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A Conservator's Guide to Respiratory Protection

Conservators face many potentially harmful inhalation hazards from the varied chemicals and techniques they use in their work. Effective methods for

reducing such exposure 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 FUME 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. To work effectively, fume 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 catalogs. Another inexpensive method for determining whether there is effective fume evacuation uses ventilation smoke tubes or candles. 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.

PAINT SPRAY BOOTHS have recommended air flow rates that vary with the task and toxicity of the solvents used. It is hard to generalize about adequate airflow rates, since they can be affected by the [CONTINUED PAGE 2]

HIGHLIGHTS OF THIS ISSUE

Qualification Standards

Preliminary Comments Sought by NPS on Proposed Federal Historic Preservation Professional Qualification Standards

The AIC Board has charged the Education and Training Committee with reviewing the proposed federal Historic Preservation Professional Qualification Standards, which are being prepared by a division of the National Park Service. The committee will review the history of these standards, clarify for the membership their contents, review comments from the membership forwarded to the committee, and advise the board on the short- and long-term implications for the field, assuming the standards will be adapted. The committee will then recommend to the board possible action and/or comment. The Education and Training Committee welcomes and encourages your comments.

Copies of the proposed standards can be obtained by calling Sue Henry at [redacted] or through the Internet at sue_henry@nps.gov. [CONTINUED PAGE 2]

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Opinions expressed in the Letters to the Editor column are those of the contributors and not official statements of the AIC. Responsibility for the materials/methods described herein rests solely with the contributors. Copy must be typed double-spaced and sent to the AIC office; the next deadline is March 31, 1995. We reserve the right to edit for brevity and clarity.

The AIC accepts position available ads only from equal opportunity employers. All position ads must conform to the standards for equal opportunity employment. The cost of Grants and Internships, Position Available, and Classified Ads is: $.85 per word for members and $2 per word for non-members; minimum charge is $50.

The cost of advertising in Supplier's Corner is $100 for 100 words. The cost of display ads is: ⅙ page $155; ⅓ page $290; ½ page $365; ⅔ page $400; one full page $600. Deadlines for camera-ready copy are February 1, April 1, June 1, August 1, October 1, and December 1.

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Standards

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The standards are also available via a World Wide Web client such as Mosaic or Lynx for connection to URL (http://palimpsest.stanford.edu/misc/secinterior/profqual.html) or through Gopher to palimpsest,stanford.edu (select Browse by subject to Historic Preservation).

Please forward your comments to committee chair Jerry Podany in care of the AIC office and/or to Sue Henry, Preservation Planning Branch, Interagency Resources Division, National Park Service, P.O. Box 37127, Washington, DC 20013-7127 (with a copy of your comments to AIC). Let your voice be heard on this matter.

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booth design, the type of work, and the object being treated. Check with an industrial hygienist for specific information about spray booth safety guidelines.

LOCAL EXHAUST DEVICES WITH FLEXIBLE TRUNKS (snorkels or elephant trunks) allow ventilation to be moved to the point where work is done. It is very useful where the conservator must travel over a wide area within the work space. 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 properly evacuating, smoke cartridges can be used to test the "pull" of the trunk. These cartridges are available through lab safety supply catalogs. Some industrial hygienists can 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.

PORTABLE EXHAUST HOODS need to be evaluated closely, since there are many on the market. While they may be similar to fume hoods, how they treat exhaust air should be considered, especially if they dump it back into the work area. If the process generates dusts 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 may be used to remove many organic solvent vapors, but it will not remove all solvent vapors, nor does it last indefinitely. It is difficult to know when to replace the filters, given the wide variety of solvents to which conservators may be exposed.

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 exposure 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 fresh air from an uncontaminated air source, either pressurized 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 are of two types: negative pressure (commonly used by conservators), in which the user 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 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.

Air-purifying respirators designed to remove particles from the air can usually use one of three types of filters. The *dust/mist filter* is for dust and mists with a threshold limit value (TLV) greater than or equal to 0.05 mg/cubic meter. This value can be found on the Material Safety Data Sheet (MSDS). (To understand TLVs, consult Monona Rossol, "Using TLVs for Common-Sense Risk Assessment for Solvents," *AIC News,* January 1993, pp. 1–5.)

The *dust/mist/fume filter* is used for the same dusts and mists, but it can also be used for fumes with a TLV greater than or equal to 0.05 mg/cubic meter. The *high efficiency (HEPA) air filter* is for dusts, mists, and fumes with a TLV of less than 0.05 mg/cubic meter. It is the most efficient respirator filter, but is also the hardest to breathe through and is slightly more expensive. All particulate filters become more difficult to breathe through as they get dirtier, a sign that the filter needs to be replaced.

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. To increase its effectiveness for other gases and vapors, chemically treated activated charcoal is used. Although conservators may most often use organic vapor cartridges, other types of cartridges are available to protect against acid gases, the combination of organic vapors and acid gases, ammonia, formaldehyde, and mercury vapor.

The cartridge service life varies with the chemical and its concentration in the air. A general guideline is that if the vapor has a boiling point of 70°C and an airborne concentration $\leq$ 200 parts per million (ppm), the chemical cartridge should last about 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 a tabouret 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 might not apply. The best way to measure the airborne concentration is to purchase relatively inexpensive (under $90) passive monitors that clip onto the conservator's shirt. The price includes analysis by the laboratory.

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 indicates 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 may vary. In addition, not all contaminants have an odor detectable at safe levels (below the TLV for that contaminant), so air-purifying respirators (even the PAPR type discussed below) are not adequate protection from contaminants with inadequate warning properties. Knowledge of such information about chemicals to which the conservator may be exposed is essential when choosing a respirator. Odor thresholds are listed in a number of publications (American Industrial Hygiene Association 1989) and are required on Canadian MSDSs. When chemical cartridge respirators cannot be used because the chemical does not have noticeable warning signs below the TLV, then air-supplying (airline) respirators (see below) are required according to OSHA standards. (All employers with salaried employees are responsible for making sure those employees adhere to OSHA standards.)

Air-purifying respirators have a number of limitations. First, they do not protect against oxygen deficiency. This situation could occur during fumigation using CO_2 or nitrogen, in which case a supplied air source would be the only safe form of protection. Air-purifying respirators are also limited to use where the contaminant is present in relatively low airborne 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 very important. If facial hair, long bangs, and temple bars on glasses come between the respirator sealing surface and the face of the wearer, leakage and a decrease in protection will result. The decrease from facial hair can be great, resulting in no protection. Spectacle kits for full facepieces are available allowing prescription lenses to be mounted inside the respirator without breaking the face-to-facepiece seal. (Half-face respirators cost around $50, with 6 cartridges for organic vapors. Full-face 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.* They cost $200–$250 with 6 cartridges.

Powered air-purifying respirators (PAPRs) use the sames types of cartridges as negative-pressure respirators. However these devices use a power source (usually a battery that needs to be recharged 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 also easier to breathe through, since the motor and blower do most of the work. PAPRs *with hoods or helmets* (not half- or full-face masks) conform to OHSA 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 $600.

Air-supplying (also called atmosphere-supplying or airline) respirators 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 user. An ordinary compressor without these safeguards cannot be used to supply air for an air-line respirator. (For the specific requirements, see Compressed Gas Association 1989.) 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 needs protection from a contaminant that does not have warning signs below its TLV to indicate the cartridge is exhausted. 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 or 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 worker, 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 $1,000 or more, since air must be "purchased" either through a special-use compressor or by renting pressurized tanks of air.

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 Material 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 (i.e., is listed as a carcinogen), then a PAPR or airline respirator may be more appropriate.

It is also necessary to determine if OSHA has a comprehensive health standard (e.g., lead, arsenic, cadmium) for the contaminant. If so, conservators should follow the specifications listed there for achieving adequate respiratory protection from the material in various airborne concentrations. 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) exist. 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. Industrial hygienists can be consulted for guidance on air sampling to determine the 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 1994).

Only respirators approved by the National Institute for Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA) should be selected. This approval is the user's assurance that the respirator meets minimum performance criteria. Respirators are also given ratings called assigned protection factors (APFs). APFs are the expected workplace level of respiratory protection that would be provided by a properly maintained and used respirator. Table 1 lists 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 by 10 times, so one tenth of that in the air is actually breathed. Due to the relatively small amounts of material used and/or the short duration of use (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 wearing passive monitors.

Proper selection requires matching the respirator to the hazard. The following simple selection steps can be used. After gathering the hazard information, divide the measured or estimated concentration of each contaminant (as determined by passive monitors or an industrial hygienist) by the TLV or other appropriate exposure limit. This determines the required APF. A respirator with an APF greater than or equal to this number must be selected. When exposure limits do not exist, select a respirator with an APF equal to the desired reduction in airborne concentration. If an airline respirator is not selected, the appropriate filter or cartridge must then be selected.

If the contaminant is a particulate (i.e., dust, mist, or fume), select a filter based on the TLV and the type of particle. For example, if the contaminant is a solvent-containing mist (i.e., a lacquer spray), select a respirator with a filter designed specifically for paint mists (PLE filter). If the contaminant is cadmium dust, select a respirator with an HEPA filter. (The HEPA filter is necessary because cadmium dust has a TLV of 0.05 mg per cubic meter; see table 2.) If the contaminant is a gas or vapor and does not have adequate warning properties, select an airline respirator. For example, methanol does not have adequate warning properties, so an airline respirator is the appropriate choice when working with this solvent.

If the contaminant has adequate warning properties, 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 properly select a respirator. This information is often found in respirator selection guides. Please note that conservators spraying varnishes or other coatings should use a respirator equipped with a *paint mist filter in addition to an organic vapor cartridge.*

TABLE 1
Assigned Protection Factors for Selected Respirators

	RESPIRATORY INLET COVERING			
TYPE OF RESPIRATOR	Half-mask [1]		Full facepiece	
Air-purifying	10		100	
	Half-mask	Full facepiece	Helmet/hood	Loose-fitting facepiece
Powered air-purifying	50	1000[2]	1000[2]	25
Atmosphere-Supplying Airline				
Pressure demand	50	1000	—	—
Continuous flow	50	1000	1000	25

1. Includes one-quarter mask, disposable half mask, and half mask with elastomeric facepieces.

2. Protection factors listed are for high-efficiency filters and sorbents (cartridges and canisters). With dust filters, an assigned protection factor of 100 is to be used due to the limitations of the filter.

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.

TABLE 2
Respirator Selection Guide

CHEMICAL	ODOR THRESHOLD	TLV	RESPIRATOR	COMMENTS
Acetone	3.6–653 ppm	750 ppm TWA	Organic vapor	Short service life
Ammonia	0.043–53 ppm	25 ppm TWA	Ammonia	Eye irritation
Cadmium	not applicable	0.005 mg/m^3 TWA	HEPA filter	
Cellosolv®	2.7 ppm	5 ppm TWA	Organic vapor	Skin absorption
Hydrochloric acid	0.255–10.16 ppm	5 ppm ceiling	Acid gas	Irritation warning
Methyl alcohol	4.2–5960 ppm	200 ppm TWA	Airline	Ineffective cartridge, inadequate warning
Methylene chloride	160 ppm	50 ppm TWA	Airline	Inadequate warning, cartridge ineffective
Nuisance particulates	not applicable	10 mg/m^3 TWA	Dust/mist fliter	
Toluene	0.16–37 ppm	50 ppm TWA	Organic vapor	
Xylene	20 ppm	100 ppm TWA	Organic vapor	

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 fit check each time the respirator is put on. A fit *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* as well as fit *checked*. Fit *tests* are used to determine which size and make of respirator fits the worker. 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 procedures for proper fit testing can be found in OSHA standards or respiratory protection manuals (Colton et al. 1991; American National Standards Institute 1992). If the conservator does not feel qualified to do the fit testing, industrial hygiene consultants and some respirator manufacturers will provide this service. Workers with facial hair (24 hours growth or more) must not be fitted, since they cannot wear this type of respirator safely.

Most people should be able to find a respirator with adequate fit, since half and full facepieces come in many 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.

Respirator Maintenance

Respirators should be cleaned and sanitized, inspected for defects, and stored properly. If the respirator will be used by more than one worker, 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. Even if the respirator is used exclusively by one worker, 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 models. Respirators should not be stored in lockers or toolboxes unless they are free from contamination, distortion, or other damage.

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 American Industrial Hygiene Association (1989) and the American National Standards Institute (1992). 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.—Craig E. Colton, Certified Industrial Hygienist

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