost $15 in a hardware store and another cost $1,500 from a safety equipment supplier?

Assigned Protection Factors

The key to answering these questions and understanding the different types of respirators and the protection they provide begins with one simple statement: all respirators leak! Therefore, a respirator that protects you better leaks less, and a respirator that is not as good, leaks more.

Everyone knows what the term "leakage" means. However, when we discuss respirator leakage, we are not as concerned about the air that leaks out of our respirator as we are with the contaminated air that leaks in. Therefore, to measure respirator leakage, we have to reverse our concept of "leakage." We need to know how much of a substance is outside the respirator and compare it with the amount that leaks inside the respirator. Outside versus inside or expressed in mathematical terms:

$$\frac{\text{OUTSIDE}}{\text{INSIDE}}$$

An APF is based on the assumption that the respirator is working properly, is worn correctly, and fits the wearer. **The lower the APF, the lower your protection. The higher the APF, the higher your protection.**

The lower the APF, the lower your protection. The higher the APF, the higher your protection.

The APF is calculated by dividing the concentration of airborne contaminants outside the respirator by the concentration inside the respirator:

$$\text{APF}=10 \qquad \frac{\text{500 ppm (concentration outside the respirator)}}{\text{50 ppm (concentration inside the respirator)}}$$

ppm: *Parts per million*

This simple formula will determine the amount a respirator leaks – or what is known as the respirator's assigned protection factor (APF) and are assigned by OSHA. The amount of leakage depends on how well the respirator face-piece seals to your face. A leak in your face-piece means that contaminated air may enter. When you inhale, you create "negative" air pressure inside your face-piece, which results in a slight suction effect. This "negative pressure" or suction can draw contaminated air inside. Having leaks in your face-piece can compromise, or lessen, the protection given by the respirator. If your protection is compromised, you may breathe in greater amounts of contaminated air. This may lead to the onset of disease or injury, depending on the type and amount of chemical or other hazard, like infectious disease, you are exposed to.

For more information on OSHA APFs for respirators, see Table 2 on page 5–26.

The cautions, limitations and restriction of use provided with the respirator must be strictly followed. If your mask does not make a tight seal all the way around your face when you inhale, you may breathe contaminated air that leaks around the edges of the face seal. Anything that prevents the face mask from fitting tightly against your face, such as a beard or long sideburns, may cause leakage. Some respirators come in different styles and sizes, and fit people differently because people's faces have different shapes and sizes. You also need training to know how to correctly put the mask on and wear it correctly. This information should be provided by the supplier of the respirator.

The purpose of respiratory protection is to reduce the amount of a contaminant inside the respirator to a level below OSHA's permissible exposure limit (PEL). Respirators must be chosen to ensure that workers are never overexposed while wearing the respirator. It is important to understand that, although there is still an exposure inside the respirator, it must be below the OSHA PEL before you can be assigned to wear the respirator. The respirator

permissible exposure limit (PEL): *Exposure guidelines set by OSHA for airborne concentrations of regulated substances that set limits upon a worker's inhalation exposure (the amount of a substance a worker can safely breath in). The PEL is the only legally enforceable exposure guidelines.*

does not totally clean the air that you breathe, but it will make it safe according to OSHA. So then the following question remains: How much of the outside contaminant level is reduced by your respirator?

- A respirator with APF of 10 reduces your exposure by 10 times, or to 1/10 of the outside level. Therefore, if the exposure level outside the respirator is 500 ppm, the exposure inside the respirator should be less than 50 ppm. If the PEL for the contaminant is higher than 50 ppm, you are protected. However, if the PEL is below 50 ppm, you would be overexposed. APF of 10 means that the respirator can be used only in exposures up to 10 times the PEL.
- A respirator with APF of 10,000 reduces your exposure by 10,000 times. The concentration inside your respirator should be 1/10,000 of the outside level.

PELs are available for chemicals used to disinfect infectious disease sites. However, there are currently no PELs for infectious diseases, so levels of respiratory protection are determined by infection control practitioners. When there's a difference, always use the higher level of protection.

Many substances that may be hazardous, like infectious diseases, for instance, do not have set PELs from OSHA or any other exposure limit from other organizations. In these cases, it is up to professionals, such as an infectious disease specialist, to determine what level of respiratory protection will be needed to best protect workers.

Maximum Use Concentration

The maximum use concentration (MUC) is the level of contamination that, if exceeded, will cause you to be exposed above the PEL (overexposed). In other words, the MUC is the highest exposure level of a contaminant or a group of contaminants for which a specific respirator can be used safely. At no time should you use a respirator in an environment that exceeds the MUC.

The MUC is calculated by multiplying the APF of the respirator that is going to be used by the PEL of the chemical or substance the respirator is going to be used against. The calculation below gives an example of calculating the MUC for a half-face respirator that is going to be used to protect you against nitric acid.

Calculate the MUC for nitric acid:

MUC = APF × PEL
APF of half-face respirator = 10
PEL for nitric acid = 2 ppm
MUC = 10 × 2 ppm
MUC = 20 ppm

You cannot use a half-face respirator in any atmosphere containing a nitric acid concentration greater than 20 ppm.

CATEGORIES OF RESPIRATORS

There are only two categories or types of respirators that you can use to protect yourself against airborne contamination. The major difference between these two types of respirators is where you get the air that you are going to breathe.

1. **Air-purifying respirators (APR):** These respirators rely on the air in your work environment as your source of breathing air. They use some type of purifying element (filter, cartridge, or canister) to clean the air to a point where it is safe to breathe.
2. **Atmosphere-supplying respirators (ASR):** These respirators do not rely on the air in your work environment. Instead, they supply you with safe breathing air from a cylinder on your back or a hose connected to a source of safe air.

AIR-PURIFYING RESPIRATORS (APR)

Air-purifying respirators (APR) clean the air you breathe by filtering or removing contamination from the air before it enters your lungs. All APRs have the two major components mentioned previously: a face-piece of some type and a purifying element (filter, cartridge, or canister). When you wear an APR, contaminated air is pulled into the purifying element either by inhalation or by mechanical means. The purifying element then removes most of the contaminant from the air before it goes through an inhalation valve and enters the respirator. When you exhale, the exact opposite happens. Exhaled air from your lungs causes the inhalation valve to shut and an exhalation valve to open, allowing your exhaled air to leave the face-piece.

N95-rated filtering face-piece.

When using a filtering face-piece respirator, like a N95-rated filtering face-piece, the face-piece is the actual filter.

It is extremely important to remember that with all APRs, you are relying on the air in your work environment as your source of breathing air, and that air must have enough oxygen in it – at least 19.5% to 23.5%! An APR will do nothing to change the oxygen content of the air. Therefore, the first question that must be asked when selecting a respirator for use must be the following: Is the atmosphere oxygen-deficient, or does it have the potential to become oxygen-deficient? If the answer is yes to either of these questions, you cannot wear an APR. You must wear an atmosphere-supplying respirator! You also cannot wear any APR in an area that is immediate dangerous to life and health (IDLH) or in unknown conditions.

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IDLH: *An exposure level in an environment likely to cause death or serious health effects with very short exposures.*

Negative-Pressure Air-purifying Respirators

Negative pressure means that the air pressure created inside the face-piece is less than the air pressure outside the face-piece. When negative pressure is created in a face-piece, the direction of airflow will always be into the face-piece. Negative-pressure APRs rely on your lung power to pull air in through the filters or cartridges. The suction that occurs when you inhale is actually momentary negative pressure, and it will draw air into the respirator through its purifying elements. However, during inhalation, the negative pressure created can also bring contaminants into the face-piece through leaks and improper seals. That is why you must be properly fitted for the respirator you are assigned to wear. When you exhale and air is being blown out, a "positive pressure" is created in the face-piece. Positive pressure means that the air pressure inside the face-piece is greater than the air pressure outside the face-piece. If leakage occurs when positive pressure is created, the direction of airflow will always be out of the face-piece. The following respirators are all negative-pressure respirators.

Disposable Paper Masks (Filtering Facepieces) and Quarter Masks

You and your coworkers are probably familiar with disposable paper masks, or "dust masks." They are the throwaway type and do not always seal to your face well enough to provide a

good fit. There is typically too much leakage with this type of mask. Furthermore, the paper-filtering element of a disposable mask is only effective for large-particle dusts. Gases, vapors, fumes, respirable dusts, and particulates, such as droplets from infectious diseases may pass right through the paper. These masks do not offer you enough protection and are normally not used for environmental projects. Although they are not always the best choice to use, NIOSH approved N95 filtering face-pieces are given an APF of 10.

The quarter mask is usually made of rubber and fits from the top of your nose to the top of your chin. It is designed to use cloth or cartridge filters. Its assigned PF of 5 is very low. Once again, this type mask is normally not used for environmental projects.

Half-face APRs

The half-face APR (*Figure 1*) is made of rubber or plastic (elastomeric). It seals across the bridge of your nose to under your chin. The "seal" of a respirator is not the outside edge of the face-piece, but rather the inner layer of rubber or plastic that lies on your skin to create a barrier and prevent leakage.

Figure 1. Half-face APR.

The half-face APR uses one or two purifying elements attached to the face-piece to clean the air to a point where it is safe to breathe. The APF assigned by OSHA for the half-face respirator is 10, which is fairly low. These respirators can be used only in situations where a safety professional, industrial hygienist, or infectious disease specialist is very confident in their knowledge of the type of hazard you will be exposed to and the highest concentrations that can be expected. Only with this knowledge can the correct MUC be calculated. While this knowledge may be available in some factory settings, it is sometimes difficult to acquire on an environmental site and very difficult on an infectious disease site. Because of this, the half-face respirator is typically used only in very stable environments where frequent air monitoring is being conducted.

Full-face APRs

A Full-face APR (FFAPR) (*Figure 2*) is also made of rubber or plastic (elastomeric). It is designed to cover your whole face. It seals across your forehead, down over your temples and your jawline, and under your chin.

Figure 2. Full-face APR.

The FFAPR has an APF of 50. This means that the FFAPR leaks 5 times less than the half-face APR with APF of 10. The higher APF for the FFAPR is created because it is easier to obtain a good seal across your forehead than it is across the bridge of your nose like the half-face. In addition, the full-face respirator is held more securely in place because it has a head harness instead of straps. The FFAPR uses the same filters and cartridges as a half-face APR; therefore, it also has the same limitations and cartridge problems. It does protect your eyes, although it has a tendency to fog up, especially in cooler environments.

Powered Air-purifying Respirators (PAPRs)

A powered air-purifying respirator (PAPR) is an APR that uses a small, lightweight battery-operated blower to draw air through its purifying elements and blow it into your face-piece (*Figure 3*).

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CFM: *Cubic feet per minute*

The blower delivers the air at a constant flow rate of 4–6 CFM and, by maintaining this flow rate, keeps a slight "positive pressure" inside your face-piece.

Figure 3. PAPR.

As we discussed previously, positive pressure reduces the likelihood of contaminants leaking into the respirator when you inhale. With positive pressure, leaks from an imperfect seal tend to be outward from the face-piece. In addition, the PAPR typically offers you increased comfort when wearing it. Because the blower draws air into the face-piece, you work a little less when you inhale.

In addition, the air being blown across your face will usually provide some degree of cooling and help with fogging problems. However, it is important to remember that the PAPR, although mechanically powered, is still an air-purifying respirator and, as such, cannot be worn in oxygen-deficient, unknown, or IDLH atmospheres. Since it uses similar types of filters and cartridges, it has the same cartridge problems as the half-face and full-face APR.

Although a full-face PAPR seals your face in the same manner as a full-face negative-pressure APR, OSHA assigns a PAPR a PF of 1,000. This higher protection factor is achieved as a result of the positive pressure created when the PAPR is operating.

When working with a PAPR, you must be aware of its two major limitations:

- Weak batteries can cause the blower motor to slow down and deliver less air to your face-piece. As less air is delivered, you rely more on your lungs to pull air into the face-piece. As a result, you begin to create moments of negative pressure each time you inhale. Creating negative pressure lowers the protection factor of the PAPR. These batteries are designed to last a full shift, and then require a full recharge in order to work properly.
- Under heavier work conditions, you can use more than the 4–6 CFM of air that a PAPR provides. You will get the extra air that you need by using your lungs to pull air into the face-piece. Once again, you create moments of negative pressure when this occurs and lower the protection afforded by the PAPR. This condition is called overbreathing a PAPR. When you begin overbreathing in a PAPR, it functions just like a negative-pressure full-face respirator with a lower PF.

Some PAPRs also utilize loose-fitting hoods or helmets instead of face-pieces (*Figure 4*). While these hoods are comfortable and may be used by workers with long hair or beards, they provide significantly less protection. OSHA assigns a PF of only 25 for loose-fitting hooded or helmet-type PAPRs, unless the manufacturer can demonstrate through testing a level of protection of 1,000.

Figure 4. Loose-fitting helmet PAPR. (courtesy MSA North America)

Limitations of All APRs (Including PAPRs)

There are several potential limitations of APRs to be aware of:

- **Oxygen-Deficient Atmospheres:** An APR can only be used when the oxygen level is between 19.5% and 23.5% by volume. Normal breathing air contains about 21% oxygen by volume. It can be less in confined spaces or in other areas where chemicals are present. You cannot wear an APR in any atmosphere that is oxygen-deficient or has the potential to become so.
- **IDLH Concentrations:** Under no circumstances should you wear an APR in an IDLH atmosphere. While for most chemicals, the MUC is lower than the IDLH level, there are exceptions in which the IDLH is lower than the MUC.
- **Filter/Cartridge Life:** The service life of filters, cartridges, and canisters is limited by their ability to block or remove contaminants. When a filter gets clogged with particulates, it becomes increasingly more difficult to breathe, and the filter needs to be replaced. When a cartridge or canister becomes saturated, it no longer absorbs the contaminant, and breakthrough occurs (chemicals begin to pass through the cartridge). APRs cannot be used for contaminants with poor warning properties (carbon monoxide for example) because of the potential for breakthrough and serious exposure.

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poor warning properties: *Absence of odor, taste, or other trait which warns about a hazardous substance's presence.*

breakthrough: *The point at which a hazardous substance begins to pass through a respirator's cartridge or canister because its saturation point has been reached.*

Some cartridges and canisters have end-of-service-life indicators (ESLI) that change color when they have become saturated (*Figure 5*). However, only a few indicators have been successfully developed, and most are for specific chemicals only.

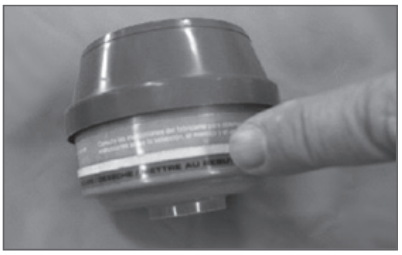

Figure 5. ESLI.

- **Cartridge/Canister Efficiency:** While there are thousands of hazardous gases, chemicals, and products in today's workplaces and on your jobsites, cartridges and canisters are manufactured using only a few varieties of sorbent materials. Obviously, breakthrough times and efficiency are not going to be the same for every hazardous substance. Studies have shown that, while one cartridge may be very efficient for some chemicals, it allows others to pass through quickly.
- **Humidity/Temperature:** Studies have shown that breakthrough can occur more quickly under conditions of high humidity and temperatures. Cartridges and canisters have faster absorption rates when the humidity and/or temperature increases, resulting in faster breakthrough times.

- **Usage/Change-out:** The useful life of a cartridge or canister is limited once the cartridge package is opened. Although a cartridge is considered to be 100% efficient when taken from a sealed package, it will gradually lose absorbing efficiency as it is used or exposed to air. Particulate filters must be changed whenever you have difficulty breathing through them or as part of a decontamination procedure.
- **Eye Protection:** Obviously, when wearing a half-face APR, you have no eye protection. Therefore, if any hazards that may injure your eyes are present, you must wear safety glasses, goggles, or a face shield.

PURIFYING FILTERS

Air-purifying respirators are typically manufactured to use two basic types of purifying elements:

A. particulate filters

B. sorbent cartridges and canisters

Particulate Filters

Particulate filters are purifying elements made of a fibrous material used to capture contaminant particles before they reach your lungs. The particles are pulled through the filter as you inhale and become trapped by the fibers of the filter.

NIOSH-approved filter.

Particulate filter respirators are used for protection against solid particles, dusts, fumes, and/or mists. They do not protect against gases and vapors. As with all respirators, particulate filter respirators must be approved by NIOSH using test criteria to simulate worst-case respirator use.

Particulate Filter Series and Efficiency Levels: There are nine classes of particulate filters. Each class of filter is a combination of one series and one efficiency level. There are:

- three filter series defined by their resistance to filter efficiency degradation, and
- three filter efficiency levels.

Filter Series: The three filter series define different degrees of resistance to filter efficiency degradation. They are labeled as N, R, and P.

N series filters have the following characteristics:

- Not resistant to oil. They cannot be used in atmospheres containing oil or for oil-based particulates.
- Used for solid or water-based particulates.
- Can be used for more than one work shift if there are no problems with hygiene, damage, or breathing.

R series filters have the following characteristics:

- Resistant to oil, but not oil proof.
- Used for solid or liquid particles.
- Can be used for an extended time in an oil-free atmosphere.
- Has limited use time in an environment containing oil (one 8-hour shift or a combined total of 8 hours).

P series filters have the following characteristics:

- Considered oil proof. Can be used as long as a worker has no breathing problems. However, the P series particulate filter may lose efficiency with long-term exposure to oil. Therefore, NIOSH recommends replacing any P filter that has been exposed to oil after the work shift.
- Used for solid or liquid particles, both oil based and not oil based.

The following is an easy way to remember the filter series:

- **N** = Not resistant to oil
- **R** = Resistant to oil
- **P** = Oil proof

Filter Efficiency Levels: Particulate filters are not designed to remove 100% of the particulates from the air. If they were, it would be too hard for you to pull air through the filters when inhaling. Filters are manufactured to create maximum filter efficiency while

keeping the resistance to breathing low. As contaminated air is drawn through the filter, the particles are captured by the filter, plugging up the holes between the fibers of the filter. This increases your breathing resistance.

Particulate filter efficiencies are usually classified into two groups: high efficiency and lower efficiency. High-efficiency filters are capable of capturing 99.97% of the particles pulled through the filter. Filters of this type are called high-efficiency particulate air (HEPA) filters, and many OSHA standards require the use of respirators with HEPA filtration. HEPA filters are used for dusts, fumes, and mists having an exposure limit less than 0.05 milligrams per cubic meter of air (5 microns). Particulates with exposure limits this low are the most hazardous to your health. For example, HEPA filters must be used for exposures to asbestos or lead. Lower-efficiency filters are less efficient than HEPA filters and are used for particulates that have exposure limits greater than 0.05 mg/m3.

Each of the three filter series described above has three filter efficiency levels. These levels are 95%, 99%, and 99.97%. They have the following designations:

- Filters with N95, R95, and P95 designations are certified as having a minimum efficiency of 95%. The series of 95% efficiency filters includes dust masks and dust/fume/mist filters.
- Filters with N99, R99, and P99 designations are certified as having a minimum efficiency of 99%.
- Filters with N100, R100, and P100 designations are certified as having a minimum efficiency of 99.97%. These filters satisfy the OSHA requirements for using high-efficiency particulate air (HEPA) filters in their standards.

The N100 and R100 have the following limitations:

N100: No oil exposure

R100: Oil exposure for one shift only

The P100 filter is the only filter that has the familiar purple or magenta color.

Table 1 lists the nine classes of particulate filters and their recommended service life.

Table 1. Nine Classes of Particulate Filters

Filter Series	Filter Efficiency Level	Filter Classes	Service Life
N Series	99.97%	N100	Nonspecific
	99%	N99	Nonspecific
	95%	N95	Nonspecific
R Series	99.97%	R100	One shift
	99%	R99	One shift
	95%	R95	One shift
P Series	99.97%	P100	Nonspecific
	99%	P99	Nonspecific
	95%	P95	Nonspecific

Sorbent Cartridges and Canisters

Sorbent cartridges and canisters are used with APRs to protect you from exposure to air that is contaminated with toxic vapors and gases. While particulate filters are effective for nearly all types of particles, sorbent cartridges and canisters are designed to protect against specific types of contaminants. Examples may include chlorine, ammonia gas, or combinations of gases and vapors, such as acid gases and organic vapors.

When you inhale, contaminated air enters the cartridge or canister and passes through a material called a sorbent. The sorbent absorbs the gas or vapor from the air and provides you with protection from potential toxic effects.

Materials used as sorbents include activated charcoal, silica gel, and various mixtures of specific chemicals that will capture the gas or vapor. Initially, the sorbent material is 100% efficient in capturing a contaminant. However, as the sorbent material becomes more saturated, its efficiency decreases. When the sorbent is totally saturated, the contaminant can pass completely through the sorbent and into the face-piece where you can inhale it.

As mentioned earlier, this is called breakthrough. The warning signs of breakthrough include odor, taste, or throat irritation.

If you notice any of these warning signs, you should follow these steps:

- Leave the work area immediately.
- Go to a location with fresh air.
- Notify your supervisor, industrial hygienist, or site safety and health officer.
- Replace the cartridge or canister if returning to the area.

Sorbents for gases and vapors are packaged into either cartridges or canisters. The major difference between a cartridge and a canister is the size and the amount of sorbent they contain.

Cartridges (*Figure 6*) are designed to be used individually or in pairs on half and full face-pieces. The amount of sorbent contained in a cartridge is small, making their service life rather short. This limitation typically restricts the use of cartridges to low concentrations of gases and vapors.

Figure 6. Cartridge.

Canisters contain larger amounts of sorbent material than cartridges. Therefore, they are bigger, can usually be used for a longer period of time, and are worn in situations where the concentration of gases or vapors is higher. Canisters are designed to be mounted on the chin, front, back, or belt. When a canister attaches to a face-piece, the respirator is typically called a gas mask.

Sorbent cartridges and canisters are designed for either one specific type of gas or vapor, or a combination of gases and vapors together.

When particulate filters are used in combination with gas and vapor sorbents, the filter portion is located on the outer side of the cartridge. The filter can be either built into the cartridge itself (dual cartridge) or held on to the outer side of the cartridge by a snap-on cover (piggybacked).

Color Coding

All chemical cartridges and filters are color-coded to show their specific applications (where and when they should be used). Although all manufacturers use color coding, filters and cartridges from one manufacturer are not interchangeable with those from another manufacturer.

ATMOSPHERE-SUPPLYING RESPIRATORS

As we discussed earlier, atmosphere-supplying respirators do not rely on the air in your work environment as the source for your breathing air. The air you breathe when wearing these respirators is supplied to you either from a cylinder on your back or through a hose (airline) connected to a source of safe air. Atmosphere-supplying respirators do not depend on filters or cartridges to clean the air in your workplace. These "supplied air" respirators deliver safe, breathable air to you when you are working in hazardous atmospheres.

The two types of atmosphere-supplying respirators are the following:

A. **SAR (Supplied Air Respirator):** Breathing air is delivered to you by an airline connected to a safe air source—a cascade system, or a breathing air compressor.

B. **SCBA (Self-contained Breathing Apparatus):** Breathing air is supplied to you from a compressed air cylinder on your back.

Breathing Air Delivery Systems

There are three types of breathing air delivery systems used with atmosphere-supplying respirators. It is important that you understand the operation and limitations of each system.

Constant Flow: A constant-flow, supplied-air respirator delivers breathing air to you through an airline connected to a pump or compressor that is located in an area where the air is safe. With this system, safe air from the pump or compressor is delivered to your face-piece at a constant flow rate, typically 4–6 CFM. Much like a PAPR, this constant flow rate creates positive pressure in your face-piece. These systems are sometimes called "Type C" air lines. However, the problem with this type of system occurs when you increase your work rate and potentially overbreathe the system. If you need more air than the constant flow rate of the system supplies, you will use your lungs to get it, thereby overbreathing the system and

creating negative pressure in the face-piece. When negative pressure occurs, your protection is reduced.

Note: The next two types of delivery systems use compressed air as your source of breathing air. Compressed air used for some breathing air systems is stored at pressures ranging from 2,000 to 4,500 pounds per square inch (PSI). It is fairly obvious that air at such a high pressure can't be safely delivered into a respirator face-piece. Therefore, the pressure of the delivered air must be "regulated." Regulators reduce the delivered air pressure and control the flow of air into the face-piece. There are two types of regulators that can be used with these compressed air systems: demand flow and pressure demand.

Demand Flow: A demand-flow system uses the negative pressure you create when you inhale to open a regulator valve and let air flow into your face-piece. In other words, when you "demand" air, you get it. When you exhale, the flow of air into the face-piece stops. The faster you breathe or "demand" air, the faster the regulator opens and shuts. The advantage of a demand-flow regulator is that you use only the air that you need and your air supply is not wasted. This will increase your service time when using this type of system. However, the major disadvantage of the "demand" system is the negative pressure you create inside the face-piece for a split second between the time you begin to inhale and the time it takes for the regulator valve to open and for the air to be delivered. This momentary negative pressure will cause an increase in leakage into the face-piece. Therefore, the PF assigned by OSHA is 10 for a half-face and 50 for a full-face for demand-type atmosphere-supplying respirators. Due to these low PFs, demand-type systems are typically not recommended for environmental projects, like infectious disease sites. A common use for demand flow is SCUBA diving.

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SCUBA: *Self-Contained Underwater Breathing Apparatus*

Pressure Demand: Pressure-demand systems are similar to demand-flow systems in that you get air when you inhale or "demand" it. However, pressure-demand systems have a secondary, or "dual regulator," configuration. Once you "energize" the system (turn the air on), both regulators open, and air flows into the face-piece to create "positive pressure." Once this positive pressure is created, the second regulator closes, and the system relies on the seal of your face-piece to hold this positive pressure inside. All the while, you are still getting air to breathe from the primary regulator by inhaling and "demanding" it.

If your seal is broken or you have a leak in the face-piece, the secondary regulator will reopen, and a constant flow of air will be delivered into the face-piece in an attempt to maintain the positive pressure that was originally created. By adjusting or tightening your face-piece, you

may be able to reseal it and stop the constant flow from the second regulator.

When the pressure demand system is functioning, is worn properly, and has a sufficient air supply, negative-pressure conditions should not exist inside the face-piece, even during inhalation. Protection factors for pressure demand-type respirators are significantly higher than those for the demand-type. Pressure demand atmosphere-supplying respirators are the ones used on most environmental projects where oxygen-deficient or unknown, or where IDLH conditions exist and/or higher protection factors are needed.

Supplied Air Respirator (SAR)

Supplied air respirators (SARs) supply air to your face-piece through a length of hose called an airline (*Figure 7*). The airline is connected to a large compressed air cylinder, to a series of connected cylinders called a cascade system (*Figure 8*), or to a breathing air compressor that is equipped with a filtering system to clean the air (*Figure 9*).

Figure 7. Supplied air respirator (SAR)

Figure 8. Cascade system

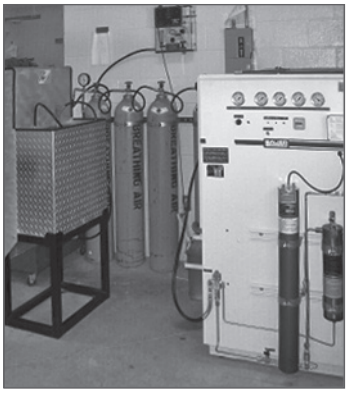

Figure 9. Breathing air compressor and filling station

With a pressure-demand regulator system, the APF for the SAR is 50 for the half-face and 1,000 for the full-face. However, like all respirators, it has certain limitations:

- Wearing an airline can get in the way and make it harder to move. It is very easy to get tangled in your own or your coworker's airline. At times, you may have to retrace your steps coming off the jobsite. Airlines can also present many slip, trip, and fall hazards.

- Your airline can be damaged on the jobsite. Rough or sharp surfaces can puncture your line. Chemicals on the ground can deteriorate or damage it. Falling containers or materials, vehicles, and heavy equipment may sever or do damage to the airline.
- If you are using a breathing air compressor, it must be located in an area away from potential chemical or contamination hazards. All filters and alarms on the compressor must be working properly, and the system must be maintained according to the manufacturer's recommendations.

Since air lines can be damaged or severed on the jobsite, you must understand that they cannot be worn in any situations that are oxygen-deficient, unknown, or IDLH unless they are equipped with an escape bottle (*Figure 10*). An escape bottle is a small cylinder of air that is attached to an SAR that can be turned on in case of an emergency, such as a severed airline. This bottle typically contains a 5 to 10 minute supply of air. This should allow you enough time to escape an emergency situation. Even though the escape bottle is not turned on during normal use of the SAR, when there is one, the APF of the SAR jumps to 10,000. In addition, the SAR with an escape bottle can be worn in oxygen-deficient, unknown, and/or IDLH atmospheres.

Figure 10. Supplied air respirator (SAR) with escape bottle
(courtesy of MSA North America)

Self-contained Breathing Apparatus (SCBA)

A self-contained breathing apparatus (SCBA) usually includes of a full-face-piece and a pressure-demand regulator system connected to a cylinder of compressed air that is worn on your back. Pressure-demand SCBAs are commonly used by firefighters, first responders, and other workers during the most dangerous parts of their jobs because they are very mobile and have the highest OSHA-assigned PF of 10,000. With an SCBA, you typically do not have the problems encountered with airlines. With a pressure-demand SCBA, you can work in oxygen-deficient, unknown, and IDLH atmospheres. However, you must receive specialized training in the safe use, care, maintenance, and limitations of the specific SCBA you are assigned to wear. In addition, all SCBAs have some type of warning device or "alarm" that is activated when you have approximately 25% of your breathing air supply remaining (a bell, whistle, and so on).

Open Circuit SCBAs: The most common type of SCBA used by firefighters, rescue workers, and on environmental projects is an "open circuit" SCBA (*Figure 11*). When you wear an open circuit SCBA, your exhaled air goes through the exhalation valves in the face-piece and directly into the outside air. Therefore, your air leaves the system, and the circuit is considered "open."

Figure 11. Open circuit self-contained breathing apparatus

Closed Circuit SCBAs: The other type of SCBA is called a "closed circuit" SCBA (*Figure 12*). Closed circuit SCBAs are sometimes called "rebreathers" because your exhaled air is recycled. Instead of leaving the system, your exhaled air is captured by an exhalation breathing tube and directed towards a breathing bag, where it is "scrubbed" by a carbon filter to remove the excess carbon dioxide.

Figure 12. Closed circuit self-contained breathing apparatus (courtesy of Biomarine, Inc.)

Some closed circuit SCBAs can supply enough breathing air for up to four hours. However, the carbon filter and oxygen cylinder must be replaced every time a unit ends its service time. This can be very costly if the unit is used continually on a worksite. There are some closed circuit SCBAs available in positive-pressure mode that can be used in hazardous areas and have an OSHA-assigned PF of 10,000.

Table 2 summarizes the APFs for the different respirators discussed.

Table 2: OSHA Assigned Protection Factor (APF) Table.

Type of Respirator[1, 2]	Quarter Mask	Half Mask	Full Face-piece	Helmet/Hood	Loose-fitting Face-piece
1. Air-purifying Respirator	5	10[3]	50	—	—
2. Powered Air-purifying Respirator (PAPR)	—	50	1,000	25/1,000[4]	25

Type of Respirator[1, 2]	Quarter Mask	Half Mask	Full Face-piece	Helmet/Hood	Loose-fitting Face-piece
3. Supplied-air Respirator (SAR) or Airline Respirator					
• Demand mode	—	10	50	—	—
• Continuous flow mode	—	50	1,000	25/1,000[5]	25
• Pressure-demand or other positive-pressure mode	—	50	1,000	—	—
4. Self-contained Breathing Apparatus (SCBA)					
• Demand mode	—	10	50	50	—
• Pressure-demand or other positive-pressure mode (e.g., open/closed circuit)	—	—	10,000	10,000	—

Notes:

[1] Employers may select respirators assigned for use in higher workplace concentrations of a hazardous substance for use at lower concentrations of that substance, or when required respirator use is independent of concentration.

[2] The assigned protection factors in Table I are only effective when the employer implements a continuing, effective respirator program as required by this section (29 CFR 1910.134), including training, fit-testing, maintenance, and use requirements.

[3] This APF category includes filtering face-pieces, and half masks with elastomeric face-pieces.

[4] The employer must have evidence provided by the respirator manufacturer that testing of these respirators demonstrates performance at a level of protection of 1,000 or greater to receive an APF of 1,000. This level of performance can best be demonstrated by performing a WPF or SWPF study or equivalent testing. Absent such testing, all other PAPRs and SARs with helmets/hoods are to be treated as loose-fitting face-piece respirators, and receive an APF of 25.

[5] These APFs do not apply to respirators used solely for escape. For escape respirators used in association with specific substances covered by 29 CFR 1910 subpart Z, employers must refer to the appropriate substance-specific standards in that subpart. Escape respirators for other IDLH atmospheres are specified by 29 CFR 1910.134(d)(2)(ii).

RESPIRATOR PROGRAM REQUIREMENTS

Safely using a respirator is more than just knowing how to put it on. OSHA has standards in 29 CFR 1910.134 that govern respirator usage in the workplace. A written respiratory protection program must be developed and put in place by your employer, and it must cover the required job-specific procedures for respirator use. It must also be updated when there are changes in workplace conditions that affect respirator use.

The respiratory protection program must include the following requirements:

1. Procedures for selecting respirators for use in the workplace.
2. Medical evaluations of employees who are required to use respirators.
3. Fit-testing procedures for tight-fitting respirators.
4. Procedures for proper use of respirators in routine situations and in reasonably foreseeable emergencies.
5. Procedures and schedules for cleaning, storing, inspecting, repairing, discarding, and otherwise maintaining respirators.
6. Procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere-supplying respirators.
7. Employee training in the respiratory hazards to which they are potentially exposed during routine and emergency situations.
8. Employee training in the proper use of respirators, including the following:
    - donning and doffing (putting on and taking off);
    - limitations; and
    - maintenance.
9. Procedures for regularly evaluating the effectiveness of the program.

RESPIRATOR PROGRAM ADMINISTRATOR

Your employer must choose a respirator program administrator (RPA) to oversee the respiratory protection program and to conduct the required evaluations of program effectiveness. To fulfill these duties, the RPA must have the training or experience that matches the complexity of the program.

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RPA: *Respirator program administrator*

As part of the administration of the program, the RPA is responsible for ensuring the following:

- That respirators are properly selected, used, and maintained.
- The type of air contaminant and its exposure concentration are considered in properly selecting a respirator.
- Workers are trained in the proper use and care of the respirators that are provided.
- Workers are medically fit to wear the respirator.

RESPIRATOR SELECTION

Your employer is responsible for selecting the appropriate respirators for you and your coworkers. To do this properly, your employer must do the following:

- Gather information.
- Use that information when selecting respirators.
- Choose your respirator based on the selection process.

Gathering Information

It is impossible to choose a respirator without knowing the hazards on your jobsite and your potential exposure levels. Your employer can use two methods for identifying these hazards and their airborne exposure levels:

- personal air monitoring devices; and
- past records of exposure levels encountered doing similar jobs.

Employers must use medical professionals and/or infectious disease specialists for infectious disease sites to determine which respirator is best for the situation when dealing with infections that cannot be measured by typical means.

General Use Conditions and Determination of Contaminants

General use conditions include the following:

- descriptions of the job tasks to be performed;
- duration and frequency of the tasks to be performed;
- work location;
- physical demands of the work to be performed; and
- respirator comfort.

Determination of contaminants includes the following:

- identity of the substances present in the air;
- actual measured exposure levels on the job; and
- if possible, an estimate of the highest level of exposure that you are likely to encounter.

Properties of the Contaminants

Information is needed on the physical, chemical, and toxic properties of the contaminant. This information includes the following:

- The physical form in which the substance is found on the jobsite, such as a dust, mist, fume, gas, or vapor.
- Chemical properties such as an organic vapor, pesticide, metal, or acid gas.
- Toxicological properties of the substance as they pertain to adverse health effects (carcinogen, sensitizer, and so on).
- Warning properties of the substance (odor, taste, irritation).

Exposure Limits

Exposure limits for many chemicals and hazardous substances are published by several different organizations:

- **OSHA:** Permissible exposure limit (PEL) – Only legally enforceable exposure limit
- **NIOSH:** Recommended exposure limit (REL)
- **ACGIH:** Threshold limit value (TLV)

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ACGIH: *American Conference of Governmental Industrial Hygienists*

Gathering exposure limit information is essential and necessary to calculate the MUCs for the types of respirators being considered for selection. The NIOSH Pocket Guide to Chemical Hazards is an excellent source of information for many chemicals and their exposure limits.

IDLH

IDLH (immediately dangerous to life and health) concentrations are life threatening and call for you to wear the most protective types of respiratory protection. The NIOSH Pocket Guide to Chemical Hazards provides IDLH concentrations for many chemicals found in the workplace.

Eye Irritation

Some contaminants have the potential to cause eye irritation. In these situations, a full face-piece respirator should be selected instead of a half-face to provide eye protection.

Service Life Information

Service life refers to the length of time a filter, cartridge, or canister provides protection. This information is necessary to determine a change-out schedule for the chosen respirator.

Medical Evaluations

Wearing a respirator may place a physical burden on you. Therefore, OSHA requires that your employer provide a medical evaluation to determine if you are medically qualified to wear a respirator. This evaluation must be done before you are fit-tested or required to use a respirator.

FIT-TESTING

A qualitative fit-test (QLFT) or quantitative fit-test (QNFT) must be performed on all negative- or positive-pressure tight-fitting respirators before you are required to wear them. You must be fit-tested on the same make, model, size, and style of respirator that you will use on the jobsite. A fit-test must be conducted at least annually or whenever changes in your physical condition may affect the respirator fit.

Such conditions may include the following:

- cosmetic surgery;
- dental changes;
- facial scarring; and
- obvious changes in body weight, typically ± 20 pounds.

When PAPRs or atmosphere-supplying respirators are fit tested, the fit tests must be done with the respirator in a negative-pressure mode. OSHA has specific requirements and procedures for performing qualitative and quantitative fit tests. By following these procedures for each fit test, the test results will be consistent from one test to another.

Qualitative Fit-test

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QLFT: *Qualitative fit test*

A QLFT is a pass/fail fit test used to check respirator fit that relies on your response to a test agent. It involves introducing a harmless odorous or irritating test agent into your breathing zone. If you do not detect the test agent, the respirator fits you properly.

Figure 13. Qualitative fit testing

There are four test agents approved by OSHA for conducting a QLFT:

- Banana oil (isoamyl acetate or isopentyl acetate)
- Irritant smoke (stannic oxychloride or titanium tetrachloride)
- Saccharin (sodium saccharin) solution
- Bitrex™ (denatonium benzoate) solution

Before a test agent is used, OSHA requires that an odor and/or taste threshold screening be done. The screening determines if you can smell or taste the test agent at low concentrations without wearing a respirator. If you can smell or taste the testing agent at a low concentration, then you can be fit-tested with it. In addition, prior to performing any test, the correct filter or cartridge for the testing agent has to be installed in the respirator.

A QLFT is simple and inexpensive, which makes it the most common type of fit-testing done on respirators (Figure 13). However, a QLFT relies upon your subjective response to the testing agent. In other words, you must honestly inform the tester if you can smell or taste the substance. Because of this subjectivity, a respirator cannot be assigned a PF higher than 10 if it is qualitatively fit-tested only.

Quantitative Fit-test

A quantitative fit-test (QNFT) is a more sophisticated and accurate type of fit-test done with a machine (Figure 14). It measures the actual amount of leakage into the respirator while you are wearing it. This will give you a "fit factor" for the respirator you are being tested with. A variety of methods are available for performing a QNFT, and each one uses a different technology.

When a QNFT is used, a respirator can be assigned the appropriate protection factor.

Figure 14. Portacount and negative-pressure fit-test devices

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QNFT: *Quantitative fit-test*

RESPIRATOR USAGE

Your employer is required to create and put in place procedures for the proper use of respirators. These procedures include the following:

- Prohibiting conditions that may result in leakage of your face-piece seal.
- Preventing you and your coworkers from removing your respirators in hazardous environments.

- Taking actions to ensure continued effective respirator operation throughout your work shift.
- Establishing procedures for the use of respirators in IDLH atmospheres.

Face-piece Seal Conditions

OSHA does not permit you to wear respirators when conditions prevent a good seal. These conditions include the following:

- Facial hair that crosses the sealing surface (stubble beard growth, beard, mustache, or sideburns).
- Caps, hats, or bandanas that project under the face-piece.
- Temple pieces on glasses.
- Absence of one or both dentures.
- Facial scars or deformities that prevent a good seal.

A beard or long sideburns prevent a good seal between your face and the respirator. Studies have shown that any facial hair reduces the protection received from a respirator. This includes a full beard, as well as a few days' growth. A mustache is acceptable if it fits under the mask without affecting the seal. Long hair may also interfere with a good seal in some situations. Long hair must be kept outside the respirator face-piece and is usually contained under a protective suit.

Figure 15. Spectacle kit

Eyeglasses are another problem for getting a proper face-piece seal. The temple bars on eyeglasses prevent a respirator from sealing against the side of your head. However, for some workers, going without eyeglasses may create vision-related problems such as tripping. Respirator manufacturers make "spectacle kits" that can be fitted with your lenses and worn inside the face-piece (*Figure 15*). OSHA requires that these "kits" be made

available at your employer's expense to anyone who needs to wear glasses. OSHA does not recommend the use of contact lenses when wearing a half-face respirator in dusty conditions. Gum and tobacco chewing are also prohibited when wearing a respirator. The chewing action puts a strain on the respirator seal and could also lead to the ingestion of contaminants.

USER SEAL CHECKS

A respirator must be adjusted when you put it on to ensure the best possible seal. This is called a user seal check, and you must do it every time you put on your respirator. You can use either of these two methods:

- Manufacturer's recommended user seal check in the instruction manual that comes with the respirator.
- Procedures below for Positive-Pressure User Seal Check and Negative-pressure User Seal Check.

You must remember that fit-tests are not a substitute for user seal checks. A fit-test must be performed before you are assigned a respirator to ensure that the respirator fits properly and affords you the required protection. User seal checks are done every time you put a respirator on to make sure it is adjusted properly and that you have a good face-piece seal.

You must do a user seal check every time you put on your respirator.

Positive-Pressure User Seal Check

To do a positive-pressure seal check, follow these steps (*Figure 16a*):

Figure 16a. Positive-pressure user seal check.

1. Cover the exhalation valve of the respirator with your palm.
2. Exhale gently for about 10 seconds. Do not exhale too hard or push the mask into your face because the check will be inaccurate.
3. If your respirator seals properly, a slight pressure should build up inside your face-piece. If you feel or hear air leaking out, the respirator is not sealing properly. You must tighten your face-piece straps slightly and repeat the user seal check.

To do a user seal check on an atmosphere-supplying respirator, follow the manufacturer's procedures.

Negative-Pressure User Seal Check

To perform a negative-pressure user seal check, you should follow these steps (*Figure 16b*):

1. Cover the filters or cartridges with the palms of your hands.
2. Inhale gently, and hold your breath for about 10 seconds. Do not push the respirator into your face too hard or the check will be inaccurate.

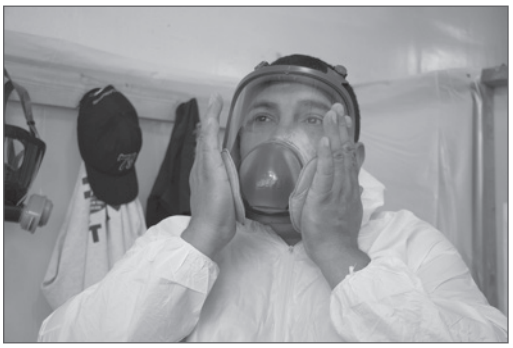


Figure 16b. Negative-pressure user seal check

If your respirator seals correctly, your facepiece should collapse slightly inward. If the respirator does not seal correctly, the facepiece will not collapse, and you will feel air leaking into the facepiece. To do this seal check on an atmosphere-supplying respirator, you would usually cover the end of the breathing tube or inlet with your hand and inhale.

MAINTENANCE AND CARE

Your employer must provide maintenance and care for the respirators being used on the jobsite. Maintenance and care should include the following:

Cleaning and Disinfecting: It is your employer's responsibility to provide a clean and disinfected respirator to you. A respirator issued for your exclusive use must be cleaned and disinfected at the end of each use to maintain it in a sanitary condition.

Storage: For your respirator to remain in good condition and in proper working order, it must be stored in a clean and sanitary location to protect it from the following:

- chemicals,
- contamination,
- damage,
- dust,

- excessive moisture,
- extreme temperatures, and
- sunlight.

Your respirator should be packed and stored to prevent the face-piece and any other parts from becoming deformed.

Inspection: All respirators must be inspected before and after each use – before you put it on and after cleaning. Atmosphere-supplying respirators that are being stored and respirators used for emergency purposes must be inspected monthly or according to the manufacturer's specifications. All written inspection records for emergency use respirators must be kept on file. Air cylinders should always be kept fully charged. They must be refilled when the pressure in the cylinder falls below 90% of the manufacturer's recommended pressure.

All respirators must be inspected before and after each use.

During a respirator inspection, the following should be checked:

- Respirator function
- Connections, including tightness
- Condition of all parts, especially rubber parts, for flexibility and deterioration

Repairs: The following list outlines OSHA's requirements for respirator repairs:

- Repairs can only be performed by a trained, qualified individual.
- Only the manufacturer's NIOSH-approved parts that are designed for the specific respirator can be used. The use of another manufacturer's parts will void the APF.
- Repairs performed on the regulator, alarms, or admission valves of an atmosphere-supplying respirator can be performed only by the manufacturer or a technician trained by the manufacturer.

BREATHING AIR QUALITY

Breathing air used for atmosphere-supplying respirators must meet at least the requirements for Grade D breathing air as described in the ANSI/Compressed Gas Association Commodity specifications for Air, G-7.1–1989.

Breathing air compressor with service label

Note: Compressors used for pneumatic tools must not be used for breathing air systems. Compressed air from compressors used for pneumatic tools contains carbon monoxide, making the air unbreathable and dangerous. Compressed oxygen should never be used with an open circuit atmosphere-supplying respirator.

TRAINING

OSHA's respiratory protection standard requires that your employer provide effective training to you and your coworkers that are required to use respirators.

Training must be:

- given to you before you begin using a respirator;
- understandable to you and your coworkers;
- comprehensive enough that it covers all required items; and
- provided annually or more often if necessary.

Your employer must ensure that you and your coworkers can demonstrate knowledge in the following topic areas:

- Why the respirator is necessary and how improper fit, usage, or maintenance can hurt the respirator's effectiveness.
- Limitations and capabilities of the respirator.
- How to use the respirator in an emergency situation.
- How to inspect, put on, use, take off, and seal check the respirator.
- Procedures for cleaning, maintaining, and storing the respirator.
- How to recognize medical signs and symptoms that may limit or prevent the effective use of the respirator.

OSHA requires employers to provide training to use respirators

OSHA also requires that retraining be done every year, or sooner, if the following situations occur:

- Changes in the workplace or to the type of respirator makes your previous training ineffective.
- You do not retain information from your previous training.
- Any other situation occurs in which retraining appears necessary to ensure safe respirator use.

PROGRAM EVALUATION

Your employer is required to evaluate the written respiratory protection program on a regular basis to ensure it is being properly followed and remains effective. This evaluation should include consulting with you and your coworkers who use respirators for your views on the program's effectiveness, as well as any problems encountered.

RECORD KEEPING

Your employer must establish and retain all of the written information regarding the following:

- Exposure assessments
- Medical evaluations
- Respirator inspections
- Written respirator program

Qualitative and quantitative fit-testing records must also be kept. They must be retained until your next fit-test. These records should contain the following information:

- name of the worker tested;
- type of fit-test performed;
- make, model style, and size of the respirator tested; and
- test date.

- Test results:
  - Pass/fail results of qualitative fit-tests.
  - Fit factor and other recordings of test results for QNFTs.

Your employer also needs to keep written documentation of your respirator training and the respirator program evaluation results.

PPE FOR DIFFERENT RISK ENVIRONMENTS

Selection of PPE should always be based on risk assessment.

Some hospitals describe the two categories for PPE as "High" and "Step Down."

- **High-Risk Protection:** Needed if there is a potential for exposure to blood and bodily fluids. Doctors Without Borders, the World Health Organization and others have used "high-risk" and "low-risk" categories for developing Ebola virus safety and health prevention programs.
- **Low-Risk Protection:** Needed if exposure does not include blood and bodily fluids. If this is the case, there is still a need for PPE and decontamination, but it is not as extensive as for bodily fluid exposures.

PPE FOR HIGH-RISK ENVIRONMENTS

It is up to employers to select PPE, following the OSHA PPE Standard, CDC guidelines, and best practice recommendations. The high-risk PPE recommended below is a combination of information from OSHA, CDC, the Nebraska Biocontainment Unit, Emory Healthcare, the New York City Environmental Contractors Association and the Mason Tenders' Union within the Laborers' International Union of North America (LIUNA). Always remember, it is better to err on the side of caution (higher safety), so if there is an area in which the level of desired protection is debatable, always choose the higher level of protection.

If the level of protection is debatable, always choose the higher level of protection.

PPE for high-risk environments includes the following:

- **Inner gloves:** double or triple nitrile.
- **Outer gloves:** extended cuff nitrile, neoprene.
- **Gowns & protective suits:** Full-body garment constructed of durable viral penetration-resistant material. (Some states may have specific requirements.) Tyvek® or fiber suits with hoods may be used for the inner suit.

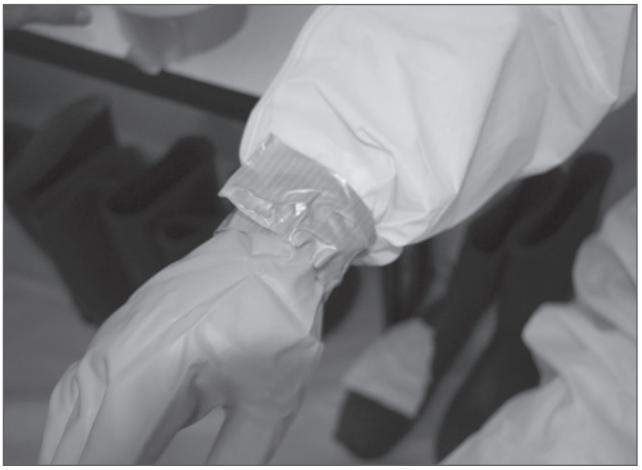
- **Head covers.**
- **Face shields.**
- **Foot protection:** Rubber boots that extend to at least lower calf, or footwear or covers with viral-penetration barrier layer.
- **Respirators:** PAPR, filtering face-piece with an N95 rating, or an APR with a P100 rating.
- **Plastic aprons.**

PPE

Gloves

Double- or triple-gloving provides an extra layer of safety during work activity and during the PPE removal process. There is a concern that more layers of PPE may make it more difficult to perform duties, and may put workers at greater risk for injury (for example, needlesticks), self-contamination during care or doffing, or other exposures to infectious diseases. However, the Nebraska Biocontainment Unit triple gloves and reports that it has no negative impact on safety or healthcare, so the same should hold true for cleanup operations.

Gowns & Protective Suits



Making a tab at the end of the tape can make PPE removal easier.

According to CDC guidance for healthcare workers, consideration should be given to selecting gowns or protective suits with thumb hooks to secure sleeves over inner glove. If gowns or protective suits with thumb hooks are not available, personnel may consider taping the sleeve of the gown or protective suits over the inner glove to prevent potential skin exposure from separation between sleeve and inner glove during activity. However, if taping is used, care must be taken to remove tape gently. Workers are advised to make a tab at the end of the tape to ease PPE removal. This is done by folding over a piece of the tape onto itself.

For cleanup operations, the type of protective suits used for both inner and outer wear will be determined by the healthcare professional and/or the infectious disease specialist on the particular cleanup job workers may be on.

Respiratory Protection

Supplied air respirators (SARs) or self-contained breathing apparatus (SCBA) are generally not recommended by the CDC for typical everyday tasks in healthcare facilities. However, their use may be needed for evaluating contaminated areas of unknown concentrations that will need to be cleaned, and also in evaluating the set-up of the decontamination unit that may be needed in the event of an emergency event.

Although a loose-fitting, powered air-purifying respirator (PAPR) or a filtering face-piece with an N95 rating is recommended by the CDC for healthcare workers, respirators used for emergency cleanup situations may require more protective respiratory protection. A tight-fitting PAPR would be the respirator of choice in such situations.

Whenever tight-fitting respirators are used, employers must be in compliance with all

elements of the OSHA Respiratory Protection Standard (29 CFR 1910.134), including fit-testing, medical evaluation, and training.

Note: The Nebraska Biocontainment Unit uses two levels of PPE: low and high. Low is when body fluids are not present or not being generated, in which case a filtering face-piece with an N95 rating and face shield is used. With high, they use a PAPR. Cal-OSHA recommends using a PAPR, if available. As previously stated, workers contracted to clean up contaminated areas should use a tight-fitting PAPR when performing such duties.

Figure 17. Example of PPE for High-risk Environments.

IMPORTANT: Street clothes should not be worn. A surgical gown or protective suit should always be worn in healthcare settings. In emergency cleanup situations, the specific type of infectious disease will dictate what type of protective clothing will be worn.

Street clothes should never be worn in emergency cleanup situations.

PPE FOR LOW-RISK ENVIRONMENTS

PPE for low-risk environments (*Figure 18*) includes the following:

- **Inner gloves:** double nitrile.
- **Gowns:** full-body garment constructed of durable viral penetration-resistant material.
- **Foot protection:** Rubber boots that extend to at least the lower calf, or footwear or covers with viral-penetration barrier layer.
- **Face shield.**
- **Respirators:** Filtering face-piece with an N95 rating, or an APR with a P100 filter rating.
- **Plastic aprons.**

Recommendations for Environmental Contractors

The New York City Environmental Contractors' Association and the Mason Tenders' Education and Training Fund (LIUNA) use a HAZWOPER approach in their health and safety approach to infectious diseases. They are contracted to clean contaminated hospital rooms, patient homes, or contaminated public locations. Their members are required to have a 40-hour HAZWOPER course and a hepatitis B vaccine to qualify for the program.

Figure 18. Example of PPE for low-risk environments.

The OSHA HAZWOPER model includes the following PPE Ensembles:

- **Level A:** Investigation team, fully-encapsulated suit, SCBA respirator, gloves, foot cover.
- **Level C:** Work remediation team, double suit, tight-fitting PAPR or APR with a P100 filter rating, gloves, foot cover.

DONNING AND DOFFING PPE AND DECONTAMINATION

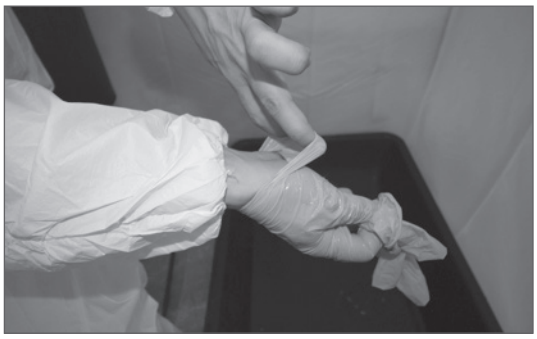
This section covers basic principles involved in putting on, taking off, and decontaminating PPE. This includes:

- hand hygiene;
- hydration;
- designated areas;
- trained observer/trained observer's assistant;
- buddy system;
- practice, practice, practice; and
- decontaminate and disinfect.

Training

Training with the PPE being used is crucial in order to maximize the protection it provides. The CDC recommends administrative procedures to document the training of observers and healthcare workers for proficiency and competency in donning and doffing PPE, and in performing all necessary care-related duties while wearing PPE. Although the CDC recommendations refer mostly to healthcare workers, this section will cover emergency response workers as well. This chapter will refer to these workers as "cleanup workers."

Because of the complexity of donning and doffing PPE and the gravity of the hazard, frequent training, drills, and competency must be built into any training plan.



Training in the proper removal of inner gloves is important to worker safety.

Training in the donning process includes assisting others with their PPE.

Designated Areas

Designated areas are established for donning and doffing PPE. Some things to consider are:

- Ensure clear separation between clean and potentially contaminated areas.
- Use physical barriers and visible signage to separate areas.

Example of a physical barrier with proper signage.

PPE Donning and Storage Area

clean room support area

PPE donning and storage is often an area outside the infectious disease contaminated room (for example, a nearby vacant patient room or a marked area in the hallway outside a contaminated room), where clean PPE is stored and where healthcare and cleanup workers can don PPE before entering the contaminated area. This storage and donning area may be referred to as the clean room or support area, and may be part of a two-, three-, or more-stage decontamination set-up, depending on the job.

anteroom: *A small separate barrier room at the entrance to the work area, with doors at each end.*

Notes regarding PPE donning and storage:

- Do not store potentially contaminated equipment, used PPE, or waste removed from the contaminated area in the clean room.
- If waste must pass through the clean room, it must be properly contained and containers must be properly disinfected.

PPE Doffing Area

More information about decon units is covered in ***Chapter 6: Work Area Preparation, Decontamination, and Disinfection.***

It is best to use an anteroom, a dedicated patient room, or an enclosed space, such as a three- or more-stage decontamination unit, outside the work area for removing PPE. The hazard present and site specifics will determine what type of area and set-up is needed to doff PPE.

DONNING PPE

Putting on PPE in a highly infectious disease environment requires the following:

- **Trained observer to oversee the process:** Because the sequence and actions involved in each donning and doffing step are critical to avoiding exposure, a trained observer should read aloud to the healthcare or cleanup worker each step in the procedure checklist and visually confirm and document that the step has been completed correctly. Typically, a trained observer will oversee the donning process and a trained observer's assistant will oversee the doffing process.
- **Step-by-step procedures, use of a posted checklist:** The selected PPE must be donned in the correct order, in order to provide an effective protection against contact with individuals with an infectious disease or contamination. The specific donning order depends on the PPE items comprising the ensemble, as the donning process is affected by how interfaces are formed. All PPE should be donned in

accordance with an established SOP, under supervision, and with assistance as needed.

- **Use of a buddy system**
- **Practice**

Key Considerations for Donning PPE

Following are some key steps when donning PPE:

- Avoid touching face or skin!
- Inspect all PPE to be used.
- Remove clothing and personal items.
    - Include jewelry, cell phones, pens, etc.
    - If you want it when you come out, don't take it in.
- Hand hygiene, check vitals, hydrate.
- Verify that a sufficient range of motion exists to perform tasks.

CAUTION!

- If PPE is not put on properly, the worker may be exposed to highly infectious diseases.
- The donning activities must be directly observed by a trained observer.
- PPE must be donned correctly, in proper order, before entry into the risk area, and not modified later while in that area.
- CDC guidance on hand hygiene: Hand hygiene in healthcare settings can be performed by washing with soap and water or by using alcohol-based hand rubs. If hands are visibly soiled, use soap and water, not alcohol-based hand rubs.

STEPS TO DONNING PPE

Although the CDC has recommended donning procedures for healthcare workers, the following steps are adapted from the CDC's steps to relate to contracted workers who are hired to clean up highly contaminated areas. In many cases, these workers will be using

tight-fitting PAPRs, not the loose-fitting hood type. An established protocol facilitates training and compliance. Use a trained observer to verify successful compliance with the protocol.

1. **Engage Trained Observer:** The donning process is conducted under the guidance and supervision of a trained observer, who confirms visually that all PPE is serviceable and has been successfully donned. The trained observer uses a written checklist to confirm each step in donning PPE, and can assist with ensuring and verifying the integrity of the ensemble. The checklist should also be posted in the clean room. No exposed skin or hair of the worker should be visible at the conclusion of the donning process. The trained observer reviews the donning sequence with the worker before the worker begins the donning process, and reads it to the worker in a step-by-step fashion.

Worker inspecting PPE with the trained observer.

2. **Inspect PPE Prior to Donning:** Visually inspect the PPE ensemble to be worn to ensure that it is in serviceable condition, that all required PPE and supplies are available, and that the sizes selected are correct for the worker.
3. **Remove Clothing and Personal Items:** No personal items (for example, jewelry, watches, cell phones, pagers, pens) should be brought into the contaminated room.
4. **Don Inner Suit:** Put on disposable boxers or cotton underwear (optional). Don the inner suit. Prepare and put on disposable duct tape belt and attach the PAPR battery to the disposable belt (if a PAPR is used).
5. **Perform Hand Hygiene:** Perform hand hygiene with alcohol-based hand rubs (ABHRs). When using ABHRs, allow hands to dry before moving to next step.

Remove all clothing and personal items before donning PPE.

6. **Don Inner Gloves:** Put on first pair of gloves. Be sure cuffs inner gloves are tucked under the sleeve of the inner suit.
7. **Don Outer Suit:** Do not zip the suit up at this time. Ensure outer suit is large enough to allow for unrestricted freedom of movement. (Some cleanup sites may require the use of double suits.)

Some cleanup sites may require the use of double suits.

8. **Don Rubber Boots:** The outer suit should be placed over the rubber boot and should be taped to the boot. No part of the suit should be exposed on the boot past the tape. If used, put on boot covers at this time.

Trained observer assisting worker donning rubber boots.

Donning boot covers.

9. **Don the Respirator:** Connect the PAPR battery and don the respirator face-piece. Perform the positive and negative user seal checks. Turn on the PAPR fan (if this type of respirator is being used.)
10. **Don the Hoods:** Don the double hoods over the respirator head harness (straps) and zip up the outer suit. Tape outer hood to the brim of the respirator face-piece to gain proper seal. Be sure the entire area around the respirator is taped so there are no gaps. You may also be required to put tape over the outer suit zipper as well.

11. **Don the Face Shield:** By wearing a face shield over the PAPR, you will be able to reuse the PAPR.
12. **Don Outer Gloves:** Put on second pair of gloves (with extended cuffs). Put the sleeve of the outer suit over the outer glove and tape the outer suit to the outer glove. Be sure to leave a tab on the tape for easy removal.
13. **Don the Apron:** If an apron is being used, don a full-body apron to provide additional protection to the front of the body.

Donning a face shield.

Note: If a filtering face-piece with an N95 rating is used instead of a tight-fitting PAPR, then a face-shield must be donned as well to protect the face and eyes.

Trained Observer taping outer suit to outer gloves.

14. **Verify:** After completing the donning process, the integrity of the ensemble is verified by the trained observer. The cleanup worker should be comfortable and able to extend the arms, bend at the waist, and go through a range of motions to ensure there is sufficient range of movement while all areas of the body remain covered. A mirror in the room can be useful for the healthcare worker while donning PPE.
15. **Disinfect Outer Gloves:** Disinfect outer-gloved hands with ABHR. Allow to dry.

DOFFING PPE

Taking off PPE requires the following:

- A PPE-trained observer's assistant to oversee and minimize the risk of contamination.

- A buddy and trained observer's assistant must wear PPE.
- Step-by-step procedures, use of a posted checklist.
- Decontamination of equipment.
- Avoid touching face or skin during the process.
- Hand washing, hydration, and showering.

Extreme care must be exercised when doffing PPE following use where contamination has occurred or is suspected. A specific sequence for doffing the PPE must be followed, in an order that prevents any contamination transfer from the PPE to the wearer or others.

CDC Recommendations for Doffing PPE

Following are CDC recommendations that should be included in operating procedures for doffing ensembles with known or suspected contamination:

- In the PPE removal area: provide supplies for disinfection of PPE and for performing hand hygiene and space to remove PPE, including a place for sitting that can be easily cleaned and disinfected, where the workers can remove boot covers.
- Provide leak-proof infectious waste containers for discarding used PPE.

Key Considerations for Doffing PPE

Doffing poses a high risk of contamination, and the principles of doffing are critical to doing it properly. A very common source of contamination occurs from workers touching their face, mouth, eyes, nose, or skin while doffing. Many people do so unconsciously.

Following are key considerations for doffing PPE:

- The wearer must assume that any surface could be contaminated.
- All doffing must be performed under supervision and with assistance as needed.
- The last items removed should be the face/eye protection or respirator, and inner gloves.
- Best practices include disinfecting gloves and soiled areas, and then putting on a clean pair of gloves before moving forward.

STEPS FOR DOFFING PPE

Although the CDC has recommended doffing procedures for healthcare workers, the following steps are slightly adjusted from the CDC's steps to relate to cleanup workers who are hired to clean up highly contaminated areas. In many cases, these workers will be using tight-fitting PAPRs, not the loose-fitting hood type. An established protocol facilitates training and compliance. Use a trained observer's assistant to verify successful compliance with the protocol.

The PPE doffing option for PAPR should be performed in the designated PPE removal area. Place all PPE waste in a leak-proof infectious waste container.

The purpose of this step is to prepare for the removal of PPE. Before entering the PPE removal area, inspect and disinfect – using an EPA-registered disinfectant wipe – any visible contamination on the PPE.

As a final step, disinfect outer-gloved hands with either an EPA-registered disinfectant wipe, or using ABHRs, and allow to dry. Verify that the trained observer's assistant is available in the PPE removal area before entering and beginning the PPE removal process.

1. **Engage Trained Observer's Assistant:** The doffing process is conducted under the supervision of a trained observer's assistant, who reads aloud each step of the procedure and confirms visually that the PPE is removed properly. These steps should be posted in the area. Prior to doffing PPE, the trained observer's assistant must remind the cleanup worker to avoid reflexive actions that may put them at risk, such as touching their face. This instruction should be posted and repeated verbally during the doffing process. Although the trained observer's assistant should minimize touching the cleanup worker or the cleanup worker's PPE during the doffing process, the trained observer's assistant may assist with removal of specific components of PPE, as outlined below. The trained observer's assistant disinfects their own outer-gloved hands immediately after handling any cleanup workers PPE.
2. **Inspect PPE Prior to Doffing:** Inspect the PPE to assess for visible contamination, cuts or tears before starting to remove. If any PPE is potentially contaminated, then disinfect using an EPA-registered disinfectant wipe. If the facility conditions permit

and appropriate regulations are followed, an EPA-registered disinfectant spray can be used, particularly on contaminated areas.

3. **Disinfect:** Disinfect apron (if used), face shield, outer gloves, outer suit, boot covers (if used, and rubber boots if covers are not used) with either an EPA-registered disinfectant wipe or with ABHRs, and allow them to dry.
4. **Doff Apron (if used):** Remove and discard the apron, taking care to avoid contaminating gloves by rolling the apron from inside to outside. Remove and discard the outer boots (if outer boots are used).
5. **Disinfect:** Disinfect the outer suit again, especially the portions where the apron and apron straps were covering. Disinfect rubber boots (if outer boots were used).
6. **Doff Face Shield:** Dispose the face shield in the appropriate receptacle after doffing it.
7. **Disinfect:** Following the face shield removal, disinfect the exposed surfaces of the respirator, including tape.
8. **Remove Tape:** Remove all exposed tape including the tape around the outer gloves, respirator, and rubber boots and dispose in the appropriate receptacle.
9. **Disinfect and Remove Outer Gloves:** Disinfect outer-gloved hands with either an EPA-registered disinfectant wipe or with ABHRs. Remove outer gloves, taking care not to contaminate the inner glove during the removal process. Discard the outer gloves in the appropriate receptacle.
10. **Inspect and Disinfect Inner Gloves:** Inspect the inner gloves' outer surfaces for visible contamination, cuts or tears. If an inner glove is visibly soiled, cut or torn, then disinfect the glove with either an EPA-registered disinfectant wipe or with ABHRs. Then remove the inner gloves, perform hand hygiene with ABHRs on bare hands, and don a clean pair of gloves. If no visible contamination, cuts or tears are identified on the inner gloves, then disinfect the inner-gloved hands with either an EPA-registered disinfectant wipe or with ABHRs.

Note: If a filtering face-piece respirator with an N95 rating is used, remove the face shield (if used) at this time: Remove the full face shield by tilting the head slightly forward, grabbing the rear strap and pulling it over the head, gently allowing the face shield to fall forward and discard. Avoid touching the front surface of the face shield.

11. **Doff Rubber Boots and Outer Protective Suit:** Remove and place in the appropriate receptacle. Depending on suit design and location of fasteners, the cleanup worker can either untie fasteners, receive assistance by the trained observer's assistant to unfasten the suit, or gently break fasteners.

    When removing the outer suit, slowly and carefully reach for the zipper or fasteners and unzip or unfasten the outer suit completely before rolling down and turning inside out if possible. Avoid contact of the outer surface of the outer suit with the outer surface of the inner suit during removal. Pull inner suit away from the body, rolling inside out and touching only the inside of the suit. Carefully dispose of the suit in the appropriate receptacle.

12. **Disinfect Inner Gloves:** Disinfect inner gloves with either an EPA-registered disinfectant wipe or with ABHRs.

13. **Remove PAPR Battery:** Remove the PAPR battery (if a PAPR is used), including the duct tape belt, and place the battery in a container or area designated for the collection of PAPR components. Place the tape in the appropriate receptacle.

14. **Doff Inner Suit:** Slowly and carefully reach for the zipper or fasteners and unzip or unfasten the inner suit completely before rolling down and turning inside out. Avoid contact of the outer surface of the disposable inner suit with skin, undergarments, or any other surface during removal. Pull inner suit away from the body, rolling inside out and touching only the inside of the suit. Carefully dispose of the suit in the appropriate receptacle.

15. **Disinfect Inner Gloves:** Disinfect inner gloves with either an EPA-registered disinfectant wipe or with ABHRs.

26. **Doff Respirator:** Cleanup workers can remove their respirator, being careful not to touch inside the respirator or their face.

17. **Disinfect and Remove Inner Gloves:** Disinfect inner-gloved hands with either an EPA-registered disinfectant wipe or with ABHRs. Remove and discard gloves, taking care not to contaminate bare hands during removal process.

18. **Perform Hand Hygiene:** Perform hand hygiene with ABHRs.

19. **Shower:** Showers are required using antibacterial soap. Disposable towels must be provided for drying off and placed in the appropriate receptacle after use.

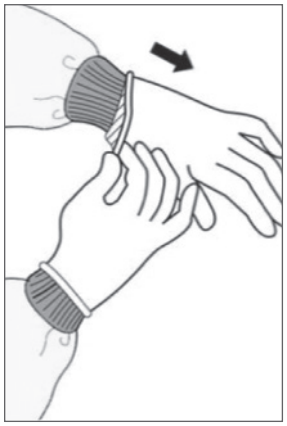
20. **Protocol Evaluation/Medical Assessment:** Either the infection preventionist, infectious disease specialist, occupational safety and health coordinator, or their designee on call at the time, should meet with the cleanup worker to review the activities performed, to identify any concerns about protocols and to record worker's level of fatigue.

SAFE DOFFING OF INNER GLOVES

Doffing the inner gloves is one of the most basic, but most important techniques you must master to work safely in an infectious disease worksite. The inner gloves must be removed in a way that minimizes or completely avoids contamination of other surfaces, such as your hands. If your hands become contaminated in the process, you may accidentally transfer biological agents to other parts of your body, or other surfaces.

The CDC has a standard protocol for doffing gloves that is used by healthcare professionals for a number of different work tasks. The same procedures apply to workers going through the decontamination process. The doffing of PPE contains a number of different steps (*Figure 19*) and equipment, and so practicing and mastering the procedures to safely doff and dispose of the inner gloves is highly recommended.

Figure 19: CDC steps for safely doffing inner gloves



- *Grasp outside edge near wrist.*
- *Peel away from hand, turning glove inside-out.*
- *Hold in opposite gloved hand.*

- *Slide ungloved finger under the wrist of the remaining glove.*

- *Peel off from inside, creating a bag for both gloves.*
- *Discard gloves in waste container.*

Additional Detailed Protocols

There must be written protocols for all workers who have potential for occupational exposure to infectious diseases based on job tasks and the site specific work flow.

Additional protocols should be written for:

- For each risk category.
- For each job task, including:
    - Anteroom nurse.
    - Environmental services.
    - Laboratory.
    - Waste management.
- Other protocols should include:
    - Spill cleanup.
    - Needlestick or cut.
    - Breech in PPE.
    - Patient transport.
    - Clinical samples.

DECONTAMINATING AND DISINFECTING PPE

The CDC guidelines for healthcare include disinfecting immediately any visibly contaminated PPE surfaces, equipment or patient care area surfaces using an EPA-registered disinfectant wipe. (More detail about using EPA-registered disinfectants is covered in *Chapter 6: Work Area Preparation, Decontamination, and Disinfection*.)

The CDC also recommends performing regular cleaning and disinfection of patient care area surfaces, even absent visible contamination. They state that this should be performed only by nurses or physicians as part of patient care activities, in order to limit the number of additional healthcare workers who enter the room.

Decontamination and disinfection procedures are specific to the industry, job task, and work site. Decontamination and disinfection are critical because workers can become contaminated with infectious material while taking off PPE and respirators.

DISPOSAL OF CONTAMINATED PPE

Disposable PPE, such as protective gowns or suits, should be put into leak-proof disposable infectious waste containers. Containers should have leak-proof labeled biohazard bags that conform to DOT Hazardous Materials Regulations (HMR) specifications: The film bags must have a minimum film thickness of 1.5 mils (0.0015 inch) and be 175 liters or smaller (46 gallons).

See Chapter 6 for more information about decontamination, and Chapter 7 for more information about handling infected waste.

Summary

The use of PPE can be complicated when dealing with infectious disease scenarios, because there is no one type of PPE that protects against all situations. As a result, there are many types of PPE that you need to become familiar with.

The OSHA PPE standard (29 CFR 1910, Subpart I) requires that employers assess the workplace, determine the presence of hazards, and then choose appropriate PPE to protect workers. Employers must select PPE that protects workers against infectious substances and other hazards to which they may be exposed. Depending on the route(s) of transmission of the pathogen of concern, and the types of potential exposures associated with a worker's job tasks, workers must wear PPE to help minimize exposure to pathogens via mucous membranes, broken skin, or through inhalation of bio-aerosols or airborne particles.

A respirator is designed to protect you from exposures through inhalation, which is the most common route of exposure to hazardous chemicals and other materials such as infectious diseases. There are many different types of respirators, all of which are useful in specific situations. OSHA designates an assigned protection factor (APF), which is the workplace level of protection that a type of respirator is expected to provide. The lower the APF, the lower your protection. The higher the APF, the higher your protection.

There are two basic types of respirators that you can use to protect yourself against airborne contamination. An air-purifying respirator (APR) relies on the air in your work environment as your source of breathing air. An atmosphere-supplying respirator (ASR) supplies you with safe breathing air from a cylinder on your back or a hose connected to a source of safe air. APRs clean the air you breathe by filtering or removing contamination from the air before it enters your lungs. These include negative-pressure air-purifying respirators, disposable paper masks and quarter masks, half-face APRs, full-face APRs, and positive-pressure air-purifying respirators (PAPRs). There are two types of ASRs. A supplied air respirator (SAR) provides air delivered by an airline connected to a safe air source. A self-contained breathing apparatus (SCBA) provides air that is supplied by a compressed air cylinder on your back.

OSHA's Respiratory Protection Standard (29 CFR 1910.134) requires employers to identify respiratory hazards, and to use feasible engineering controls to reduce such hazards. A written respiratory protection program must cover the required job-specific procedures for

selecting respirators, medical evaluations, fit-testing, proper use, maintenance and training. Your employer must appoint a respirator program administrator to oversee the respiratory protection program, and to conduct the required evaluations of program effectiveness.

Selection of PPE should always be based on risk assessment. The level of protection needed for a work environment can be grouped into two categories: high-risk protection and low-risk protection.

PPE for high-risk environments includes gloves (inner and outer), protective suits (inner and outer) with hoods, foot protection, face shield, respirators, and plastic aprons. PPE for low-risk environments includes gloves (inner only), gowns, foot protection, face shield, respirators, and plastic aprons. Training with the PPE being used is crucial in order to maximize the protection it provides.

Designated areas should be established for donning and doffing PPE. It is best to use an anteroom, a dedicated patient room, or an enclosed space (such as a three-stage decontamination unit), outside the work area for removing PPE. Donning (putting on) PPE in a highly-infectious disease environment requires a trained observer to oversee the process, step-by-step procedures and a posted checklist, use of a trained observer, and practice. Doffing (taking off) PPE also includes decontamination of equipment, and hand washing, hydration and showering. There must be written protocols for all workers who have potential for occupational exposure to infectious diseases, based on job tasks and the site-specific work flow.

The CDC guidelines for healthcare include disinfecting immediately any visibly contaminated PPE surfaces, equipment or patient care area surfaces using an EPA-registered disinfectant wipe. Decontamination procedures are specific to the industry, job task, and work site. Decontamination is critical because workers can become contaminated with infectious material while taking off PPE and respirators. Disposable PPE, such as protective gowns or suits, should be discarded into leak-proof, disposable infectious waste containers. Containers should have leak-proof, labeled biohazard bags that conform to DOT Hazardous Materials Regulations (HMR) specifications.