



Conservators face many potentially harmful inhalation hazards from the varied chemicals and techniques they use in their work. Effective methods for reducing such exposures include administrative controls (removing workers from areas where the contaminant is present), replacement of hazardous materials with safer substitutes, engineering controls, and the use of respirators. Since administrative controls and substitution of materials are often not viable options for conservators, this article considers the use of engineering controls such as local exhaust ventilation and, where these methods are inadequate protection, the use of respirators.

VENTILATION DEVICES

Conservators can protect themselves with a variety of ventilation devices:

Laboratory Hoods allow enclosure of the work process by placing relatively small pieces of work inside the hood. Keeping the face opening of the hood small by partially closing the sliding door or “sash” improves the overall performance of the hood. Placement of the work further into the hood can also increase the containment of the chemicals, provided that the item(s) does not block the exhaust slots or baffles at the back of the hood. To function effectively, laboratory hoods need proper airflow. Suggested face velocities range from 80-125 feet per minute. Often the manufacturer can supply meters to measure the face velocity upon request. Meters are also available at low cost from laboratory safety supply houses. Another inexpensive method for determining whether there is effective exhaust uses smoke generating cartridges, matches, or tubes. The smoke will show how well the contaminants are captured and how fast the hood clears the smoke. Smoke coming out the front may indicate that an expert should evaluate the hood because the flow may be too high, excess storage is blocking air circulation, or the plenum and ducts are blocked.

Local Exhaust Devices With Flexible Trunks (snorkels or elephant trunks) allow ventilation to be moved to the point where work is done. This type of ventilation is very useful where the conservator must travel over a wide area within the workspace or work on a larger object. The capacity of the exhaust should be sufficient to reach laterally over the length of the work. Even if the vacuum cannot be perceived easily, the trunk still may be effectively evacuating fumes. If the user has concerns that the exhaust is not working properly, smoke-generating devices can be used to test the “pull” of the trunk. These smoke generating devices are available through the lab safety supply houses. Instrumentation may be used to quantitatively evaluate the effectiveness of local exhaust devices. It is important to keep the exhaust opening close to the work. A general guideline suggests that the hood be no more than one diameter of the exhaust opening away from the work.

Paint Spray Booths have recommended airflow rates that vary with the task and toxicity of the solvents used. It is hard to generalize about adequate airflow rates, because they can be affected by the booth design, the type of work, and the object being treated. Check with an industrial hygienist for specific information about spray booth safety guidelines.

Portable Exhaust Hoods need to be evaluated closely, since there are many on the market. While they may be similar to lab hoods, treatment of exhaust air should be considered, especially if it is exhausted back into the work area. If the process generates dust or other particles, a high efficiency particulate air (HEPA) filter should be installed so that the particles are not recirculated. Removal of solvent vapors is more challenging. Typically, activated charcoal filters are used to remove many organic solvent vapors, but they will not remove all solvent vapors, nor do they last indefinitely. When the service life of the charcoal filter is exhausted, the solvent vapor passes right through the filter and may be dumped back into the room. It is difficult to know when to replace the filters, given the wide variety of solvents with which conservators work. For some solvents the filter can last a long time (perhaps months depending on the filter's size) or a very short time (perhaps days or weeks) for something like acetone or methylene chloride.

Unfortunately, engineering controls do not always solve the problem. These controls may be too costly, impractical, time-consuming, or inapplicable in some operations. When engineering controls or work practices cannot reduce exposures sufficiently, sometimes respirators can. For effective protection it is important to select the proper device, use it correctly and maintain it properly.

RESPIRATORS

There are two types of respirators: air-purifying and atmosphere-supplying. Air-purifying respirators filter the air contaminants with a particulate filter or chemical cartridge. Atmosphere-supplying respirators provide breathable air (often fresh air) from an uncontaminated air source; oxygen generators, pressurized oxygen or air tanks or through a specialized compressor. Because there is no all-purpose respirator to protect against all contaminants and concentrations in all situations, it is important to match the expected respiratory protection needs with the protection offered by the various designs.

Air-Purifying Respirators

Air-purifying respirators are of two types: negative pressure (commonly used by conservators), in which the wearer inhales to draw air through the cartridge or filter, and powered air-purifying (PAPR), in which air is blown through the cartridge or filter by a power pack most often worn at the waist. Both types use chemical cartridges to remove specific vapors and gases, while filters remove particulate matter such as dusts, mists or fumes. The air-purifying respirator consists of a chemical cartridge and/or a filter attached to a half facepiece (covering the mouth and nose), full facepiece (covering mouth, nose and eyes) or hood (PAPRs only). The chemical cartridges and particle filters remove the contaminants differently. This means the criteria for determining how long they last are different and will be discussed later.

Air-purifying respirators are designed to remove particles and gases and vapors.

Particles

The conservator may be able to choose from up to nine particulate filters depending on the manufacturer they use. The nine types of filters fall into three “series” of filters; N, R, or P. Each series has three levels or classes of filter efficiency. The three classes are 95 (95% efficient), 99 (99% efficient) and 100 (99.97% efficient). The efficiency level stated is for the most difficult particle size to filter. This means that when the filter is being used, its efficiency will be greater than that stated.

N-series filters are for use in atmospheres free of oil aerosols. They may be used for any solid or liquid airborne particulate hazard that does not contain oil. Generally, these filters should be used and reused subject only to consideration of hygiene, damage and increased breathing resistance.

R-series filters are intended for removal of any particle including oil-based liquid aerosol. They may be used for any solid or liquid airborne particulate hazard. If the atmosphere contains oil, the R-series filter should be used only for 8 hours of continuous or intermittent use.

P-series filters are intended for use against any particle including oil-based liquid aerosols. They may be used for any solid or liquid particulate airborne hazard. All P-series filters must be discarded according to the time-use restriction supplied by the respirator manufacturer. This time use limitation is longer than that for R-series filters, so the P-series filters can be used for much longer times when used in atmospheres containing oil mist.

The following guide might be helpful in remembering which filter series to use:

- N** for **N**ot resistant to oil,
- R** for **R**esistant to oil,
- P** for oil **P**roof.

See Table 1 for more on filter description and uses. These filters are used on the respirator by themselves when there is only a particulate hazard. They may also be used in combination with chemical cartridges when there are both vaporous and particulate hazards such as during varnish spraying (see below).

Gases and Vapors

Air-purifying respirators use chemical cartridges to protect against gases and vapors. These cartridges contain a granular, porous material, typically activated charcoal for organic vapors that has a large surface area per gram of material. Although conservators may most often use organic vapor cartridges, other types of cartridges are available to protect against:

- acid gases,
- combination of organic vapors and acid gases,
- ammonia,
- formaldehyde and
- mercury vapor.

To increase their effectiveness for these other gases and vapors, chemically treated activated charcoal is used. The multi-gas cartridge is one that works for all of those contaminants, except mercury vapor, but is the same size as the cartridges listed above. While it is effective against many more chemicals, it does not last as long as the cartridge that is designed for a specific contaminant or contaminant type.

When gases or vapors and particulate hazards are present (e.g., varnish spraying) the air-purifying respirator needs to be equipped with both a chemical cartridges and particle filters on top of the cartridge.

TABLE 1. Description and Use Guide for Particle Filters

Filter Type	Efficiency	Types of contaminants	Service time
Air-purifying respirators	(laboratory test with loading)		
<i>N-Series</i>		<i>Non-oil aerosols</i>	
• N-95	95%	Solid and water-based particles (<i>i.e. Non-oil aerosols</i>) Includes bioaerosols such as mold, frass, animal droppings, metal dusts, insecticide dusts	Limited by considerations of hygiene, damage and breathing resistance
• N-99	99%		
• N-100	99.97%		
<i>R-Series</i>		<i>Oil and non-oil aerosols</i>	
• R-95	95%	Oil mists, including lubricants, cutting fluids, glycerin, wood finishing oils and non-oil aerosols	8-hours. When no oil aerosols are present, limited the same as N-Series filters
• R-99	99%		
• R-100	99.97%		
<i>P-Series</i>		<i>Oil and non-oil aerosols</i>	
• P-95	95%	Oil mists, including lubricants, cutting fluids, glycerin, wood finishing oils and non-oil aerosols	Limited by the manufacturers time-use limitation. When no oil aerosols are present, limited the same as N-Series filters
• P-99	99%		
• P-100	99.97%		
Powered Air-Purifying Respirators	(laboratory test; no particle loading)		
• HE (HEPA)	99.97%	Oil and non-oil aerosols	Limited by considerations of hygiene, damage and maintaining the proper air flow as indicated by the flow meter or low air flow alarm

These filters can be replaceable or permanently attached to the cartridge.

Air-purifying respirators have a number of limitations. First they do not protect against oxygen deficiency. This situation could occur during fumigation using CO₂ or nitrogen, in which case an atmosphere-supplying respirator would be the only safe form of protection. Air-purifying respirators are also limited to use where the contaminant is present in relatively low concentrations. Finally, they must have the proper air-purifying element for removal of the contaminant. In cases where oxygen deficiency or high concentrations may be present, it is best to consult an industrial hygienist.

Face fit is crucial. Beards, mustaches, sideburns, long bangs, facial jewelry, or glasses may prevent the respirator surface from sealing properly and completely. An incomplete seal between the respirator and skin can nullify the respirator's effectiveness. Individuals with facial hair or jewelry must consider a different type of PPE, such as a powered air-purifying respirator. Spectacle kits for full facepieces are available allowing prescription lenses to be mounted inside the respirator without breaking the face-to-facepiece seal. A typical half-facepiece respirator with 6 cartridges for organic vapors costs approximately \$60. Full face respirators typically cost

about \$350-\$400 with 6 cartridges. Half-face and full-facepiece air-purifying respirators *do not provide a complete seal for those with facial hair, and they do not conform to OSHA standards for bearded workers.*

Powered Air Purifying Respirators

Powered air-purifying respirators (PAPRs) use the same types of cartridges as air-purifying respirators. Unlike negative pressure air-purifying respirators, there is only one particle filter available for PAPRs. It is called a high efficiency filter (see Table 1). These devices use a power source (usually a battery that needs to be charged after 8 hours of use) to operate a blower that passes air across the filter or cartridge into a half or full facepiece, loose-fitting facepiece, helmet or hood. A wider variety of facepiece styles is available in PAPRs than in air-purifying respirators, and they are generally more protective. They are easier to breathe through, since the motor and blower do most of the work. PAPRs *with hoods and helmets* (not half- or full-face masks) conform to OSHA standards for those with facial hair or other facial features that would affect the sealing capability of a "facepiece" type respirator. Disadvantages include increased weight and size, complexity, and cost, usually around \$1500.

Cartridge Service Life

The length of time a cartridge lasts (*i.e.* its service life) varies with the chemical and its concentration in the air. When the end of its service life is reached, the solvent vapor then passes right through the cartridge. Since this can occur rapidly, it is important to replace the cartridge before this happens. A general guideline is that if the organic chemical has a boiling point greater than 70°C and an airborne concentration ≤ 200 parts per million (ppm), the chemical cartridge should last at least 8 hours. Solvents with a boiling point greater than 70°C include toluene, xylene, methyl ethyl ketone, propyl and butyl alcohol, Cellosolv®, ethanol, diacetone alcohol, dimethyl formamide, and most of the Shell aliphatic hydrocarbons. Acetone and methanol have boiling points below 70°C.)

However, this guideline of 8 hours assumes the cartridges are stored in a resealable plastic bag when not in use. A cartridge lying exposed on any work surface in a room in which there are solvent vapors will be using up a part of its service life even if it is not being worn. Also, if the conservator is working very close to the solvent the airborne concentration may be higher than 200 ppm and in this situation the eight-hour guideline may not apply. There are several ways to measure the concentration; one can have an industrial hygienist do a sampling study or purchase relatively inexpensive (under \$120) passive monitors that clip onto the conservator's shirt. The price includes analysis by the laboratory. This concentration information can be used to obtain a better service life estimate for determining when to change the cartridge than following this guideline. Most respirator manufacturers have information or computer programs on their webpage that allow the cartridge's service life to be determined. It is important to use the manufacturer's program that corresponds to the chemical cartridge brand in use. To use these programs, the conservator typically needs to know four things:

1. Chemical name(s),
2. Chemical airborne concentration(s),
3. Chemical cartridge model number, and
4. Work environment (*e.g.*, temperature, humidity and work level).

These programs then provide a specific service time for changing the cartridge based on the conservator's situation.

Another option for determining how long an organic vapor cartridge lasts is to use the on-line Occupational Safety and Health Administration (OSHA) Wood Model Table:

www.osha.gov/SLTC/etools/respiratory/change_schedule_mathmodel.html.

This is a table listing cartridge service time for several organic solvents at various concentrations. It is very easy to use. To use this table only the chemical name and its concentration is required. The conservator can look up the organic solvent in the Wood Model Table and then select the concentration from the table. The time in minutes for that concentration is an estimate of how long the cartridge will last. If your concentration is not specifically listed, then the concentration closest, but higher than that measured should be used. The time listed for this concentration is the time estimate to use.

There are at least four shortcomings to the Wood Model Table:

1. Only lists the more common organic vapors and the estimate is only for organic vapor cartridges. It does not work for chemicals that are not organic vapors, *e.g.*, ammonia and ammonia cartridges,
2. Does not list all concentrations, *e.g.*, it lists 250 ppm and 500 ppm among some others. If your concentration is 400 ppm, you need to select the time at 500 ppm which could result in throwing away the cartridge early,
3. Is not based on any one manufacturer's organic vapor cartridge, but rather a conglomerate of all of the models on the market and includes those manufactured as long ago as the 1970s. This can result in a very conservative estimate, meaning you could be throwing it away earlier than needed, and
4. Is not able to be used for mixtures (*i.e.*, more than one vapor in the air at a time).

In addition, there is no help available for the Wood Model Table. Most, if not all, manufacturers have people you can access for help with their program.

Currently in 2016, all mercury vapor cartridges and one manufacturer's (3M) organic vapor cartridges are now available with an end-of-service-life indicator (ESLI). The one for organic vapors works for many solvents, but not all of them. The respirator manufacturer can help in identifying which chemicals for which it is best suited. These indicators provide a visual clue, (a color change in a small window on the cartridge) that indicate when it is time to change the cartridge. When the color change or the length of the stain indicates the cartridge is used up, it is time to throw that one away and get a new one. If cartridges with service life indicators are not available for a specific hazard, establish a cartridge change-schedule using the respirator manufacturer's program. The time estimate from the program indicates the maximum length of time the cartridge lasts under the work conditions identified by the conservator. This time indicates whether the

cartridge will last for the duration of the job, and if not, how soon it should be replaced.

Cartridge re-use is another issue to address if the cartridge is not used up in one day. The chemical boiling point is used as a guide to determine if the cartridge should be re-used. If the boiling point of the organic chemical is less than 65°C, then the cartridge should never be reused, even if the cartridge has not been used for the full duration of the time estimate. Low boiling point chemicals, like acetone and methanol, can “migrate” through the organic vapor cartridge when it is not being used and can come off the cartridge as soon as the conservator puts it on the next day, breathing in the chemical. The higher the boiling point of the chemical, the less volatile the chemical, resulting in lesser degree of migration. There is no fine line between the chemicals that migrate and the ones that do not. An organic solvent with a boiling point of 70°C does not migrate as fast as one with a boiling point of 65°C, but it migrates a little faster than one with a boiling point of 75°C (see Table 2 for boiling points of some common chemicals used by conservators.)

Cartridges used against chemicals with boiling points greater than 65°C and less than 85°C should not be stored over a weekend and then reused. For this reason, some people use the “running clock” method for these organic chemicals with a boiling point greater than 65°C. In this technique, the time

estimate is used to indicate the total time before the cartridge is thrown out after it has been removed from the manufacturer’s packaging. As an example, if the service-time estimate is 40 hours, the clock starts ticking at the moment the cartridge package is opened. It is then thrown away 40 hours later. So if it is opened on Monday morning (e.g., 8:00 am), it is then thrown away at the end of the day on Tuesday (i.e. midnight). A new cartridge is used to start Wednesday morning. Some respirator users even use the “running clock” guideline for chemicals with boiling points greater than 85°C.

Regardless of the boiling point of the chemicals you are using, a cartridge, in most cases, is expended very rapidly toward the end of its service life. At that point the chemical breaks through, and the often suddenly noticeable odor, taste or irritation may also indicate that it is time to replace cartridges. Although these warning signs may be noticed by most users, they may not be evident to all, since users’ sense of smell vary. In addition, not all contaminants have an odor detectable at safe levels—that is below the threshold limit value (TLV) for that contaminant. The TLV value can often be found on the Safety Data Sheet (SDS). To understand TLV’s consult Monona Rossol, “Using TLVs for Common-Sense Risk Assessment for Solvents,” *AIC News*, January 1993, p. 1-5. Also see Rossol’s data sheet on TLV’s available on the AIC Health & Safety website.

TABLE 2. Respirator Selection Guide

CHEMICAL	ODOR THRESHOLD	TLV	BOILING POINT	RESPIRATOR	COMMENTS
Acetone	3.6-653 ppm	250 ppm TWA* 500 ppm STEL**	56.5°C	Organic vapor	Short service life
Ammonia	0.043-53 ppm	25 ppm TWA 35 ppm STEL	Not applicable	Ammonia	Eye irritation
Bioaerosols (e.g., mold, frass, animal droppings)	Not applicable	NA (see nuisance particulates)	Not applicable	N, R, or P100 or PAPR with HE filter	
Cadmium	Not applicable	0.005 mg/m ³ TWA	Not applicable	N, R, or P 100	OSHA requirement
Cellosolv®	2.7 ppm	5 ppm TWA	135 °C	Organic vapor	Skin absorption
Hydrochloric acid	0.255-10.16 ppm	2 ppm ceiling***	Not applicable	Acid gas	Irritation warning
Methyl alcohol	4.2-5960 ppm	200 ppm TWA 250 ppm STEL	64.7 °C	Airline	Ineffective cartridge
Methylene chloride	160 ppm	50 ppm TWA	39.75 °C	Airline	OSHA requirement
Nuisance particulates	Not applicable	10 mg/m ³ TWA	Not applicable	N, R, or P95	
Stoddard solvent	1-30 ppm	100 ppm TWA	140-200 °C	Organic vapor	
Toluene	0.16-37 ppm	20 ppm TWA	110.6 °C	Organic vapor	
Xylene	20 ppm	100 ppm TWA 150 ppm STEL	139.3 °C	Organic vapor	

*TWA: Time Weighted Average- average concentration for a conventional 8- hour work day

**STEL: Short Term Exposure Limit- 15 minute TWA exposure limit that should not be exceeded at any time during a work day

***Ceiling: the concentration that should not be exceeded during any part of the working exposure

These reasons illustrate the importance of determining the cartridge service life and why the conservator should not rely on odor as the primary indicator for changing the cartridges. Odor thresholds are listed in a number of publications (American Industrial Hygiene Association, 1989) and are required on Canadian SDS. This information allows the conservator to decide if odor should be used as a secondary or “backup” indicator to change the cartridges. Methylene chloride, isocyanates, and urethane have TLVs well below the odor threshold).

Chemical cartridge respirators cannot be used when:

- the cartridge is not effective against the solvent (breakthrough occurs too quickly for practical use),
- there is no cartridge available for the gas or vapor, or
- a chemical cartridge change-schedule cannot be determined.

Atmosphere-supplying (specifically airline) respirators (see below) are required in these situations according to OSHA standards. (All employers with salaried employees are responsible for making sure those employees adhere to OSHA standards.)

Primary Providers of Air-Purifying Respiratory Protection Equipment

3M Personal Safety Division

(800) 243-4630
3M.com/workersafety

Draeger Safety, Inc.

(800) 858-1737
www.draeger.com

Mine Safety Appliances

MSA Customer Service

(800) MSA-2222
www.msanet.com

Moldex

(800) 421-0668
www.moldex.com

Honeywell Safety Products

(includes North by Honeywell and Survivair)
Customer Service: (888) 212-7233
Technical Support: (800) 873-5242
www.honeywellsafety.com

Scott Safety

(800) 247-7257
www.scottsafety.com

Atmosphere-Supplying Respirators

Supplied air (also called airline) respirators are a type of atmosphere-supplying respirator that receive air from either pressurized tanks of Grade D air or from a special-use compressor that has suitable safeguards (*i.e.*, inline filters or oil free lubrication) to provide Grade D air to the wearer. Grade D is one grade of breathing air established by the Compressed Gas Association. Other grades of breathing air are used for underwater diving and medical air. (For the specific requirements of Grade D air, see Table 3.). Air is delivered either continuously (continuous flow) or intermittently (pressure demand) in sufficient volume to meet the wearer’s breathing requirements. Generally airline respirators offer the same degree of protection as PAPRs, but they are required if the user does not establish a chemical cartridge change-schedule for gas and vapor exposures or there are no cartridges effective against the contaminant. It is important that the compressor be located in an uncontaminated area (*i.e.*, not where the conservator is using solvents).

Continuous-flow airline respirators are available with either a half or full facepiece, loose-fitting facepiece, helmet, or hood. Pressure-demand airline respirators are equipped with either half or full facepieces. Since airline respirators do not rely on filters or cartridges, they are applicable for use with a wider range of chemicals than air-purifying respirators and PAPRs. Continuous-flow airline respirators with helmets and hoods can be used by workers with facial hair or other features that would affect the sealing capability of a half, full or loose-fitting facepiece. Airline respirators can be designed to provide cooling or heating to the wearer, so they can be more comfortable to wear. Disadvantages include having to secure an air supply for the respirator, dragging an air hose around, and relatively complex maintenance. The cost may approach \$1000 or more, since air must be “purchased” either through a special-use compressor or by renting pressurized tanks of air.

TABLE 3. Requirements for Grade D Breathing Air

Limiting Characteristic	Limiting Quantity
Oxygen Content (v/v)	19.5-23.5%
Oil (condensed)	≤ 5 mg/m ³
Carbon monoxide	≤ 10 ppm
Carbon dioxide	≤ 1000 ppm
Odor	Lack of noticeable odor
Water	No liquid water

RESPIRATOR SELECTION

Selecting the appropriate respirator requires considering the properties of the inhalation hazard and the capabilities and limitations of the various respirators. First, the potential airborne contaminants and the existing TLV or other occupational exposure limits must be determined. Exposure limits may not exist for many materials conservators use. In these cases, the conservator should use common sense to evaluate what level of respiratory protection may be desired or seek the help of an industrial hygienist. For example, if the contaminant has no TLV but the Safety Data Sheet lists it as a respiratory irritant only, a half-face respirator may be adequate. However, if the material has no TLV but it is an eye irritant or is toxic, then a PAPR or airline respirator with a full facepiece or hood may be more appropriate.

It is also necessary to determine if OSHA has a comprehensive health standard for the specific contaminant of concern (as they do for arsenic, lead, cadmium, formaldehyde and others). These are listed as 29 CFR 1910.1000+ series, to be found at www.osha.gov. If so, conservators should follow the specifications listed there, if any, for the type of respiratory protection to be used. Next, it is important to determine if the potential for oxygen deficiency or chemical concentration exceeding the level immediately dangerous to life or health (IDLH) exists. If so, none of the respirators discussed here is acceptable, and an industrial hygienist should be consulted. The contaminant concentration should be measured or estimated, since the selection of respirators depends on concentration levels.

Finally, the physical state of the contaminant (*i.e.*, dust, mist, fume, gas, or vapor) should be determined. A particulate filter is needed for a dust, mist or fume. A chemical cartridge is required for a

gas or vapor. Industrial hygienists can be consulted for guidance on air sampling to determine concentration levels, or the information can be obtained from the passive monitors mentioned earlier. There are also a number of industrial hygiene references to help make these determinations (American Industrial Hygiene Association 1989; National Institute for Occupational Safety and Health, 2005).

Only respirators approved by the National Institute for Occupational Safety and Health (NIOSH) should be selected. This approval is the user's assurance that the respirator meets minimum performance criteria. OSHA has given respirators ratings called assigned protection factors (APFs). APFs are the assigned workplace level of respiratory protection provided by a properly fitted, maintained and used respirator. Table 4 lists OSHA's APFs for respirators that conservators might typically use. The number can be thought of as the level of reduction of the airborne concentration. An APF of 10 means the concentration is reduced 10 times, so one tenth of the contaminant in the air is actually breathed. Due to relatively small amounts of material used and/or the short duration of use by conservators (compared to industrial applications), exposure will probably be below 10 times the TLV. Therefore, a half facepiece respirator with an APF of 10 will generally be sufficient. Concern about possible higher concentrations can be addressed by personal dosimetry or an industrial hygiene survey.

If the contaminant is a particle (*i.e.* dust, mist, fume), select a filter based on the presence or potential of oil mists in the air. For example, if the contaminant is a solvent containing mist (*i.e.* varnish spray) or water containing mist, select a respirator with an N, R or P

TABLE 4. Assigned Protection Factors for Selected Respirators^{1,2}

TYPE OF RESPIRATOR	RESPIRATORY INLET COVERING			
	Half facepiece ³		Full facepiece	
Air-purifying	10		50	
	Half facepiece	Full facepiece	Helmet/Hood	Loose-fitting facepiece
Powered air-purifying	50	1000	25/1000 ⁴	25
Airline				
• Pressure demand	50	1000	---	---
• Continuous flow	50	1000	25/1000 ⁴	25

¹ Taken from 29 CFR 1910.134 (d)(3)(i)(A).

² These assigned protection factors are only effective when the employer implements a continuing, effective respirator program as required by 29 CFR 1910.134, including training, fit testing, maintenance and use requirements.

³ This APF category includes filtering facepiece respirators (disposable dust respirators), and half mask with elastomeric (rubber, silicone or plastic) facepieces.

⁴ To use an APF of 1000, you must have evidence from the respirator manufacturer that testing of these respirators demonstrates performance at a level of protection of 1000. Absent such testing, all other PAPRs and airline respirators with helmets/hoods receive an APF of 25.

Note: For combination respirators, *e.g.*, airline respirators equipped with air-purifying filters, the mode of operation in use will dictate the assigned protection factor to be applied.

series particulate filter. If there is a question whether the material contains oil, check the SDS to see if it describes any of the contents as oily (Not all SDS contain a description of the contents based on its oily characteristics). The respirator manufacturer can also be consulted as they often have selection guides that indicate which filter should be used with a specific chemical. If oil mist is present such as from using oil-lubricated, pneumatic hand tools or spraying an oil finish, select a respirator with either an R or P series particulate filter. Or for the small price difference (about 15%) between N and P, just assume oil is present. Typically any filter class (95, 99, or 100) is acceptable. The 95 class will typically be easier to breathe through and is probably the most frequently used. The 100 class will also clog up faster than the 95. However, if an OSHA standard requires a HEPA filter, then a Class 100 filter must be used.

If the contaminant is a gas or vapor, ask the respirator manufacturer if there is a chemical cartridge suitable for the contaminant. Some manufacturers publish selection guides to assist in choosing the right respirator for the task. If there are questions about the suitability of a respirator for a given task, consult the respirator manufacturer and/or an industrial hygienist. Table 2 lists some chemicals commonly used by conservators along with information needed to select a respirator. This information is often found in respirator selection guides. If a cartridge change-schedule cannot be determined or the service life is so short that the use of a chemical cartridge is not practical, select an airline respirator. For example, a 200 ppm concentration of methanol can break through an organic vapor cartridge in 10 minutes, so an airline

respirator may be the most appropriate choice when working with this solvent.

Please note that conservators spraying varnishes or other coatings should use a respirator with a combination cartridge consisting of an organic vapor cartridge integrated with a particulate filter or an organic vapor cartridge fitted with a replaceable approved particle filter. Combinations with replaceable filters allow the conservator to change only the filter when the chemical cartridge has not been used up. Permanently attached filters require the cartridge to be thrown away with the filter when it clogs. P100 filters will clog faster than P95 filters used under the same conditions. P95 filters designed for spray painting will last even longer than “regular” P95 filters in these applications.

To be effective, respirators must fit well and be worn properly during all times of exposure. Not wearing the respirator for even a short time while the chemical is present can practically eliminate the benefit of wearing it. *This time period can be as short as 6 minutes for a one-hour time exposure.* Respirator manufacturers provide training aids, such as videos and posters, and instructions on how to properly put on and adjust the respirator to the face.

Conduct a *user seal check* each time the respirator is put on. A user seal check consists of putting on the respirator, covering the cartridge or filters, and sucking in or blowing out air. If the user can do this easily, the respirator is not adjusted properly, may be missing valves, or filters are not properly installed. Tight-fitting respirators (*i.e.* half or full facepiece respirators) must be fit *tested* in addition to performing a *user seal check*.

Definitions Related to Airborne Contaminants

Dusts: Solid particles generated by handling, crushing, grinding, rapid impact, detonation, and decrepitation of organic or inorganic materials, such as rock, ore, metal, coal, wood, and grain. Dusts do not tend to flocculate, except under electrostatic forces; they do not diffuse in air but settle under the influence of gravity.

Fume: Airborne particulate formed by the condensation of solid particles from the gaseous state. Usually, fumes are generated after initial volatilization from a combustion process, or from a melting process (such as metal fume emitted during welding). Usually less than one micron in diameter.

Gas: A state of matter in which the material has very low density and viscosity, can expand and contract greatly in response to changes in temperature and pressure, easily diffuses into other gases, and readily and uniformly distributes itself throughout any container. A gas can be changed to the liquid or solid state only by the combined effect of increased pressure and decreased temperature (below the critical temperature).

Mists: Suspended liquid droplets generated by condensation from the gaseous state to the liquid state or by breaking up a liquid into a dispersed state, such as by splashing, foaming, or atomizing. Formed when a finely divided liquid is suspended in air.

Vapors: The gaseous form of substances that are normally in the solid or liquid state (at room temperature and pressure). The vapor can be changed back to the solid or liquid state either by increasing the pressure or decreasing the temperature alone. Vapors also diffuse. Evaporation is the process by which a liquid is changed to the vapor state and mixed with the surrounding air. Solvents with low boiling points volatilize readily.

Definitions from Fundamentals of Industrial Hygiene, by Barbara A. Plog et al., 2012, published by the National Safety Council.

RESPIRATOR FIT TESTING

Fit tests are used to determine which size and make of respirator fits the worker. It also demonstrates that the conservator can put it on correctly. One type, a qualitative fit test, uses a material that can be detected by taste or smell by the wearer. If the wearer detects the material during a properly conducted test, the respirator does not fit and a different size or brand should be tried. The other type of fit testing is a quantitative fit test in which either air leakage is evaluated or a test substance is measured both inside and outside of the respirator. The quantitative fit test provides a calculated fit factor for the respirator and is more objective than a qualitative fit test, though it requires special equipment and is more expensive.

The procedures for proper fit testing can be found in OSHA standards or respirator protection manuals (Colton *et al.* 2001; American National Standards Institute 2010; OSHA 2016). Industrial hygiene consultants and some respirator manufacturers or distributors will provide this service.

These fit tests have three components: a medical evaluation conducted by a health care provider, a training lecture, and the actual fit test.

Persons with facial hair (24 hours growth or more) must not be fitted, since they cannot wear half or full facepiece respirators safely.

Most people should be able to find a respirator with adequate fit, since half and full facepieces come in many shapes and sizes to fit a wide variety of face types and shapes. However, for those who cannot be properly fitted, a helmet or hood-type respirator can be used.

While employers are required to provide fit testing for their employees, the Health & Safety Committee recognizes there are many conservators who do not have access to fit tests; therefore, the Committee offers a fit test at the annual meeting. In addition, the committee works to help local conservation groups organize fit tests for their members.

Please contact the committee for more information
www.conservation-us.org/healthandsafety
HealthandSafety@conservation-us.org

RESPIRATOR MAINTENANCE

Respirators should be cleaned and sanitized, inspected for defects, and stored properly. If the respirator will be used by more than one individual, it must be cleaned and sanitized after each use. This involves removing the cartridges and filters, washing the respirator in warm water with a mild detergent, and sanitizing it with household bleach (2 tablespoons per gallon of water). Commercial sanitizing wipes are also available, but those containing alcohol are not suitable for use on nonsilicone respirators, which they can damage. Also, alcohol alone may not be an adequate germicidal agent for many serious biohazards like TB, hepatitis and HIV. Even if the respirator is used exclusively by one person, it should be cleaned after each day's use.

If defects are found, repairs must use replacement parts designated for that specific respirator. When the respirator is not in use, it should be stored in a resealable plastic bag to prevent damage to the elastic material from temperature extremes, damaging chemicals, and excessive moisture. Silicone respirators are usually more resistant to organic solvents than PVC or rubber models. Respirators must be stored in locations that ensure they are packed or stored so as to prevent deformation and contamination of the respirator. Storing respirators in lockers, paint spray booths or toolboxes often result in contamination. Cramming the respirator into small areas or placing heavy tools on them when storing in a locker or toolbox can result in a distorted facepiece that will not fit properly. Seal cartridges in plastic if they are to be reused, and store in a place where they will not absorb additional contaminants.

While at first the process of appropriate respirator selection may seem overwhelming, there are many sources of information and help. In addition to the respirator manufacturer, two additional references are worth consulting: the Colton *et al.* (2001) and the American National Standards Institute (2015). By selecting the proper respirator, using it correctly, keeping it in good repair, and wearing it during all times of exposure, conservators can reduce the inhalation hazard.

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http://www.conservation-wiki.com/w/images/f/fb/H%26S_TLV_Data_Sheet.pdf

**For conservation specific resources and more information,
visit the Health & Safety Committee website & wiki:**

www.conservation-us.org/healthandsafety
www.conservation-wiki.com/wiki/Health_&_Safety

About the Health & Safety Committee

The Health & Safety Committee provides educational and technical information to the AIC membership to increase knowledge of safety hazards and general health issues related to the conservation profession. It offer information through lectures, workshops, displays, AIC's publications, AIC's website and other electronic and print media. It also addresses health and safety issues of concern to the AIC membership by maintaining current information through research, by collaboration with health and safety professionals and with other health and safety organizations and, periodically, by statistically valid surveys, the results of which will facilitate establishing priorities.

Contact the Health & Safety Committee via email:
HealthandSafety@conservation-us.org.

About AIC

The American Institute for Conservation of Historic & Artistic Works (AIC) is the national membership organization supporting conservation professionals in preserving cultural heritage by establishing and upholding professional standards, promoting research and publications, providing educational opportunities and fostering the exchange of knowledge among conservators, allied professionals and the public.

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