9

Personal Protective Equipment

Personal protective equipment includes respirators, gloves, face shields, goggles, ear plugs and muffs, and protective clothing and equipment.

WHEN TO USE PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment should be your last resort because it can be uncomfortable for long periods, it can restrict your mobility, and it does not protect other people in the same environment. In addition, personal protective equipment does not remove the contaminants from your immediate environment. Before deciding to use personal protective equipment, you should try other methods of control, such as substitution of less toxic materials or less hazardous techniques, ventilation, and housekeeping. In fact, this concept is part of the Occupational Safety and Health Act.

If you do decide to use personal protective equipment, then you should be careful to use equipment that meets proper standards. In most cases, these

standards are set by the American National Standards Institute (ANSI) and are used by the Occupational Safety and Health Administration (OSHA). (In Canada, safety equipment is approved by the Canadian Standards Association, CSA.) Approved equipment might cost a little more, but you can be more certain that it will protect you adequately.

RESPIRATORY PROTECTION

Respirators are personal protective devices worn over the mouth and nose, and sometimes the entire face, to protect the wearer against the inhalation of toxic airborne materials. OSHA standards state that respirators are to be used only when appropriate engineering controls are not feasible, while engineering controls are being installed, or in emergencies. OSHA has specific regulations regarding respirator use in workplaces, including a written respirator program.

Types of Respirators

Respirators are of two basic types: air-supplying and air-purifying. Air-supplying respirators provide a source of uncontaminated air for the wearer to breathe. The air can come from a self-contained breathing apparatus (SCBA), compressed air tanks, or a compressor providing Grade D air. Air-supplying respirators are expensive and are needed only in cases of oxygen deficiency, or with materials that are immediately dangerous to life or health. Examples of these conditions include welding with cadmium or other highly toxic metals, spraying polyurethane foam resins, sandblasting, and processes that produce asbestos dust. In general, I advise artists not to work with any of these processes because of the extreme hazards involved.

Air-purifying respirators, on the other hand, remove the toxic materials from the air you breathe. They consist of two basic parts: the face piece, and the cartridge and/or filters. The cartridges (or canisters for full-face types) contain chemicals to remove the contaminating gases or vapors. Particulate matter—dust, metal fumes, and mists—are removed by filters that entrap the particles. In some disposable dust respirators, the mask itself is a filter. Also, most respirators can combine a cartridge with a filter to protect against both vapors or gases and particulates.

Air-purifying respirators come in various forms, including full-face masks, half-face masks (covering the nose, mouth, and chin), and quarter-face masks (covering just the mouth and nose). Examples of several different types of respirators are shown in Figure 9-1.

Air-purifying respirators have several advantages. They are inexpensive, easy to maintain, not too large, and restrict the wearer's movements the least. Full-face respirators have the additional advantage of protecting against eye

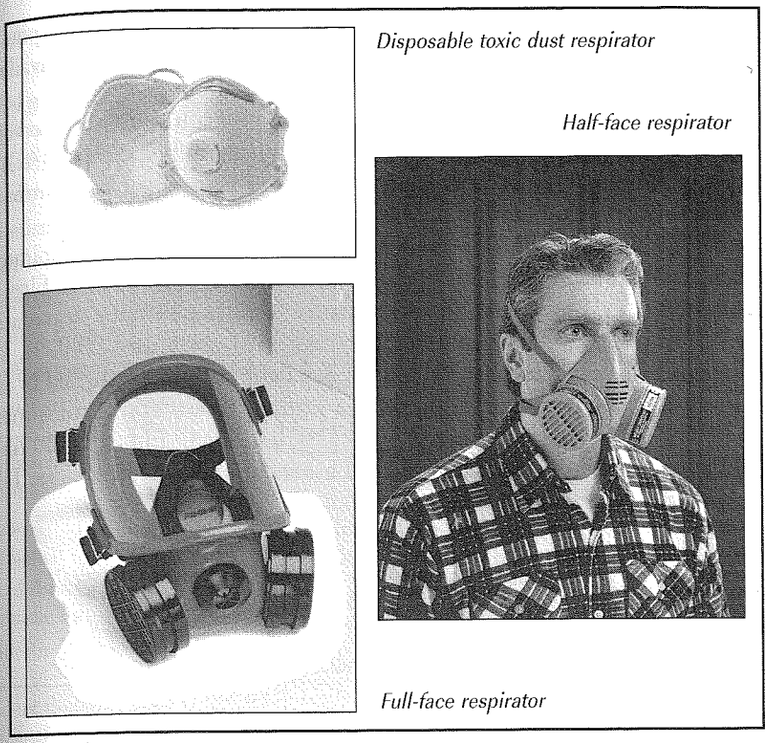


Figure 9-1. (Courtesy of Lab Safety Supply, Inc., Janesville, WI)

irritants and, because of the larger canister sizes, protecting against larger concentrations of toxic contaminants.

The disadvantages of air-purifying respirators are discomfort, difficulty in fitting, need to replace filters and cartridges frequently, and, with half- and quarter-face models, lack of eye protection. In addition, air-purifying respirators do not stop all chemicals from passing though. The standard half-face respirator, for example, is assigned a protection factor of 10. This means that one tenth of the airborne material may pass through the cartridge.

Choosing a Respirator

Choosing the appropriate respirator for your needs is crucial. In many cases, people have used a respirator that is not suited to the contaminants to which they were exposed. This is particularly true of cheap dust masks bought in hardware stores. The most important rule to follow—and, for employers, it is the law—is to buy respirators approved by the National Institute for Occupational

Safety and Health (NIOSH) for the particular contaminants to which you are exposed. Different cartridges and filters or combinations of the two are available for protection against particular substances.

There are several types of cartridges approved by NIOSH: organic vapor (OV) to protect against solvents and other organic vapors; acid gas (AG) to protect against sulfur dioxide, chlorine, and other acid gases; and ammonia (A). There are also combination acid gas/organic vapor cartridges.

In 1995, NIOSH published revised standards for particulate respirators. The new regulation provides for nine classes of filters: three levels of filter efficiency, each with three categories of resistance to filter efficiency degradation from oil. The three levels of filter efficiency are 95%, 99%, and 99.97%. The three categories of resistance to filter efficiency degradation are labeled N (not resistant to oil) , R (resistant to oil—for a limited time), and P (oil-proof). N95 and N99 filters outperform the older DM and DMF filters. N100 filters should be used for silica dust, asbestos, and other carcinogenic dusts. (see Table 9–1 for the best one to choose).

Table 9-1. *Selection of Respirator Cartridges and/or Filters*

Substances or Process	Cartridge	Filter
Acid gases (except nitric acid)	AG	—
Acid mists	AG	N95
Aerosol spray cans	OV	N95
Air brush	—	—
water-based	—	N95
solvent-based	OV	N95
cadmium, chromium (VI) pigments	—	N100, HEPA
Ammonia	A	—
Asbestos (low levels only)	—	N100, HEPA*
Chlorine gas	AG	—
Clay, glaze powders	—	N100
Dye powders	—	N95
Enamel powders	—	N95
Fiberglass dust	—	N95
Formaldehyde	OV	—
Hydrofluoric acid	AG	—
Hydrogen chloride gas	AG	—
Lacquers	OV	—
Lead-containing powders/fumes	—	N99, N100, HEPA

Metal fumes (casting, welding)	—	N95
lead, cadmium nickel	—	N100, HEPA
Metal grinding		
oil-based lubricant	—	R95, P95
water-based/no lubricant	—	N95
Metal powders	—	N95
Oil mists	—	P95, R95
Paint strippers (solvent type)	OV	—
Pastel dusts	—	N95
Pigment powders	—	N95
Plastic resins and glues	OV	—
Plastics sanding, grinding	—	N95
polyvinyl chloride	AG	N95
polyurethane	OV	N95
formaldehyde plastics	OV	N95
Silica	—	N100, HEPA
Soldering, lead		
acid fluxes	AG	N100, HEPA
organic fluxes	OV	N100, HEPA
Soldering, hard (cadmium-free)		
fluoride fluxes	AG	N95
borax fluxes	—	N95
Solvents	OV	—
Spraying		
water-based (no solvents)	—	N95
solvent-based	OV	N95
polyurethane foam resins	SCBA**	—
Sulfur dioxide	AG	—
Welding (see metal fumes)		

* Supplied air recommended for high levels of asbestos dust.
** SCBA self-contained breathing apparatus

Air-purifying respirators should not be used in situations involving exposure to substances that are immediately dangerous to life or health (IDLH), including possible long-term effects such as cancer, or exposure to gases or vapors that have poor odor-warning properties. Examples of the latter are carbon monoxide from gas-fired kilns, nitric acid etching gases, and solvents such as methyl alcohol. These gases or vapors with poor odor-warning properties give no warning as to when the cartridge or canister is used up and you are being exposed to hazardous concentrations of these substances. Local exhaust ventilation or supplied-air respirators are recommended in these cases.

Full-face respirators should be used instead of half- or quarter-face respirators when the contaminant is an eye irritant (e.g., ammonia), or when the concentration of the contaminant is high (between 10 and 50 times the TLV). At higher concentrations, supplied-air respirators are necessary. If you think you are being exposed to very high concentrations of toxic contaminants, you should seek professional help. See the resources in Chapter 2.

Having decided what type of respirator and cartridge and/or filter you need, you have to decide what brand of respirator to buy. The names of safety equipment suppliers that sell NIOSH-approved respirators and other personal protective equipment are listed in the Appendix at the end of this chapter. Many of these companies have local offices in major cities. In addition, most large cities have companies that specialize in distributing personal protective equipment of all types (try the Yellow Pages under Safety Equipment).

Fit Testing

The crucial factors in deciding which company's respirator or brand of respirator to buy are how well and how comfortably the respirator fits.

The correctness of fit is crucial since, if air leaks in, so can toxic contaminants. Since people have different face sizes and shapes, it is not surprising that one model of respirator does not fit everyone. In the past, women in particular had difficulty finding respirators that fit, since most respirators were designed for men's faces. Today, most companies have respirators in different sizes, so you should be able to find one that fits.

There are some simple tests that can be used to find out if a respirator fits properly. The first, a negative pressure test, consists of closing off the inlets of the cartridges or filters by covering them with the palms of your hands (or by putting on the seal), inhaling gently until the mask collapses slightly, and holding your breath for 15 to 20 seconds. If the fit is not adequate, air will leak in and the mask will resume its normal shape (or if there is a very bad fit, it will not collapse in the first place).

The second is a positive pressure test. This consists of blocking the exhalation valve with your finger and gently breathing out, causing the mask to expand. If air leaks past the edge of the mask (particularly near the eyes), the mask will collapse to normal.

If the respirator fails either of these tests, try adjusting the straps and face piece. Note that in any fitting test, the straps of the respirator should not be too tight, since this can cause discomfort when wearing the respirator for any length of time. If this still does not work, try another respirator of the same model or another model.

More sophisticated qualitative fit tests involve testing with substances to see if you can detect the odor. One such fit test is done with isoamyl acetate

vapor (banana oil) using organic vapor cartridges. Of course, you must be able to detect the presence of the solvent at low concentrations for this test to work.

The following is a protocol for qualitative fit testing with isoamyl acetate:

1. Check first with a small concentration of isoamyl acetate to make sure you can detect the odor of banana oil. If you cannot detect the odor of banana oil, repeat the steps below with irritant smoke tubes and N95 dust filters. Be sure to close your eyes when doing this test.
2. Put on the respirator and adjust the straps to get a comfortable fit.
3. Carry out a negative pressure test to see if the fit is approximate.
4. Carry out a positive pressure test if possible.
5. If you do not pass either the negative or positive pressure test, go to step 9.
6. Wear the respirator for a while in a clean atmosphere to get used to it.
7. Saturate a sponge or piece of fabric with isoamyl acetate and then move it around the face-piece seal. An improved version of this test involves using a hood (e.g., the plastic lining of a 55-gallon drum on a wire frame) and placing the saturated fabric or sponge inside the hood.

   It is important to keep individuals to be tested isolated from the isoamyl acetate-contaminated environment, since olfactory fatigue can reduce the ability to detect the isoamyl acetate odor over time.
8. Perform the following exercises for two minutes: (a) normal breathing, (b) deep breathing (five breaths), (c) moving head up and down, (d) moving head from side to side, (e) talking, and (f) normal breathing. If you can detect the odor of the banana oil, then the respirator fails the test.
9. If your respirator fails either the positive or negative pressure test, or the isoamyl acetate test, then you should first readjust the position of the face piece and adjust the straps to get a comfortable yet secure fit. Then retry the fit test. If you still cannot get a fit, try another model or size.

This test can also be used to determine if your organic vapor cartridge is used up and as a regular checkup to determine if your respirator has been damaged and no longer gives a good fit.

You should carefully read the label on the package of the respirator you purchase and any accompanying instructions, since they might have particular instructions about the fitting and care of the particular brand of respirator.

Beards, sideburns, stubble, and sometimes even moustaches make it difficult or impossible to get a good respirator fit. The facial hair lying between the skin and the respirator edge will prevent a proper seal, which means that air and contaminants can leak in. Similarly, broken noses, facial scarring, or other

problems that could interfere with a proper fit could prevent a person from safely wearing a respirator.

Medical factors may also preclude wearing respirators. These include heart and lung problems (since the breathing resistance of respirators do put some strain on the heart), asthma, and claustrophobia. If there is any question, you should obtain a medical examination to determine whether you can wear a respirator safely. OSHA requires medical evaluations.

If the respirator is not comfortable, there may be a tendency not to wear it when you should. For this reason, comfort is important. Other factors affecting comfort are the degree of difficulty in breathing through the respirator, interference with wearing eyeglasses, restriction of vision due to bulkiness, and restriction of head movements.

Use and Maintenance of Respirators

The filters and cartridges of air-purifying respirators have to be replaced regularly. Since the lifetime of chemical cartridges depends on the concentration of the gas or vapor and the period of exposure, there is no accurate way to tell how long a cartridge will last, since different people will be working under different conditions. The only indication that the cartridge is used up is the smell of gas or vapor coming through the respirator. This is why it is so important not to use chemical cartridge respirators to protect against vapors or gases with inadequate odor-warning properties. As mentioned above, the isoamyl acetate vapor test can be used to determine if the cartridge is still good. A rule of thumb is that you should change cartridges 10 days after opening a new cartridge, after 8 hours of use, or if you can detect odor breakthrough.

It is easier to tell when a filter is clogged because it becomes difficult to breathe through it. An extra supply of filters should always be on hand, since they can clog up very quickly in dusty atmospheres. Also, instead of using a respirator with a disposable filter, in many instances you can use disposable dust respirators that are approved for many different situations.

Respirators should be worn by only one person who is responsible for its upkeep. If the respirator is used only occasionally, then weekly or even monthly cleaning are all that is necessary. If more than one person uses the respirator, it should be cleaned and disinfected. Otherwise, the following cleaning procedure may be followed:

1. Remove filters, cartridges, canisters, etc.
2. Wash face piece and any tubing with warm water (between 120° and 140°F (49° to 60°C)) and a detergent. Use a handbrush to remove dirt.
3. Rinse completely in warm water.
4. Air dry in a clean place. Do not heat.

5. Clean any other parts as recommended by the manufacturer.
6. Inspect parts for defects and reassemble the respirator. Look for excessive dirt, cracking, tearing, inflexibility, or broken parts in cartridge holders, straps, cartridges, etc. In many cases the broken or defective parts can be replaced, but be sure they are the approved parts for that respirator. Never improvise or use parts from other models even if they seem to fit.
7. Place in a sealable plastic bag or other container for storage. Do not hang on the wall or store with chemicals that might contaminate the insides of the respirator.

To disinfect the respirator, use a solution of two tablespoons of household chlorine bleach per gallon of water. Immerse the respirator in this solution for eight minutes after washing and then rinse thoroughly. If the rinsing is not complete, then you run the risk of getting dermatitis.

FACE AND EYE PROTECTION

There are five basic categories of hazards against which the eyes and face must be protected: (1) impact from flying particles (e.g., chipping, grinding); (2) heat (e.g., molten metal spash, glassblowing, metal casting); (3) chemical splashes or dusts of acids, alkalis, solvents, or other irritants; and (4) optical radiation (e.g., welding, soldering). The type of eye and face protection needed depends on the type of the hazard and its severity. OSHA specifies that all goggles and face protection must meet the standards set by the American National Standards Institute (ANSI). Table 9-2 is a selection chart for the appropriate type of protection excerpted from ANSI Z87.1-2003, *American National Standard for Occupational and Educational Personal Eye and Face Protection Devices.* All equipment meeting these standards must state so on the box, and the actual goggle will have a Z87 stamped on it somewhere.

Impact

The face and eye equipment designed to protect against the flying particles produced in grinding, chipping, and machining are of four basic types: (1) spectacles with side shields, (2) flexible-fitting goggles, (3) cushion-fitting goggles with rigid frame, and (4) chipping or cup goggles. Spectacles without side shields are not recommended. Face shields by themselves are also not recommended. Face shields protect the face only; they do not adequately protect the eyes. If you are wearing a face shield, you should wear goggles under it.

People who wear eyeglasses can either have a special prescription built into their goggles or can wear flexible or cushioned goggles over their eyeglasses.

Table 9-2.

Selection Chart

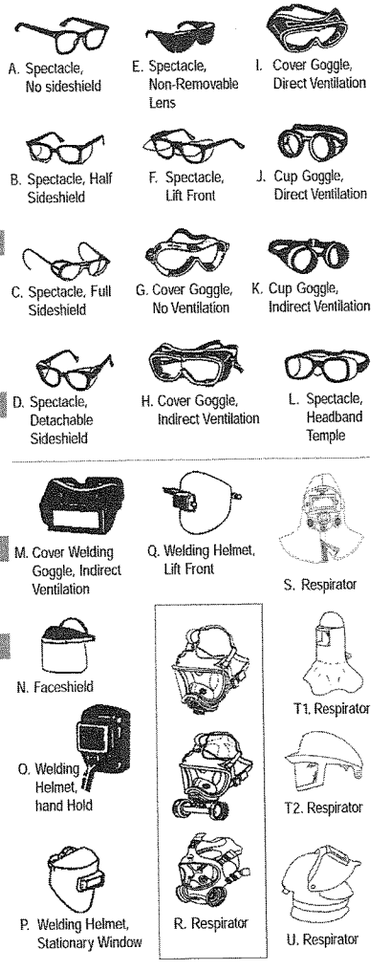
Care shall be taken to recognize the possibility of multiple and simultaneous exposure to a variety of hazards. Adequate protection against the highest level of the hazards must be provided.

Activity and Assessment	Protector Category and Styles	Limitations	Not Recommended
IMPACT			
Chipping, grinding, machining, masonry work, riveting, and sanding. Flying fragments, objects, large chips, particles, sand, dirt, etc.	Spectacles, goggles: B, C, D, E, F, G, H, I, J, K, L. For severe exposure add N. Respirators, R,T. Faceshields shall only be worn over spectacles or goggles. Persons whose vision requires the use of prescription (Rx) lenses shall wear either protective devices fitted with prescription (Rx) lenses or protective devices designed to be worn over regular prescription (Rx) eyewear. Wearers of contact lenses shall also be required to wear appropriate spectacles or goggles depending on the specific hazard. Dusty and/or chemical environments may represent an additional hazard to contact lens wearers. Wearing of contact lenses under an R respirator is permitted. Goggles, helmets and faceshield windows that bear the marking "Z87+" comply with the High Impact Test Requirements. Those with "Z87" markings comply only with Basic Impact Testing Requirements. Spectacle lenses that are marked with the manufacturers logo and no "+" comply only with the High Impact Test Requirements. Those spectacle lenses marked with the manufacturers logo and a "+" sign comply with the High Impact Test Requirements. (It is important during the selection process to remember that different product categories are tested at different levels of impact resistance. Goggles are tested at a higher level of impact than spectacles and face shields are tested at a higher level than goggles.) The Z87-2 frame marking indicates the frame meets high impact requirements with a minimum lens thickness of 2mm.	Protective devices do not provide unlimited protection. **Note:** Caution should be exercised in the use of metal frame protective devices in electrical hazard areas. Metal frame protective devices could potentially cause electrical shock and electrical burns through contact with, or thermal burns from exposure to the hazards of electrical energy, which include radiation from accidental arcs. Atmospheric conditions and the restricted ventilation of the protector can cause lenses to fog. Frequent cleaning may be required.	Protectors that do not provide protection from side exposure. Filter or tinted lenses that restrict light transmittance, unless it is determined that a glare hazard exists. Refer to OPTICAL RADIATION. Use of faceshields alone, without spectacles or goggles.
HEAT			
Furnace operations, pouring, casting, hot dipping, gas cutting, and welding. Hot sparks Splash from molten metals High temperature exposure	**Note:** Operations involving heat may also involve optical radiation. (See electric arc, gas, and glare under Optical Radiation below.) Protection from both hazards shall be provided. Faceshields shall only be worn over spectacles or goggles. Goggles, spectacles: B, C, D, E, F, G, H, I, J, K, L. For severe exposure add N. Respirators R, T. Faceshields worn over goggles H,K. Respirators R, T or S, U if optical radiation hazard exists. Screen faceshields, Reflective faceshields over spectacles or goggles.	Spectacles, cup and cover type goggles do not provide unlimited facial protection. Operations involving heat may also involve optical radiation. Protection from both hazards shall be provided.	Protectors that do not provide protection from side exposure. Use of faceshields alone, without spectacles or goggles.
CHEMICAL			
Acid and chemicals handling, degreasing, plating. Splash and irritating mists.	Indirect vented: goggles, eyecup and cover types: G, H, K. For severe exposure, add N. Respirators R, T. Irritating Mist: Special purpose goggles: G. Cover goggle – No ventilation. Respirators R, T.	Provides protection from splash entry with adequate ventilation. Atmospheric conditions and the restricted ventilation of the protector can cause lenses to fog. Frequent cleaning may be required.	Spectacles, welding, helmets, or handshields
DUST			
Woodworking, buffing, general dusty conditions. Nuisance dust.	Goggles, eyecup and cover types: G, H, K. Respirators R, T.	Atmospheric conditions and the restricted ventilation of the protector can cause lenses to fog. Frequent cleaning may be required.	
OPTICAL RADIATION			
WELDING: Electric Arc Viewing electric arc furnaces and boilers	**Note:** Welding helmets or handshields shall be used only over spectacles or goggles. TYPICAL FILTER LENS SHADE: 10-14 Respirators S, U — PROTECTORS: Welding helmets or Welding Shields: O, P, Q.	Protection from optical radiation is directly related to filter lens density. Select the darkest shade that allows adequate task performance. **Note:** Filter lenses shall meet the requirements for shade designations in Table 1. **Note:** Faceshields and welding helmets shall only be worn over spectacles or goggles.	Protectors that do not provide protection from optical radiation. **Note:** Filter lenses shall meet the requirements for shade designations in Table 1. Use of welding helmets or faceshields alone, without spectacles or goggles.
WELDING: Gas, and viewing gas-fired furnaces and boilers	TYPICAL FILTER LENS SHADE: 4-8. PROTECTORS: Welding goggles, Helmets. Welding Face sheilds over spectacles or goggles: J, K, L, M, N, P, P, Q or Respirators, S,U.		
CUTTING	TYPICAL FILTER LENS SHADE: 3-6. PROTECTORS: Welding goggles, Helmets. Welding face shields: J, K, L, M, N, O, P, Q, or Respirators S,U.		
TORCH BRAZING	TYPICAL FILTER LENS SHADE: 3-4. PROTECTORS: Welding goggles, Helmets. Welding face shields: J, K, L, M, N, O, P, Q, or Respirators, S,U.		
TORCH SOLDERING	TYPICAL FILTER LENS SHADE: 1.5-3. PROTECTORS: Spectacles or Welding Faceshield over spectacles: B, C, D, E, F, N, or Respiratos, S,U.		
GLARE	Spectacle: A, B, Faceshields N over spectacles or goggles.	Shaded or Special Purpose lenses, as suitable. **Note:** Refer to Section 6.2.4.1 Special Purpose Lenses.	

Protective Devices

The illustrations shown are only representative of protective devices commonly available at this time. Protective devices do not need to take the forms shown, but must meet the requirements of the standard.

Protective Devices



Regular eyeglasses or contact lenses are not considered adequate protection against flying particles because they do not meet ANSI impact-resistant standards.

Heat

Protection against high temperatures, molten metal splashes, and hot sparks needs either spectacles with side shields or goggles. For severe exposures, a face shield should be worn with goggles underneath. The eye and face protection should also protect against infrared radiation when molten glass or metals are present (see Optical Radiation below).

Chemical Splashes and Dusts

If the protection needed is only against eye irritation, or from dusts and non-corrosive chemicals, then hooded goggles with direct ventilation are sufficient. Indirect vented goggles can protect against splashes of irritating chemicals. If the chemical splash risk is from concentrated acids or alkalis in which face and neck protection is also needed, then approved face shields should be used with goggles underneath. If nonventilated goggles are used for protection against irritating vapors, then a nonfogging material should be used. For severe exposure from irritating vapors, full-face respirators are preferred. ANSI-approved chemical splash goggles also protect against light impact.

Contact lenses are a special problem. Dusts may get under the lens and cause corneal scratching, and soft contact lenses may absorb hazardous gases and vapors. In addition, in case of splashes in the eyes, it takes time to remove the lenses to rinse out the eyes. Contact lenses do not protect the eyes. If you wear contact lenses, you should wear tight-fitting, sealed (nonventilated) goggles.

Optical Radiation

Ultraviolet, infrared, and visible glare radiation require goggles with appropriate degrees of shading to protect against the intensity of the radiation. Processes in which this type of protection is needed include welding, brazing, furnace operations (including kilns), molten metals, and carbon arcs, for example. A general rule of thumb is to use the darkest shade you can, while still having visibility.

For protection against infrared radiation (soldering, glassblowing, molten metal, looking into hot kilns), use welding goggles with shade numbers between 1.7 and 2.5, or the new polycarbonate goggles developed for infrared radiation. For protection against ultraviolet radiation, see Table 9-2. Handheld shields can be used in some cases (e.g., for looking into kilns).

If the operation involves intense ultraviolet radiation that could damage the skin, or possible splashing of molten metals and sparks (e.g., arc welding), then a combination of face shields and appropriate goggles or welding helmets is recommended.

For laser radiation, there are special laser goggles, depending on the type and intensity of the laser radiation.

Besides being resistant to radiation, all face shields and handheld shields should also be impact resistant.

HAND PROTECTION

There is a wide variety of equipment available to protect your skin against dermatitis from solvents and other chemicals, as well as against radiation, abrasion, heat, and cuts. This includes gloves and barrier creams.

Gloves

Gloves are one of the most important ways of preventing skin problems, since the skin of the hands and fingers is the area most exposed to hazards. Gloves are available that can protect you against most skin hazards. These include chrome-tanned leather gloves for protection against heat, sparks, molten metal, chipping, and cuts; cotton or fabric work gloves for protection against dirt, abrasion, cold, and slivers; metal mesh gloves to protect against knives and similar tools (but not power tools); and plastic and rubber gloves to protect against corrosive and toxic liquids. Note that I do not recommend asbestos gloves (or other asbestos clothing) because they can release cancer-causing asbestos fibers into the air, even when new.

One problem with gloves is that there is no one type of glove that will protect against all chemicals. Therefore you have to choose a type of glove for the particular chemicals with which you are working. Table 9-3 is a glove selection chart to use as a guide. You should also check with glove manufacturers if there is any question. Most glove manufacturers have glove charts for their gloves.

Other factors to consider when choosing gloves include the degree of dexterity required, their grip, whether lined or unlined, disposable or nondisposable, and the length of the glove. With respect to the last point, gloves are available that extend up to elbow length. These are particularly useful when you might be dipping your hands into deep containers of liquids.

The life of a glove in use depends on several factors, including thickness of glove material, length of contact with the chemicals, temperature, concentration of the liquid, and physical wear and tear. For example, your gloves will last

longer if you are just using them to protect your hands against solvent-soaked rags than if you are using them to dip your hands into pure solvent for long periods of time. The life of your gloves (and your hands) can be prolonged by washing them with soap and warm water before removing, and allowing them to air-dry before using them again. Irritation and sweating can be prevented by dusting the insides of the gloves with cornstarch or an asbestos-free talc (e.g., baby powder), or by using lined gloves. I do not recommend latex rubber gloves since they can cause severe, even life-threatening, allergic reactions in some people.

The gloves available in hardware stores or art supply stores are usually latex rubber, neoprene, or polyvinyl chloride (vinyl gloves). As seen in Table 9-3, the latex and vinyl gloves do not provide good protection against many solvents. Other types of gloves can be purchased from safety equipment companies and scientific supply houses. Some of these are listed in the Appendix at the end of the chapter.

Protective Creams and Waterless Hand Cleansers

Protective barrier creams, the so-called invisible gloves, are creams that are applied before work to prevent chemicals from coming into contact with your skin. They should be used only when gloves are not practical, since they do not provide as much protection as gloves.

The protective creams come in two basic types: water-soluble types, for protection against organic solvents, cutting oils, paints, lacquers, and varnishes; and water-resistant types for use with water-containing materials such as dye baths, acrylics, and mild acids.

Note that protective creams should be washed off with soap and water and reapplied frequently; they do not protect against highly corrosive substances.

There is a large number of waterless hand cleansers on the market that are meant to remove paint and inks and other materials from the hands, but many of these products are just as hazardous as solvents, since they contain kerosene or other hazardous solvents, alkalis, or harsh abrasives. Obtain waterless hand cleansers from safety equipment suppliers. As an alternative, baby oil or even vegetable oils will usually work to remove paint, grease, and grime.

In using waterless hand cleansers, remember that they are not a substitute for soap and water. You should wash your hands with soap and water after using these products. In addition, mild lanolin-containing skin creams used after washing can help keep your skin from becoming dry.

The Appendix to this chapter lists companies that manufacture and sell protective barrier creams and waterless hand cleansers.

HEAD AND FOOT PROTECTION

Head Protection

Some art processes might require head protection for safety. For example, if you have long hair and are working around machinery in which your hair might get trapped, you should wear a hair net or hair-restraining cap. You should also do this when working around chemicals into which your hair could fall. You should wear protective headgear when welding or working with other processes that might create flying sparks or splatters of molten metal. Hard hats can be used not only to protect your head against falling objects but against flying particles and electric shock. Hard hats or safety hats should meet the requirement of ANSI Z89.1 *American National Standard for Industrial Head Protection.* See the Appendix to this chapter for a list of manufacturers and distributors.

Table 9-3. *Choosing the Right Gloves*

The following guide was developed from information in several sources. The information presented here is believed to be accurate; however, we cannot guarantee its accuracy. Many factors may affect the breakthrough time of glove materials including, but not limited to:

1. Thickness of glove material
2. Concentration of chemical worked with
3. Amount of chemical the glove comes in contact with
4. Length of time which the glove is exposed to the chemical
5. Temperature at which the work is done
6. Possibility of abrasion or puncture

This information is provided as a guide to proper glove material selection. Glove performance varies between manufacturers, so always consult the manufacturer to make sure you have the right glove for your application.

Selection key:

- E Excellent, breakthrough times generally greater than 8 hours
- G Good, breakthrough times generally greater than 4 hours
- F Fair, breakthrough times generally greater than 1 hour
- NR Not recommended, breakthrough times generally less than 1 hour
- ? Not Tested or No Information, check other references

Type of Chemical	Example	Natural Rubber	Neoprene	Butyl	PVC	Nitrile	Viton
Mineral acids	Hydrochloric acid (37%)	G	G	E	G	G	G
	Nitric acid (70%)	?	NR	F	?	NR	E
Organic acids	Glacial acetic acid	F	G	E	F	NR	E
Alkalis	Sodium hydroxide (50%)	E	E	E	E	G	G
Alcohols	Ethyl alcohol	NR	F	E	NR	G	E
	Methyl alcohol	NR	NR	E	NR	NR	E
Aliphatic hydrocarbons	Naphtha	NR	F	NR	G	E	E
Aromatic hydrocarbons	Toluene	NR	NR	NR	NR	NR	E
Chlorinated hydrocarbons	Methylene chloride	NR	NR	NR	NR	F	G
Esters	Ethyl acetate	NR	NR	G	NR	NR	NR
Ketones	Acetone	NR	NR	E	NR	NR	NR
Miscellaneous	Photographic solutions	G	E	?	G	E	?
	Turpentine	NR	NR	NR	NR	F	E

Viton is a registered trademark of DuPont Dow Elastomers.

Physical Resistance Chart*

Coating	Abrasion Resistance	Cut Resistance	Puncture Resistance	Heat Resistance	Flexibility	Ozone Resistance	Tear Resistance	Relative Cost
Natural Rubber	E	E	E	F	E	P	E	Medium
Neoprene	E	E	G	G	G	E	G	Medium
Chlorinated Polyethylene (CPE)	E	G	G	G	G	E	G	Low
Butyl Rubber	F	G	G	E	G	E	G	High
Polyvinyl Chloride	G	P	G	P	F	E	G	Low
Polyvinyl Alcohol	F	F	F	G	P	E	G	Very High
Polyethylene	F	F	P	F	G	F	F	Low
Nitrile Rubber	E	E	E	G	E	F	G	Medium
Nitrite Rubber/ Polyvinyl Chloride (Nitrile PVC)	G	G	G	F	G	E	G	Medium
Polyurethane	E	G	G	G	E	G	G	High
Styrene-Butadiene Rubber (SBR)	E	G	F	G	G	F	F	Low
Viton	G	G	G	G	G	E	G	Very High

* Grip/slip is related to glove surface and enhanced when the glove surface is rough.

Dexterity/tactility is related to glove thickness and decreases as the glove thickness increases.

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Foot Protection

Safety shoes may be needed to protect against electric shock, sparks, or molten metal from welding, heavy stones that might fall in sculpture or lithography, and slippery floors, as well as to prevent static electricity when working with large amounts of flammable solvents. These shoes come in a variety of styles for both men and women, such as safety toe, insulated, nonsparking, wooden sole, and rubber. Men's safety shoes must meet the standards of ASTM F2412-05 and F2413-05. There are no standards for women's safety shoes as yet. These various types of safety shoes are available from the safety equipment companies listed in the Appendix to this chapter.

HEARING PROTECTORS

Noise and hearing loss are described in the next chapter. There are three types of hearing protectors to protect against excessive noise: ear plugs, ear muffs, and the rarer helmets. However, these all have the same disadvantages of possibly reducing the use of your ears as a warning device and of being uncomfortable.

Ear Plugs

Ear plugs, properly fitted and used, can reduce noise levels by 25 to 30 dB at the more hazardous higher frequencies. This allows their use at noise levels of 115 to 120 dB. They can be made of a variety of materials, including pliable rubber, plastics, or wax. One of the most effective types of ear plugs today are moldable foam types. These are compressed to fit into the ear, and then expand to fit the ear canal. Custom-molded ear plugs made of silicone are also available. These are custom fitted and should not be used by others. In addition, these custom molded ear plugs must be fitted by trained personnel. Cotton or other homemade ear plugs are not recommended. They do not reduce the sound levels sufficiently, and may cause infections.

Ear Muffs

Ear muff-type protectors can reduce noise levels by 10 to 15 dB more than ear plugs, allowing them to be used against noise levels in the range of 130 to 135 dB. These are easier to fit and come in a variety of styles, depending on how they are attached. In cases in which the noise level is very high and engineering controls have no effect, you can wear a combination of ear plugs and ear muffs to get greater noise reduction.

Whatever type of ear protector you choose, you should first make sure that the ear plug or muff will sufficiently reduce the noise level. If in doubt, sound-

level measurements should be made. In addition, you should have regular audiograms to test your hearing.

OTHER PROTECTIVE CLOTHING AND EQUIPMENT

Just as it is important to protect your hands and fingers against many types of hazards, it is also important to protect other parts of your body. For example, when welding, your arms, legs, and the front of your body need protection against radiation and flying sparks. When pouring concentrated acids to make up etching solutions or pickling baths, you need protection against accidental splashes by the corrosive acids. When glassblowing you need protection against infrared radiation.

There are special types of clothing to protect you against all of these. Clothing to protect particular parts of the body or the entire body includes leggings, sleeves, hair coverings, aprons, overalls, knee pads, shoe coverings, and complete body suits. Again, as with gloves, these are available in a variety of materials for different purposes: leather to protect against heat, sparks, and molten metal; wool to protect against ultraviolet and infrared radiation; leather and metal mesh to protect against cuts and impact; impervious plastics and synthetic nonwoven clothing to protect against chemicals; and many others. In some cases—for example, complete body suits—the clothing is disposable.

As mentioned in previous chapters, you should wear separate clothing for work, even if it is not special protective clothing, and change it immediately after work so as not to contaminate living areas and the home. Protective and work clothing should also be washed separately from other clothing so as not to contaminate your regular clothing.

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APPENDIX: SOURCES OF PERSONAL PROTECTIVE EQUIPMENT

The following lists large, full-line distributors of safety equipment.

Alaska Safety, Inc., **Anchorage, AK**, www.alaskasafety.com, (907) 561-5661

AWISCO NY Corp., **Maspeth, NY**, www.awisco.com, (718) 786-7788

Delta Safety Supply, **Stockton, CA**, www.deltasafety.com, (209) 466-9866

Direct Safety Company, **Tempe, AZ**, www.directsafety.com, (800) 528-7405

Dolphin Safety Supply, Inc., **Pascagoula, MS**, (800) 769-2163

Dunrite, Inc., **Fremont, NE**, www.dunriteinc.com, (402) 721-3061

DXP/Safety Master, **Houston, TX**, www.dxpe.com, (713) 996-6071. Also in **Empire, CO,** (303) 271-0107; **Billings, MT**, (406) 248-8098; **Farmington, NM,** (505) 326-3333; and **Casper, WY**, (307) 266-2140

Fisher Safety Company, **Pittsburgh, PA**, www.fishersafety.com, (412) 490-8780. Also in **Mobile, AL,** (334) 661-2338; **Orlando, FL**, (407) 678-2701; and **Atlanta, GA,** (770) 446-8509.

Great Lakes Safety & Supply, **Schererville, IN**, www.greatlakessafety.com, (800) 499-5253

Guy Miyashiro and Co., Inc., **Waipahu, HI**, (808) 678-0287

Hagemeyer, **Gray, ME**, (207) 657-5011

Industrial Safety Products, Inc., **Cleveland, OH**, www.indsaf.com, (216) 524-0360

Industrial Safety Supply Corporation, **Emeryville, CA**, www.issc.com, (510) 658-0414

Industrial Safety & Supply, **W. Hartford, CT**, www.industrialsafety.com, (800) 243-2316

Interstate Safety, **Sparks, NV**, www.interstatesafety.net, (775) 355-2000

Industrial Supply Co, **Salt Lake City, UT**, (801) 484-8644

Lab Safety Supply, Inc., **Janesville, WI**, www.labsafety.com, (608) 757-4636

Magid Glove & Safety Mfg. Co., **Chicago, IL**, www.magidglove.com, (773) 384-2070

McDonald Safety Equipment Inc., **Wilmington, DE**, www.mcdonaldsafety.com, (302) 999-0151

Medsafe, **Little Rock, AR**, www.gosafe.com, (501) 227-5513. Also in **Tulsa, OK**, (918) 622-8128; and **Deer Park, TX**, (800) 442-8839.

Metropolitan Safety, Inc, **Landover, MD**, www.MetropolitanSafety.com, (301) 772-1717

Mid-Continent Safety, LLC, **Wichita, KS**, www.midsafe.com, (316) 522-0900

NORCO, **Bend, OR,** www.norco-inc.com, (503) 382-2362. Also in **Boise, ID**, (800) 574-5885

NORCO, The Olympic Glove & Safety Company, Inc, **Elmwood Park, NJ**, www.ogs-inc.com, (800) 526-0122

Northern Safety Co., Inc., **Utica, NY**, www.northernsafety.com, (315) 793-4900

Orr Safety Corporation, **Charleston, WV**, www.orrcorp.com, (304) 755-4800. Also in **Louisville, KY**, (502) 774-5791; and **St. Louis, MO**, (314) 343-0158

SAFECO, Inc., **Raleigh, NC**, www.safecoinc.com, (919) 231-3232. Also in **Charleston, SC**, (843) 554-8775; **Richmond, VA**, (804) 222-9100; **Kingsport, TN**, (423) 378-5665; and **Miami, FL**, (800) 972-3326

Safety Services, Inc., **Kalamazoo, MI**, www.safetyservicesinc.com, (616) 382-1052

Safety Environmental Control, **Marlborough, NH**, (888) 357-9760

Safety Source-Northeast, **Sturbridge, MA**, www.safetysourcenortheast.com, (508) 248-4265

Saf-T-Gard International, Inc., **Northbrook, IL**, www.saftgard.com, (847) 291-1600

SIM Supply, Inc., **Hibbing, MN**, www.simsupply.com, (218) 262-6125

Sound Safety Products, Inc, **Everett, WA**, www.soundsafetyproducts.com, (425) 259-0026

S. J. Smith Co., Inc., **Davenport, IA**, www.sjsmith.com, (319) 324-5237

Southland Fire & Safety Equipment, Inc, **Gonzales, LA**, www.southlandfire.com, (225) 621-3473

Canadian Safety Equipment Distributors

Acklands-Grainger Inc., www.acklandsgrainger.com, (800)-265-9135. Has over 200 sales offices across Canada.

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Physical Hazards

Artists can also face a number of physical hazards, in addition to the chemical hazards associated with art materials. These physical hazards can include electromagnetic radiation, noise, ergonomic hazards, machine safety, electrical safety, and heat stress.

ELECTROMAGNETIC RADIATION

Electromagnetic radiation includes X-rays, ultraviolet radiation, visible light, infrared radiation, radio waves, and microwaves, as shown in Figure 10-1.

Electromagnetic radiation can be characterized by frequency (or wavelength) and by intensity. The higher the frequency, the more energy is contained in the radiation, and the shorter the wavelength. High-energy radiation, for example, X-rays and shorter wavelength ultraviolet radiation, is called ionizing radiation because it can strip electrons off atoms and cause serious tissue destruction.