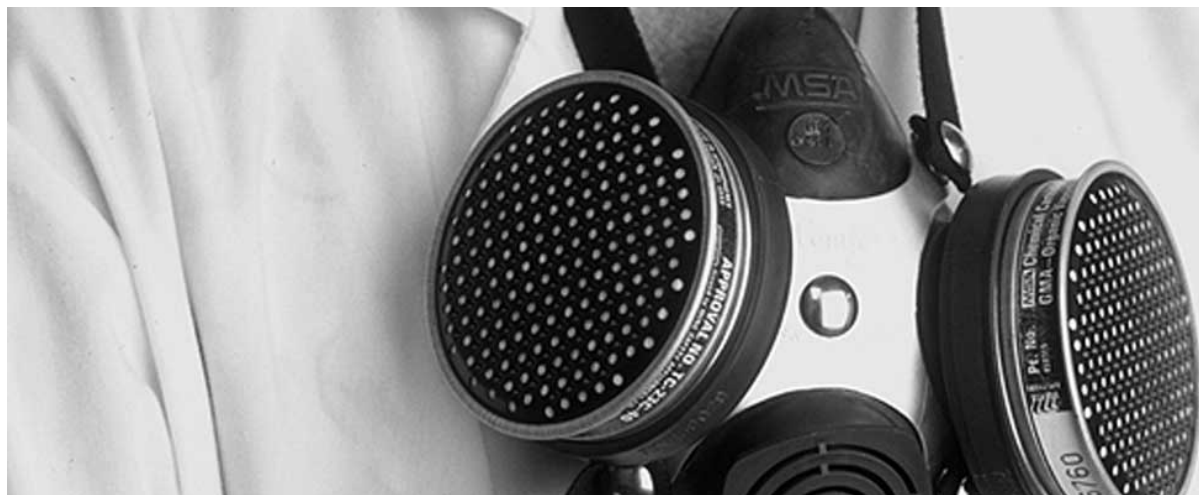


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Controlling laboratory hazards involves a combination of substitutions, engineering controls, administrative controls and work practices, and protective clothing and equipment. Generally, the hierarchy of hazard control should be:

- Removal
- Replacement/substitution
- Engineering controls
- Administrative controls
- Protective clothing and equipment

Protective clothing and equipment should only be used when other controls are not feasible, while they are being implemented, or during emergency situations. Respiratory protection is a type of personal protective equipment used to control those health effects caused by breathing air contaminated with harmful or potentially harmful gases, vapors, or aerosols. Other types of protective equipment used to minimize the risk from laboratory hazards include emergency drenching facilities, such as safety showers and eyewash stations.

This section provides guidance for EPA laboratories on protective clothing and equipment in the following chapters:

Chapter	Topic
E2	Personal Protective Equipment
E3	Respiratory Protection
E4	Emergency Eyewashes and Showers

## 1.0 Introduction

EPA laboratory employees face the risk of exposure to a wide variety of hazardous substances, including chemical, physical, and biological agents. Engineering controls, standard operating procedures, administrative controls, and materials substitutions are considered the first line of defense in controlling workplace hazards. Personal protective equipment (PPE) should be used only in the capacity of a secondary exposure control strategy, where other controls are not feasible or fully sufficient.

Unlike engineering controls that isolate or otherwise control a hazard, PPE isolates the wearer from the hazard. PPE and, more specifically, chemical protective clothing (CPC), provide a physical barrier to the hazard.

Exposure to chemical, physical, and biological hazards without the use of PPE or other controls can have a number of different adverse effects. For instance, several general effects of chemical exposure can be experienced based on the type and degree of exposure. Exposures can be either acute (i.e., short-term and generally high concentrations) or chronic (i.e., long-term and generally lower concentrations), and the effects can be either localized or systemic. Localized effects are seen at the point of contact, such as burns of the skin when exposed to a corrosive substance, while systemic effects are seen in a target organ. An example of a systemic effect is the depression of the central nervous system caused by the skin absorption of phenol.

In addition, many laboratory personnel are working with samples that contain unknown chemical and/or biological hazards. The majority of adverse effects could be prevented with properly selected and used PPE and CPC.

This chapter addresses the use of PPE in a laboratory setting. It also discusses the hazards against which protection is needed, and the types of PPE that are available. Finally, it focuses on the PPE requirements to control exposure to chemical, physical, and biological hazards via contact with the skin, eyes, or mucous membranes. Respiratory protection will be addressed in the following chapter.

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### *EPA Program Requirements*

Each location must conduct and certify a hazard assessment for laboratory tasks and areas to determine what potential hazards are present that necessitate the use of PPE. Where PPE is needed, laboratories must:

- Select and have each employee use the appropriate types of PPE based on the results of the hazard assessment.
- Communicate selection decisions to each affected employee.
- Select PPE that properly fits each affected employee.
- Establish a maintenance and care program for PPE.
- Provide training to each employee required to wear PPE.
- Maintain required documentation.

EPA SHEM Guide 44 provides guidance on conducting the hazard assessment and implementing an effective PPE program.

In addition, it outlines the requirements of the U.S. Occupational Safety and Health Administration (OSHA) standards on PPE contained in 29 CFR 1910 Subpart I.

***Program Administration***

To effectively manage the laboratory PPE program, responsibilities should be assigned for:

- Completion and certification of the PPE hazard assessment
- Selection of appropriate PPE based on the workplace hazards, the level of risk, and the individual needs of the worker (e.g., fitting requirements)
- Procurement and distribution of selected PPE
- Training of employees in the use, maintenance, and limitations of PPE
- Performance of periodic checks to ensure that employees are properly using required PPE and that damaged or defective equipment is not used
- Evaluation of the effectiveness of the overall PPE program
- Maintenance of required records (e.g., assessment certification, training documentation)

## 2.0 Hazard Assessment and Selection of PPE

EPA SHEM Guide 44 provides detailed guidance on conducting the hazard assessment and implementing an effective PPE program. These requirements will not be repeated here. Instead, the following information is provided to supplement SHEM Guide 44.

The individual or group designated to conduct the hazard assessment must:






- Be familiar with the potential hazards, the type of protective equipment that is available, and what it can do (e.g., splash protection, impact protection).
- Compare the hazards associated with the environment (e.g., impact velocities, masses, projectile shape, radiation intensities) with the capabilities of the available protective equipment.

- Select the protective equipment that ensures a level of protection greater than the minimum required to protect the employees from the hazards.
- Select equipment that meets the American National Standards Institute (ANSI) design specifications as presented in Table E2-1.

An example of a completed laboratory hazard assessment, referenced from EPA SHEM Guide 44 Personal Protective Equipment, is located in Attachment E2-1 of this manual.

EPA SHEM Guide 44 also includes examples of forms that can be used for documentation. Laboratory locations can use the types of hazard assessment forms most suitable for their needs, as long as all required information is documented. An alternate example of a form is included in Attachment E2-2 of this manual. Completed PPE Assessments must be maintained with the laboratory's chemical hygiene plan.

**Table E2-1: ANSI Design Specifications**

Equipment	Specifications
 Head Protection	ANSI Z89.1-1997, Industrial Head Protection
 Eye and Face Protection	ANSI Z87.1-1989, Practice for Occupational and Educational Eye and Face Protection
 Hearing Protectors	ANSI S12.6-1997, Methods for Measuring Real-Ear Attenuation of Hearing Protectors
 Protective Footwear	ANSI Z41-1991, Personal Protection-Protective Footwear
 Hand Protection	Selection based on performance characteristics of gloves in relation to tasks to be performed.

There may be multiple hazards associated with specific jobs or tasks. PPE Selection must be based on all potential hazards. For additional guidance on multiple hazards, refer to the risk assessment information located in Chapter B of this manual.

### 2.1 Selection Process

Selection of the most appropriate PPE depends on the work scenario; chemical, biological, physical, and environmental hazards; expected duration of exposure; current controls; worker compliance; and other factors. Accident data may also be reviewed to help identify problem areas.

The hazard assessment must be updated regularly to determine if hazards have changed and if the selected PPE is appropriate for hazards present.

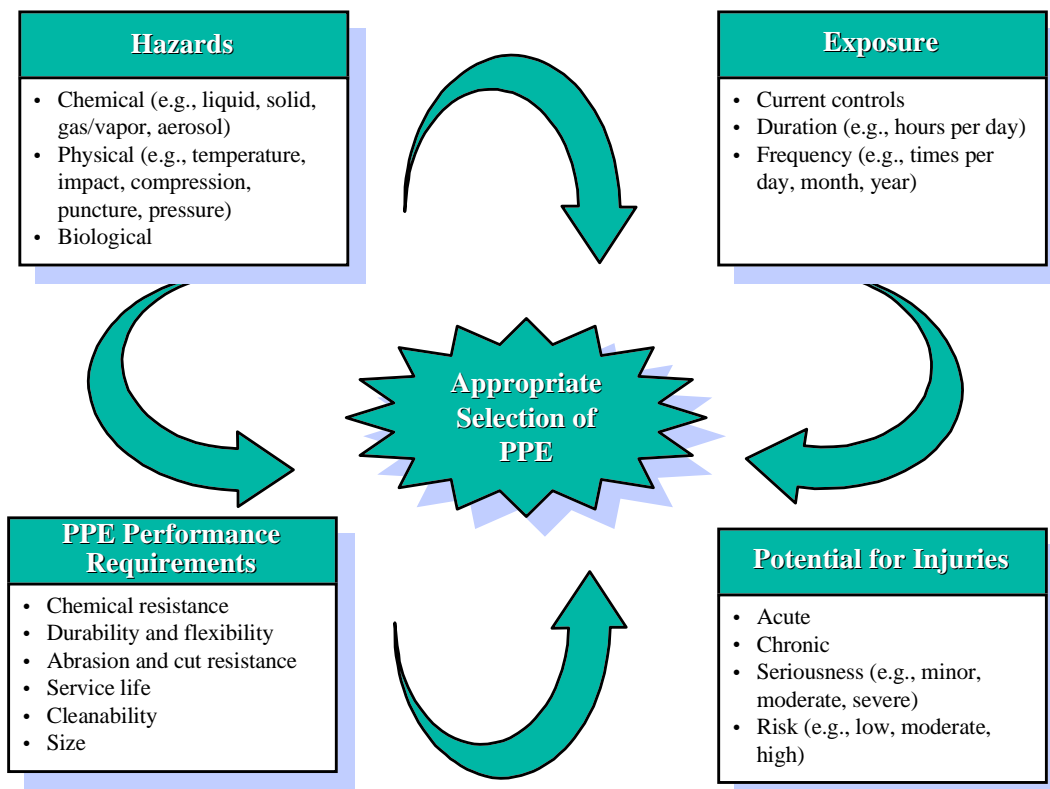
After identifying potential hazards associated with a task, the following criteria should be used in evaluating hazards and selecting PPE:

- Type of hazard and degree of exposure
- Duration of exposure
- Frequency of exposure
- Type and seriousness of potential injury
- Level of risk of injury
- Required chemical and physical performance of PPE

PPE selection factors are illustrated in Figure E2-1.

Selection of the most appropriate personal protective equipment ensemble should be made by a trained health and safety professional since it encompasses multiple steps and decision points.

**Figure E2-1: PPE Selection Factors**





Whenever possible, employees should be allowed to choose the particular style/model of clothing and equipment from a preselected group of different types that meet the performance and job requirements.

## 2.2 Additional Resources

Information on chemical and physical performance of select protective materials is contained in Attachment E2-3 of this manual. The tables contained in this attachment summarize chemical resistance of a number of materials against chemicals commonly used in EPA laboratories, and also provide general information on physical performance of select materials.

Vendor catalogs often provide permeation data and other recommendations that can be used in the selection of PPE. Many also offer a technical assistance number to further assist in selection decisions. Often an Internet search may produce a variety of PPE selection guidance information.

A definitive comprehensive document that reviews the selection process for PPE is entitled, "Guidelines for the Selection of Protective Clothing, 3rd edition." It was prepared by Arthur D. Little, Inc. (A.D. Schwope et al.). This publication is available from the American Conference of Governmental Industrial Hygienists, Inc.

Other useful resources include:

- Material Safety Data Sheets (MSDSs)
- Laboratory chemical hygiene plan
- Technical references related to PPE (e.g., OSHA, NIOSH)

## 3.0 Types of PPE

OSHA requires that protective equipment be provided, used, and maintained in a sanitary and reliable condition. PPE must be accessible to laboratory personnel at all times.

Basic PPE requirements for laboratory tasks include:

- Laboratory coat with long sleeves
- Safety glasses with side shields
- Closed-toe, practical shoes—no open-toed shoes or sandals

Additional PPE will be required for certain tasks based on the results of the laboratory-specific hazard assessment.

The following sections provide additional guidance on the specific types of protection:

- Eye and Face
- Hand
- Body
- Head
- Hearing

### 3.1 Eye and Face Protection

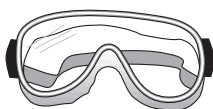
Protective eye and face equipment are required, under 29 CFR 1910.133, when there is a reasonable probability of injury to the eyes or face that could be prevented by the use of such equipment. This includes potential exposure to chemical splashes, gases or vapors, or dusts. Suitable eye and face protection must be made available to workers for laboratory operations where there is a hazard of flying objects, liquids, glare, injurious radiation, or a combination of these hazards.



### Safety Glasses

Safety glasses have traditionally been used as the eyewear of choice in the majority of EPA

laboratories. Safety glasses are available in many different configurations and styles, and can be fitted with prescription lenses if required. For operations where there is a hazard from flying objects, the safety glasses must have sideshields. However, sideshields are highly recommended for all laboratory operations.



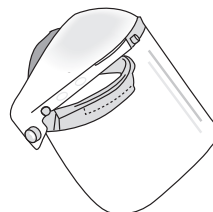
### Goggles

In work areas where a splashing liquid or rapidly moving airborne particulate may cause potential injury, clear plastic goggles that completely enclose the eyes will provide superior protection over safety glasses.

Goggles may be either “chemical splash goggles” or “safety goggles,” for protection against particulate matter. Be sure to specify the desired type in ordering.

Both safety glasses and goggles are available in tints and shades that permit their use for exposure to non-ionizing radiation such as ultraviolet light. When working with lasers, the frequency of the radiation must be known to provide adequate protection, since the absorbing media are frequency-specific and, when there is a potential for exposure to nonionizing radiation the spectral distribution must be determined in order to provide adequate protection.

For specific eyewear recommendations related to laser safety, refer to Chapter C6 of this manual.



### Faceshields

Based on the exposure scenario, faceshields may be required to eliminate the risk of facial injury from chemical splashes and fast-

moving objects. For instance, faceshields should be used for dispensing cryogenic liquids or working with substantial amounts of corrosive liquids. Caution should be used with faceshields. The potential does exist for entrapment of chemicals inside the shield close to the eyes and face, especially when working with volatile chemicals below the face level.

Faceshields can be either clear or tinted and flat or contoured. Faceshields should be selected based on a combination of the requirements for physical and chemical resistance. Safety glasses or goggles must always be worn beneath a faceshield.

Where needed, throat protectors can be attached to the face shield to provide additional protection. For instance, throat protectors should be used for tasks involving explosive materials.

## 3.2 Hand Protection

Hand protection is required when there is a potential for exposure to hazards from skin absorption of chemicals, chemical burns, contact dermatitis or sensitization, cuts or lacerations, severe abrasions, punctures, thermal burns, or contact with blood or



other potentially infectious materials. Hand protection is essential for protecting laboratory employees from contact with and possible absorption of hazardous materials, as well as from physical hazards (e.g., cuts, burns, etc.).

Using two dissimilar pairs of gloves, referred to as “double gloving,” is highly recommended when working with materials known to be highly hazardous, or where there are unknowns. For instance, when handling samples—which generally contain a number of unknown contaminants—using two dissimilar pairs of disposable gloves (e.g., nitrile disposables over vinyl disposables) can provide adequate protection for the short duration of contact and will also allow the required hand and finger dexterity.

Whenever using disposable gloves, it's important to change them:

- As soon as possible after known contact with a hazardous material
- Whenever the integrity of the glove has been compromised
- Periodically throughout the day

Also, when worn near moving machinery, gloves must fit tightly enough to avoid getting caught or pulled into the moving parts.

A summary of recommended types of gloves for various hazards is presented in Table E2-2.

### 3.3 Body Protection

At a minimum, long-sleeve, button-up laboratory coats must be worn for all laboratory tasks. Long pants should also

be worn to protect the skin between the bottom of the lab coat and the top of shoes. For most tasks, a laboratory coat will provide adequate protection. However, there may be some operations where additional protection is needed. For example, a splash apron may be necessary for glassware operations to protect the body and clothes from contact with corrosive chemicals. Also, animal handlers may wear jump suits for greater freedom of action and better coverage.

Caution must be used with the sleeves of laboratory coats. Loose sleeves have a tendency to drag through the chemicals being used, thereby creating the same potential dermal exposure the coat is intended to eliminate. Employees should consider taping sleeves tight if this is a potential hazard.

Laboratory coats and other types of protection must not be worn out of laboratory areas into public areas such as lunch rooms, restrooms, the library, conference rooms, etc.

### 3.4 Head Protection

Head protection must be worn when there is a risk of flying or falling objects or electrical shock. It is not anticipated that head protection will be needed in the majority of EPA laboratories. However, there may be instances where head protection is required, under 29 CFR 1910.135, based on the results of the hazard assessment.

Hard hats are available in a variety of styles, including those used for light duty (i.e., bump caps) and electrical operations.



Hard Hat



Bump Cap

### 3.5 Foot Protection

Foot protection is required, under 29 CFR 1910.136, where there is a danger of foot injuries due to falling or rolling objects, sharp objects piercing the sole, or where feet are exposed to electrical hazards. For example, manually moving compressed gas cylinders is a task where foot protection would be required.

When selecting the appropriate footwear, a primary consideration is the type of sole since slips, trips, and falls are one of the most common causes of occupational injuries.

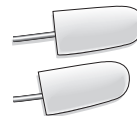
At a minimum, laboratory employees must wear closed-toe, “sensible” shoes whenever working in the laboratory. Sandals or open-toed shoes must not be allowed.

### 3.6 Hearing Protection

Laboratory employees must be provided with hearing protection if noise levels are above the limits established by OSHA (29 CFR 1910.95). OSHA requires that a hearing conservation program be implemented if noise levels exceed an 8-hour time-

weighted-average (TWA) sound level of 85 decibels (dBA). The program must include a comprehensive monitoring program, personnel training, hearing testing, and PPE. As part of this program, hearing protection must be provided to employees working in areas with noise levels exceeding 90 decibels (dBA). Some laboratories may supply hearing protection to employees for increased comfort, even where it's not required according to the OSHA standard. As a rule, if it's necessary to raise voices when communicating at arm's length, the area should be tested and evaluated to determine if engineering controls are needed to reduce noise and/or if the use of hearing protection is required.

Two basic styles of hearing protection are available:








Earplugs  
(worn inside the ear)



Earmuffs  
(worn over the ear)

Earplugs are available in a variety of materials and configurations ranging from inexpensive disposables to custom-fit devices. A trained health and safety professional should select the necessary types of hearing protection based on noise monitoring data, exposure scenarios, and the noise reduction rating (i.e., measure of noise suppression) of candidate protective devices.

**Table E2-2: Types of Hand Protection**

Hazard	Type of Glove	
Abrasion, cut, or puncture	Canvas or leather "work glove"	
Laceration	Cut-resistant material (e.g., Kevlar™)	
Contact with hot object	Thermal glove	
Contact with corrosive or toxic material	Chemical-resistant "utility glove"	
Contact with biological or other chemical	Impervious "disposable glove"	

**4.0 Performance Requirements for Chemical Protective Clothing (CPC)**

There are a number of performance requirements that must be considered in selecting the appropriate chemical-protective material. Their relative importance is determined by the particular work activity and laboratory conditions. Performance requirements include:

- Chemical resistance
- Durability
- Flexibility

- Temperature
- Service life
- Cleanability
- Size
- Cost

User factors, such as the potential for allergic response to protective materials (e.g., latex) must be considered as well.

Each of these performance requirements is discussed in the sections that follow.

#### 4.1 Chemical Resistance

Chemical resistance is the ability of a material to withstand chemical and physical change. A material's chemical resistance is the most important performance requirement. The material must maintain its structural integrity and protective qualities upon contact with a hazardous substance.

##### Principles of CPC

- There is no protective material that is impermeable.
- There is no one material that affords protection against all chemicals.
- For certain contaminants and chemical mixtures, there are no materials available that will protect for more than an hour after initial contact.

The effectiveness of materials to protect against chemicals is based on their resistance to penetration, degradation, and permeation. Each of these properties must be evaluated when selecting the style of CPC and the material from which it is made. In choosing protective materials, the information in the following sections should be kept in mind.

##### 4.1.1 Penetration

Penetration is the transport of chemicals through openings in a garment. A chemical may penetrate due to design or garment imperfections. Stitched seams, button

holes, pinholes, zippers, and woven fabrics can provide a route for the chemical to penetrate the garment. A well-designed and -constructed garment prevents this by using self-sealing zippers, seams overlaid with tape, storm flap closures, and non-woven fabrics. Rips, tears, punctures, or abrasions to the garment also allow penetration.

##### 4.1.2 Degradation

Degradation is a chemical action involving the molecular breakdown of the material due to chemical contact. Degradation is evidenced by physical changes to the material that may cause the material to shrink or swell, become brittle or soft, or change its chemical properties. Other changes may be slight discoloration, rough or gummy surface, or cracks in the material. Such changes may enhance permeation or allow penetration by the contaminant.

##### 4.1.3 Permeation

Permeation is a chemical action involving the movement of chemicals, on a molecular level, through intact material. Permeation is a process that involves the sorption of the chemical on the outside surface, diffusion through, and desorption of the chemical from the inside surface of the protective material. A concentration gradient (e.g., high on the outside: low on the inside) is established. Because the tendency is to achieve concentration equilibrium, molecular forces "drive" the chemical into the material toward the area of lower concentration. Eventually the highest flow of permeating chemical exists. Once the chemical desorbs from the fabric, exposure may occur via direct contact with liquid, contact with contaminated

inner clothing that becomes soaked with the chemical, or by contact with the chemical vapor.

Two terms quantify permeation: permeation rate and breakthrough time. These values are determined in a controlled laboratory test specified by the American Society for Testing and Materials (ASTM) F739.

Permeation rate is the quantity of chemical that will move through an area of protective material in a given time. It is usually expressed in micrograms of chemical permeated per square centimeter per minute of exposure ( $\mu\text{g}/\text{cm}^2/\text{min}$ ).

Factors affecting permeation rate include:

- Type of material
- Thickness of material
- Chemical concentration
- Contact time
- Temperature
- Material grade
- Humidity
- Solubility of the material in the chemical

A general rule of thumb is that the permeation rate is inversely proportional to the thickness ( $2 \times \text{thickness} \propto \frac{1}{2} \times \text{permeation rate}$ ).

Another measure of permeation is breakthrough time, expressed in minutes. Breakthrough is the elapsed time between initial contact of a chemical with the outside surface and detection at the inside surface of the material. Breakthrough times vary from seconds to days, depending on the chemical/material combination and concentration, exposure scenario, and

environmental conditions. Like permeation rate, breakthrough time is chemical-specific for a particular material and is influenced by the same factors. A rule-of-thumb concerning breakthrough time is that it is directly proportional to the square of the thickness ( $2 \times \text{thickness} \propto 4 \times \text{breakthrough time}$ ).

Permeation test data are available through the majority of CPC manufacturers, and most of the data are currently generated through several independent third-party testing laboratories. Individuals making CPC selection decisions should use chemical resistance information available from the actual manufacturer of the candidate material, as well as from third-party testing laboratories. For instance, the guidelines developed by Arthur D. Little (see reference in Section 2.2) have PPE recommendations for 465 individual chemicals and 21 generic classes of chemicals (i.e., aldehydes, inorganic acids).

However, caution should be exercised when using "generic" chemical resistance information since similar CPC materials (e.g., nitrile) available from different manufacturers may perform in a radically different manner when challenged with the same chemical.

#### 4.2 Durability

Durability is the ability to withstand wear and to resist punctures, abrasions, and tears. It is the material's inherent strength. Certain physical requirements may be placed on an item of PPE based on the use scenario. Physical hazards involved may include cut, slash, and puncture from various sharps. Several materials are available

that provide good cut and slash resistance, including stainless-steel fibers, Kevlar®, Spectra®, and chrome leather. Puncture resistance, however, is a difficult hazard to provide protection against. The puncture resistance of CPC materials increases with increasing thickness, but at the expense of dexterity and flexibility. The primary control measure for puncture hazards should be safe work practices and procedures.

### 4.3 Flexibility

Flexibility is the ability to bend or flex (i.e., pliability). It is extremely important for glove materials, because it directly affects the worker's mobility, agility, and ability to work.

### 4.4 Temperature Resistance

Temperature resistance is the ability of a material to maintain its chemical resistance during temperature extremes (especially heat) and to remain flexible in cold weather. A general tendency for most materials is that higher temperatures reduce their chemical resistance and lower temperatures reduce flexibility.

### 4.5 Service Life

Service life is the ability of a material to resist aging and deterioration. Factors such as chemicals, extreme temperatures, moisture, ultraviolet light, oxidizing agents, and others, decrease a material's service life. Storage away from, and proper care against, these conditions can help prevent aging and extend the life of the suit. Manufacturers should be consulted regarding any recommendations on a protective material's shelf-life.

### 4.6 Cleanability

Cleanability is the ability to effectively decontaminate protective materials. Cleanability is a relative measure of the ability of a material to release the contact substance. Some materials are nearly impossible to decontaminate, so it may be important to cover those materials with disposable garments to prevent gross contamination.

### 4.7 Size

Size is the physical dimension or proportion of clothing. Size is directly related to comfort and influences the number of unnecessary physical accidents. Ill-fitting gloves, boots, or suits limit a worker's mobility, dexterity, and concentration. It's essential that protective clothing properly fit the individual.

### 4.8 Cost

The cost of chemical protective clothing varies considerably. Cost will often play a role in selection. Less expensive, single-use gloves are often as safe as more costly clothing. Other situations require costly high-quality clothing that may have to be discarded after limited use. It is always important not to let cost get in the way of selecting proper protective clothing.

Protective clothing can also be categorized as disposable or reusable based on the cost of the garment. Disposable garments are typically constructed of thin plastic films or laminates, are relatively inexpensive and light-weight, and exhibit only fair to poor physical properties (i.e., abrasion and cut resistance). Reusable garments are



typically constructed of a rubber-based material, are more expensive and heavier than disposable garments, and offer improved physical properties.

### 5.0 Care and Maintenance

The following sections provide guidance for EPA laboratories on the care and maintenance of protective equipment. These requirements address only protection against eye, skin, and clothing contact; requirements for respiratory protection are presented in Chapter E3 of this manual. A special testing facility may be required for testing the integrity of electrical safety devices and PPE.

In order to ensure the anticipated level of protection, it's important that PPE is properly cared for and maintained. This section outlines practices for inspection, storage, and disposal.

#### 5.1 Inspection Practices

A general inspection of PPE should be conducted before each use and include a check of the following:

- Abrasions, cuts, holes, or tears
- Signs of chemical contamination, such as discoloration, rough surfaces, gummy feeling, cracks
- Missing, damaged, or defective components

Supervisors and staff must be trained in inspection practices. The manufacturer's recommendations for inspection should always be referenced.

**Damaged or defective PPE must never be used!**

### 5.2 Storage Practices

PPE must be stored properly to prevent damage or malfunction due to the conditions listed in Table E2-3.

**Table E2-3: Factors Affecting PPE in Storage**

Factor	Hazard
Damaging Chemicals	Contaminates and breaks down material
Moisture	Can cause mold or break down material
Sunlight	Damages materials and increases aging
Dust	Contaminates material
Extreme Temperatures	Can alter configurations of material; melt (hot) or crack (cold)
Impact	Can damage, break, or tear material

### 5.3 Disposal Practices

General disposal practices for PPE include the following:

- Disposable items should be discarded after each use or when the material's integrity is suspect. For instance, disposable gloves should be discarded after known contact with a hazardous substance, whenever rips or holes are identified, or periodically (e.g., after 3 or 4 wearings).
- Any street clothing contaminated with a chemical or biological agent (e.g., by a spill) should be discarded as laboratory-contaminated waste, unless decontamination is possible.

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Any street shoes contaminated with a chemical will also be disposed of in the same manner.

- Contaminated non-disposable items should be stored in covered containers until washed. If washing is done by laboratory personnel, they may need gloves and disposable suits while handling contaminated items, depending on the amount and nature of the contamination. If washing is done by an outside service, they must be notified (in writing) that they are handling items with potential contamination. Outside services must provide labeled containers. Contaminated clothing should never be taken home by employees for cleaning or discarding.
- Employees must be informed of the standard procedures for washing and disposing of PPE specific to the laboratory. For each item of protective equipment, employees must also understand who is responsible for cleaning and disposal.

### 6.0 Effect of PPE on Job Performance

PPE should be selected to have minimum impact on job performance. However, certain types of PPE, may interfere to some degree with a worker's ability to perform his/her assigned duties. Worker productivity may be reduced, and the PPE itself may introduce additional health and safety problems to the situation. For instance:

- Gloves may reduce dexterity and tactility.

- Respirators can obstruct and distort vision, stress the respiratory system, and interfere with speech intelligibility.
- Garments may restrict mobility and induce heat stress.
- Some types of PPE may increase the time it takes to complete a task.

These and other effects may present a risk to the worker (e.g., induced heat stress) or contribute to some other risk (e.g., slips, trips, and falls). The magnitude of the effects will depend on the type of PPE used, the nature and duration of the work, environmental conditions, and worker training.

Individuals assigned to selecting PPE should consider the physical and psychological effects of using such equipment and do their best to select PPE that provides optimum protection with minimum impact on job performance.

### 7.0 Recordkeeping

Laboratories must maintain the following PPE documentation:

- Hazard assessment certification
- Training verification

The hazard assessment certification must include:

- The workplace evaluated
- The person certifying the evaluation
- The date(s) of the hazard assessment

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In addition, most laboratories will find it helpful to document the specific tasks evaluated and the recommended PPE as part of the hazard assessment certification.

The training verification must include:

- The name of each employee trained
- The date(s) of training
- The subject of certification

In addition, records of PPE assignment, disposal, and/or replacement should be maintained.

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Attachment E2-1: Example of a Completed PPE Hazard Assessment

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**Purpose:** To provide an example of a completed PPE Hazard Assessment

**Instructions:** Not Applicable

## PPE Hazard Assessment

1. Hazard Source <sup>1</sup>	2. Operation	3. Room/Area	4. Hazard Assessment	5. Risk	6. PPE	7. PPE Criteria <sup>2</sup>
Chemicals in the laboratory	Laboratory operations	All labs	Splashing of acids and chemicals during handling  Absorption of acids and chemicals during handling	Burns and irritation to the hands, face, body  Irritation of the skin, hands, and eyes	Spectacles Lab coat Shoes Gloves	Z87 Full length No open toes Chemical-specific (see below)
Generic chemical and product handling	Laboratory operations	All labs	Contact with chemicals and dusts during handling	Contamination of the skin	Gloves	Latex, nitrile or PVC
Acids	Preparing the acid solutions for glassware washing	Re 185	Splashing of acids and chemicals during handling	Burns and irritation to the hands, face, and body	Gloves Apron Face Shield Goggles	Nitrile Rubber – Splash
Solvents	Transfer of liquids, greater than 4 liters	All labs	Absorption of acids and chemicals during handling	Irritation of and absorption into the skin, hands, and eyes	Gloves Goggles	Chemical- specific Splash
Methylene Chloride	Organic sample preparation and analysis	Rms 177a, 178, 179	Absorption of acids and chemicals during handling	Irritation of and absorption into the skin, hands, and eyes	Gloves	Viton
Diazomethane	Methylation (generating diazomethane)	Rm 181	Impact from explosions	Cuts and lacerations to the face and eyes	Gloves Spectacles with face shield Explosive shielding	Nitrile – See manufacturer
Perchlorates	Perchlorination	Rm 181	Impact from explosions	Cuts and lacerations to the face and eyes	Gloves Explosive shielding	Nitrile See manufacturer
Heat	Hotplates Autoclave Ovens	Throughout Rm 185 Rms 185, 197, 204	Contact during the handling of hot glassware	Burns to the hands and arms	Gloves	Insulated
Sharp Objects	Laboratory	All labs	Sharp objects such as needles and broken glassware	Cuts to hands and skin	Gloves	Leather or heavy-duty knit-lined rubber
Compression	Cylinders	Lab and Warehouse	Moving and rolling cylinders (gas and cryogenic) and containers (including drums in the warehouse)	Crushing of the foot	Shoes	Steel toes
Impact	Drill Press	Rm 203	Impact from flying fragments, objects, large chips, etc.	Irritation or damage to the eye	Spectacles	Z87, with side shields

<sup>1</sup>Categories include: Impact; Penetration; Compression; Chemical; Heat; Harmful dust; Light radiation; Noise; Electrical

<sup>2</sup>Footwear = ANSI 41.1991; Head protection = ANSI Z89.1 1986; Hand protection = PPE Program; Eye and face protection = ANSI Z87.1 1989;

<sup>3</sup>Spectacles are being specified for laboratory splash hazards for both laboratory operators and visitors. Spectacles are considered a downgrade for laboratory operators and an upgrade for visitors. Spectacles are required only in laboratory rooms, and only during ongoing operations other than auto sampling and administrative tasks (e.g., using computers). Goggles are preferable for laboratory operations where the splash hazard is greater (transferring liquids from containers at least 4 liters in volume), or during the bulk handling of chemicals and wastes.

<sup>4</sup>Viton gloves may not offer the dexterity needed to perform the operation. Latex or Nitrile gloves, if in contact with Methylene Chloride, may contaminate the sample. Gloves need to be disposed of as soon as they become deteriorated (minutes after contact for Nitrile and Latex, up to two weeks for Viton).

Assessment performed by: \_\_\_\_\_

Date: \_\_\_\_\_

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Attachment E2-2: PPE Hazard Assessment

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**Purpose:** This form is to be utilized for the completion of a PPE Hazard Assessment.

**Instructions:** A walk-through survey of the work areas and operations should be performed to identify sources and locations of hazards, and to identify the operation with which the hazards are associated. The risk related to the hazards present should also be characterized. PPE must be selected based on the hazards and the degree of risk present. The final column is used to identify the PPE specifications (e.g., glove material, etc.).



## PPE Hazard Assessment

Department:		Assessor:
Job Task:		Date:
<b>Health and Safety Hazards</b>		
<b>Chemical Hazards</b>		
	Vapors/Gases	
	Dusts/fumes/mists	
	Liquid splash	
	Other	
Comments		
<b>Physical Hazards</b>		
	Impact—flying dust, particles, chips	
	Penetration/puncture	
	Cuts/lacerations	
	Compressions—pinch, crush, rollover	
	Heat—sparks, molten splash, high temperatures	
	Cold—cryogenics, cold temperatures	
	Light (optical radiation)	
	Electrical shock	
	Fire	
	Radiation — Ionizing — Non-ionizing	
Comments		
<b>Biological Hazards</b>		
	Bloodborne pathogens	
	Animals	
	Other(s)	
Additional Notes		

## PPE Hazard Assessment (continued)

Personal Protective Equipment Recommendations			
Where engineering and administrative controls are not feasible or sufficient for controlling hazards, PPE must be used to protect workers. The following PPE are recommended for this task:			
<b>Eye and Face Protection</b>			
	Safety glasses with side shields		Reflective goggles/faceshield
	Chemical splash goggles		Cutting/brazing/welding
	Faceshield		Other:
Comments			
<b>Head Protection</b>			
	Hard hat, bump cap		Helmet, cowl, hood
	Welding helmet/mask		Other:
Comments			
<b>Foot Protection</b>			
	Safety shoes/boots		Other:
	Chemical-resistant boots		
Comments			
<b>Hand Protection</b>			
	Leather, canvas, cotton gloves		Chemical-resistant gloves Type of chemical(s): Type of glove:
	Other:		
Comments			
<b>Body Protection</b>			
	Apron (splash, work)		Heat-reflective garments
	Coveralls (work, chemical resistant) Type of chemical(s): Type of coveralls:		Sleeves (cut-resistant)
			Other:
Comments			
<b>Electrical Protection</b>			
	Rubber insulating gloves		Rubber insulating sleeves
	Rubber insulating hoods		Other:
<b>Respiratory Protection</b>			
	Respirator		Type of respirator:
Comments			
Hazard assessment certification: _____			
Signature			Date

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Attachment E2-3: Chemical and Physical Performance of Select Materials

**Chemical Protective Clothing Resistance Chart  
Breakthrough Times for Common EPA Laboratory Chemicals Against Select Materials**

PROTECTIVE MATERIAL	CHEMICAL					
	Methylene Chloride	Hexane	Nitric Acid <sup>1</sup>	Acetone	Hydrochloric Acid <sup>2</sup>	Sulfuric Acid <sup>2</sup>
Butyl rubber	< 1 hr	< 1 hr	> 8 hrs	> 8 hrs	> 8 hrs	> 8 hrs
Neoprene	< 1 hr	< 1 hr	> 8 hrs	< 1 hr	1 to 4 hrs	> 8 hrs
Nitrile	< 1 hr	> 8 hrs	> 8 hrs	< 1 hr	< 1 hr	1 to 4 hrs
Polyvinyl alcohol	> 8 hrs	> 8 hrs	< 1 hr	< 1 hr	< 1 hr	< 1 hr
Polyvinyl chloride	< 1 hr	< 1 hr	> 8 hrs	< 1 hr	< 1 hr	> 8 hrs
Teflon™	1 to 4 hrs	> 8 hrs	NO DATA	> 8 hrs	NO DATA	> 8 hrs
Viton™	< 1 hr	> 8 hrs	NO DATA	< 1 hr	NO DATA	> 8 hrs
Saranex™	< 1 hr	< 1 hr	> 8 hrs	< 1 hr	> 8 hrs	> 4 hrs
4H & Silvershield™	> 8 hrs	> 8 hrs	> 4 hrs	> 8 hrs	1 to 4 hrs	> 4 hrs

1. Data based on a concentration of < 30%
2. Data based on a concentration of 30 to 70%

IMPORTANT NOTES:

- This table is based ONLY on permeation data. Additional factors must be considered in the selection process, such as the physical characteristics required (e.g., need for cut resistance, temperature resistance, etc.), and the human factors required (e.g., need for dexterity, flexibility, etc.).
- The data in this table are based on GENERIC protective materials, with the exception of a few specific tradenames, and represents average breakthrough times. Specific manufacturer's information must be used to supplement this data, since material available from different manufacturers will provide varying levels of protection based on the thickness or grade of material.

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Attachment E2-3: Chemical and Physical Performance of Select Materials

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**Physical Characteristics of Select Chemical Protective Clothing Materials\***

Glove Material	Abrasion Resistance	Cut Resistance	Flexibility	Puncture Resistance	Tear Resistance	Cost
Butyl	F	G	G	G	G	HIGH
Coated Tyvek <sup>R</sup>	F	P	G	F	F	LOW
Natural Rubber	E	E	E	E	E	MED
Neoprene	G	E	G	G	G	MED
Nitrile	E	E	E	G	G	MED
Polyethylene	F	F	G	F	F	LOW
Polyvinyl Alcohol	F	F	P	G	G	HIGH
Polyvinyl Chloride	G	P	F	G	G	LOW
SilverShield <sup>R</sup> / 4H <sup>R</sup>	F	P	F	F	F	LOW
Viton	G	G	G	G	G	HIGH

\*Ratings are subject to variation depending on formulation, thickness, and whether the material is supported by fabric.

E=Excellent

G=Good

F=Fair

P=Poor

US EPA ARCHIVE DOCUMENT

## 1.0 Introduction

The respiratory system is able to tolerate some exposures to toxic gases, vapors, and particulates, but only to a limited degree. Some chemicals can impair or destroy portions of the respiratory tract, or they may be absorbed directly into the bloodstream from the lungs. Chemicals that enter the blood may eventually affect the function of other organs and tissues. The respiratory system can be protected by avoiding or minimizing exposure to harmful substances. Engineering controls such as ventilation help decrease exposure. When these methods are not feasible or not fully sufficient, respirators may be used to provide protection. Certain respirators can filter gases, vapors, and particulates in the ambient atmosphere.

The various types of respiratory protective devices available on the market can be placed into two categories: air-purifying or air-supplied respirators. An air-purifying respirator, as the name implies, protects the user by removing contaminants from inhaled air. The mechanism by which contaminants are removed from the air is substance-specific; that which effectively eliminates one contaminant will not necessarily do the same to another. An air-supplied respirator provides an external source of breathable air that is not affected by a hazardous environment.

Today there are many respirators available for use in an endless variety of situations. The regulations and recommendations affecting their use are continuing to evolve with changing technology. This chapter

presents information for the development of a respiratory protection program and provides direction for its implementation.

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### *EPA Program Requirements*

Each laboratory where respirators are used must ensure that:

- Engineering and administrative controls have been implemented wherever feasible
- A written program outlining the specific procedures for selection, assignment, use, and maintenance has been developed and implemented
- Employees required to wear respirators have been provided with medical evaluation, training, and fit-testing
- Periodic inspection of work activities requiring respirators is conducted, as well as an evaluation of the effectiveness of the overall program
- Required documentation is maintained

EPA laboratories with respirator use are required to comply with all provisions of the U.S. Occupational Safety and Health Administration (OSHA) standard 29 CFR 1910.134 and, included by reference in this OSHA standard, the American National Standards Institute (ANSI) standard for Respiratory Protection Z88.2-1-992. In addition, EPA SHEM Guide 46 addresses requirements and guidelines for respiratory protection.

***Program Administration***

To effectively manage the selection, procurement, use, and care of respirators, responsibilities should be assigned for:

- Assessing respiratory hazards to identify engineering and administrative controls wherever feasible
- Selecting appropriate respiratory protective equipment
- Developing and maintaining a written respiratory protection program
- Procuring and distributing selected respirators
- Coordinating a medical evaluation program for respirator users
- Providing fit-testing for respirator users
- Implementing a maintenance and care program for respirators
- Conducting training for respirator users
- Maintaining required records (e.g., training, medical evaluation, fit-testing, etc.)



## 2.0 Written Respiratory Protection Program

For respirators to provide optimum protection, they must be properly selected, inspected, and maintained in good working condition and only be used by trained and qualified individuals according to the provisions of the respiratory protection program. All laboratories with respirator use must develop, implement, and document a respiratory protection program. The purpose of a written program is to specify and document work-specific procedures for the selection, assignment, use, and maintenance of respirators.

### Written Program Elements

- Procedures for selecting respiratory protection
- Medical evaluation of respirator users
- Fit-testing procedures
- Training of employees
- Procedures for handling foreseeable emergencies
- Care and maintenance, including inspection, cleaning, and storage
- Procedures for safe use of respirators in dangerous atmospheres
- Procedures for disposal of contaminated air-purifying elements
- Air quality for supplied-air respirators, if applicable
- Training of employees in respiratory hazards and proper use of respirators
- Inspection and evaluation of the overall program

The written program serves as a handbook of the respirator program. Laboratories must revise it, as necessary, to reflect current practices, usage, and changing regulations. Guidance for developing a written program is included in SHEM Guide 46, Respiratory Protection.

## 3.0 Requirements for Respirator Users

In order to ensure that respirators are used safely, there are a number of requirements for the user. Each employee assigned to a task requiring a respirator must:

- Use only respirators approved by the National Institute for Occupational Safety and Health (NIOSH)
- Receive a medical evaluation to ensure he/she can safely wear a respirator
- Be fit-tested on the specific size and model of the respirator
- Complete the required training

Each of these requirements is discussed in more detail in the following sections.

### 3.1 NIOSH-Approved Respirators

The respiratory protection program must specify that laboratory staff may use only respirators certified by NIOSH. Furthermore, the staff must use and maintain the respirators in a manner that is consistent with the manufacturer's instructions and recommendations.

For chemical-cartridge air-purifying respirators, the certificate indicates approval of the entire assembled mask. This procedure precludes interchanging the parts of one manufacturer's respirator with those of another manufacturer.

The NIOSH certificate explicitly lists the contaminants for which the certified equipment is effective and describes the conditions under which it may be used. The maximum use concentrations differ for the listed contaminants as a function of both the relative effectiveness of the equipment against the different substances, and their relative toxicological characteristics. In cases where uncertainty exists about the actual use concentration, one should exercise caution and opt for a more protective respirator.

### 3.2 Medical Evaluation

The use of a respirator can impose significant physiological and psychological stress on the wearer. Since such stress may place the individual at an elevated risk of injury or illness, a physician must evaluate the fitness of each user assigned to wear a respirator. Of course, the physician must be familiar with respirators and the conditions under which they are worn. Such an evaluation should include, but not be limited to:

- Medical history, with special emphasis on cardiovascular or pulmonary disease
- Facial abnormalities that may interfere with a respirator seal
- Visual acuity
- Hearing ability
- Cardiovascular fitness
- Pulmonary function test

- Other tests deemed appropriate by the physician (e.g., endocrine evaluation, psychological status, neurological health, exercise stress tests)

After the evaluation, the physician should provide a written statement of the results of the exam, including whether or not the person is medically qualified to use a respirator and, if so, under what limitations, if any.

### 3.3 Fit-Testing Procedures

Not all respirators fit everyone, so each individual must find out which mask he/she can properly wear. At best, any given respirator will fit 60 percent of the working population. But with the large number of respirators available, at least one type should be found to fit an individual.

The integrity of the face-to-facepiece seal of a respirator can be tested either quantitatively or qualitatively. The quantitative test is an analytical determination of the concentration of a test agent inside the facepiece compared to that outside the mask. The concentration ratio of test agent measured outside the mask versus inside quantifies the potential performance of the respirator under specified conditions. This concentration ratio is called the Protection Factor (PF) and is a measure of the relative protection offered by a respirator. Protection factors are an important aspect of the selection process.

In a qualitative fit-test, sensory perceptions (e.g., odor) or involuntary responses (e.g., coughing from irritant smoke) of the user are relied on for detection of the test agent

inside the mask. Detection of the chemical agent inside the facepiece indicates the presence of a leak and the mask must be adjusted or replaced with another size, model, or brand until a proper fit is achieved.

The laboratory must fit-test all employees who are required to wear negative-pressure respirators to determine which mask best conforms to their facial features. A laboratory should fit-test an employee prior to initial assignment to any job that may require the use of a respirator, and at least annually thereafter. More frequent fit-testing is necessary for new mask configurations, or if one's facial contours change radically from weight loss, injury, or illness.

EPA SHEM Guide 46-06 provides additional guidance on fit-testing, and Attachment E3-1 of this manual outlines several fit-testing procedures.

Another factor that may affect the fit and protection afforded by a respirator is the presence of facial hair between the mask and the surface of the face. Facial hair will permit the passage of unpurified air into the interior of the facepiece. For this reason, laboratory staff with facial hair cannot rely on negative-pressure respirators with tight-fitting half or full facepieces. Facial hair in the seal area is unacceptable for persons required to wear a respirator.

Respirators must not be worn with temple bars or other parts penetrating through the face-to-facepiece seal. Special corrective lens inserts designed specifically for that respirator must be used.

### 3.4 Training

The quality and quantity of training provided to respirator users are critical in determining the level of protection afforded in a given situation. At a minimum, the laboratory should offer appropriate training on initial assignment, and at least annually thereafter, or whenever the potential for exposure changes.

#### Training Program Elements

- Functional components of a respirator
- Pre-use inspection
- Air-purifying element selection
- Donning instructions
- Positive/negative-pressure fit checks
- Limitations
- Typical-use situations
- Emergency instructions
- Care and maintenance
- Storage locations

### 4.0 Respirator Selection Process

Selection of the proper respirator is one of the most important components of this program. There are many factors to consider when selecting a respirator, including:

- Type, identity, and concentration of hazard
- Exposure limit and Immediately Dangerous to Life and Health (IDLH) value
- Concentration of ambient oxygen
- Chemical/physical characteristics of the hazard
- Acute/chronic health effects of exposure
- Warning properties
- Employee comfort level
- Ease of escape from contaminated area
- Length of time for which respirator must be worn
- Work activities and characteristics
- Need for face and/or eye protection
- Respirator characteristics and limitations

EPA SHEMP Guide 46-04 contains additional details on each of these elements, which must be considered in the selection process.

Additional resources to aid in the respirator selection process are the ANSI standard for Respiratory Protection (ANSI Z88.2), the NIOSH decision logic, and the OSHA decision logic.

NIOSH has compiled many of the decisions that go into the selection process in a document entitled the “NIOSH Respirator Decision Logic.” Use of the decision logic provides a rigorous framework within which one can progressively exclude inappropriate respirators until only correct respirators remain under consideration. OSHA has published a second decision logic as part of its Industrial Hygiene Technical Manual.

After each of these factors are evaluated, the selection process should attempt to provide employees with the “optimum” respiratory protection, a maximum level of comfort, and a minimum impact on worker productivity.

***Protection Factors and Maximum Use Concentration***

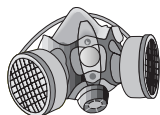
The basis for assigning respirators is the protection factor (PF). The PF is the minimum level of performance that NIOSH considers to be achievable in the workplace when the respirator is used by a trained, properly fit-tested, and medically qualified worker according to a well-defined respiratory protection program.

**Table E3-1: Respirator Protection Factors (PF)**

Respirator Type	PF
Half-Facepiece	10
Full-Facepiece APR	100
Full-Facepiece PAPR (with HEPA filters and sorbent cartridges)	1000
Full-Facepiece PAPR (with dust filter)	100
Self-contained breathing apparatus (SCBA)	*

\*Recent studies have concluded that all users of positive-pressure SCBAs may not achieve protection factors of 10,000. Therefore, ANSI has not listed a definitive protection factor but has suggested that for emergency planning purposes where hazardous concentrations can be estimated, an assigned protection factor of no higher than 10,000 be used.

*Source: ANSI Z88.2-1992*



Half-Face  
Respirator



Full-Face  
Respirator

The protection factor is then used to determine the Maximum Use Concentration (MUC) of a fit-tested respirator. The MUC is the highest concentration of a specific contaminant in which the respirator can be worn and is calculated by multiplying the PF by the exposure limit for that contaminant ( $MUC = PF \times \text{Exposure Limit}$ ). However, the MUC is only identifying the upper limit for the respirator; there may be other conditions that would preclude personnel entry into areas where concentrations approach the MUC (e.g., if the IDLH value is exceeded).

Protection factors and the maximum use concentration are only two of the several considerations for selecting the proper respirator. As mentioned previously, there are many factors to consider in the respirator selection process. The facility or regional health and safety officer should be consulted for selection decisions.

### 5.0 Respirator Use

Respiratory protective equipment must only be used:

- For operations involving exposure to air contaminants above the allowable limits where engineering and administrative controls are not feasible or are not sufficiently effective

- For temporary control to reduce or eliminate employee exposure in contaminated environments while engineering or administrative controls are being implemented
- For emergencies

Prior to each use, the wearer must inspect the respirator to make sure that all the necessary parts are present, that it is clean, and that it is equipped with the proper cartridges for the contaminant(s) expected to be encountered. The cartridges should be attached firmly to the facepiece, and should be clean and dry.

In addition, negative-pressure respirators with tight-fitting facepieces must be fit-checked before each use to ensure that the respirator is providing an effective face-facepiece seal. The procedures for fit-checking are described in the sections that follow, as well as some considerations for service life.

### 5.1 Fit-Checking Procedures

Before each use, the wearer must conduct both a negative and a positive pressure fit-check:

**Negative-pressure fit-check:** Cover the inhalation port(s) of the respirator (i.e., canister of cartridges for air-purifying respirators) with the palm(s) of the hand while inhaling gently. The respirator should fit tightly, collapse slightly, and allow no air to pass around or through for approximately ten seconds. This blockage should be maintained to determine if there is any leakage. The facepiece seal is



considered effective if a negative pressure can be maintained with no evidence of inward leakage from the seal.

**Positive-pressure fit-check:** Cover the exhalation valve with the palm of one hand while exhaling gently. The facepiece seal is considered effective if a positive pressure can be maintained with no evidence of outward leakage from the seal.

## 5.2 Service Life

One of the most important considerations when using a respirator is that all respirators have a limited service life. At some point, the protective capability of a respirator (e.g., cartridges or air supply) will be used up, and it will be necessary to change the cartridges. Thus, the user must have some warning that this is about to happen.

When chemical-type air-purifying respirators are used, the airborne contaminant must have good warning properties. The user should be alerted to the presence of contaminant(s) by a taste, smell, or irritation (i.e., breakthrough). This occurs when the adsorptive capacity of the respirator cartridge has been exceeded and the contaminant is no longer being removed from the inspired air. An air-purifying respirator should not be used for a substance with poor warning properties (e.g., carbon monoxide).

Particulate-type air-purifying respirator cartridges may reach the end of their useful life by clogging up (i.e., load-up). Here the filter gets so loaded that it makes breathing difficult. This increased breathing resistance is a signal to change filter cartridges. Users of air-purifying

respirators must be fully aware of each of these conditions. In addition, some respirator cartridges may be equipped with end-of-service-life indicators.

## 6.0 Maintenance and Care

Maintenance and care of respirators is a critical element of an effective program. Using a poorly maintained or damaged respirator can be as or more dangerous as not wearing a respirator at all. Laboratories where respirators are used must establish a maintenance and care program that includes provisions for:

- Inspection for defects
- Cleaning and disinfection
- Replacement of parts
- Storage

Wherever possible, respirators should be assigned to individuals for their exclusive use. The user is responsible for routine maintenance and care, including cleaning, disinfecting, and properly storing the respirator after each use. Finally, respirators that have been designated for general or emergency use must be inspected at least monthly, and cleaned and disinfected after each use.

The procedures to be followed for care and maintenance are described in detail in the sections that follow.

### 6.1 Inspection

Inspections must be performed by each respirator wearer prior to use. The following general procedures should be used for inspection of air-purifying units (if

available, specific inspection instructions from the respirator manufacturer should also be used):

- Inspect facepieces for scratches and abrasions that may obstruct vision.
- Check threads and any “O” rings or gaskets that may be in the unit.
- Examine straps for cuts, tears, broken buckles, cracks, or signs of drying out.
- Inspect elastomer parts, including inhalation and exhalation valves, for holes, cracks, and any misshapen pieces.

Where disposable respirators are used, they should be inspected for:

- Holes or other damage to the mask
- Damage to or lack of elasticity of the straps
- Deterioration of the nose clip

Emergency-use respirators must be inspected at least monthly. For those laboratories that maintain self-contained breathing apparatus (SCBAs) or escape units for emergency use, guidance on inspection is contained in Attachment E3-2 of this manual.

## 6.2 Cleaning and Disinfection

Respirator manufacturers specify correct cleaning procedures for the particular respirator. Typically, they recommend that the user break down the respirator into its component parts and wash each part thoroughly with a mild detergent. The user should then rinse the components thoroughly and allow them to air dry.

Where a specific procedure is not outlined by the respirator manufacturer, the following procedures should be used for cleaning and disinfecting:

- Remove the cartridge to keep cartridge dry or for disposal
- Remove straps, head harness, cradle, and adaptor and keep dry; wipe only with alcohol disinfecting pad
- Remove all of the following and wash each separately
  - Inhalation port valves
  - Exhalation port valves
  - Cartridge connector/adaptor
  - Exhalation port cover
- Wash in sanitizing solution
- Agitate the respirator in the sanitizing solution and allow it to soak for two (2) minutes.
- Rinse in warm water
- Dry at room temperature in a non-contaminated atmosphere
- Reassemble

## 6.3 Replacement of Parts

Upon reassembly, the user should carefully inspect the respirator and replace any worn or missing parts. Users should pay particular attention to the inhalation and exhalation valves, the condition of the facepiece, the elasticity of the straps, and the presence of any rusted metal parts. They should also check the date on the air-purifying element and, if necessary, they should replace the old elements with fresh ones.

The replacement of old or depleted air-purifying elements is part of the normal care and maintenance of a respirator. In



cases where the cartridge/canister may be safely reused, depletion of the air purifying capacity is indicated by:

- Penetration of the substance through the cartridge (breakthrough)
- Increase in the resistance to breathing (overloading)
- A change in the end-of-service-life indicator (ESLI). An end-of-service-life indicator is a visible signal that the air-purifying capability of a cartridge or canister is, or is not, viable. It is particularly important for substances with poor warning properties, like carbon monoxide, for which a cartridge/canister breakthrough is not detectable either by smell or taste.

Upon evidence of any of these signs, the user should replace the cartridge/canister without delay. However, the user should anticipate the need to change the cartridge/canister and regularly replace old or used air-purifying elements. The frequency of replacement can vary from weekly, for high-use respirators, to annually for respirators used only for non-routine tasks or emergencies. In any case, one should place the service date on the side of the cartridge/canister.

Special disposal procedures may be necessary when the air-purifying elements, by virtue of the contaminants in question, become a possible source of exposure after use. Such may be the case with cartridges used to clean up a hazardous material spill. In these instances, it may be necessary to

treat the contaminated cartridges/canisters as hazardous waste, and dispose of them accordingly.

Any repairs must be performed only by persons trained in proper respirator maintenance and assembly.

#### 6.4 Storage

Respirators must be stored to protect against damaging elements:

##### Damaging Elements

- Damaging chemicals
- Dust
- Direct sunlight
- Mechanical damage
- Extreme heat or cold
- Excessive moisture
- Any other factor that could impair its function

After the respirator is cleaned and dried, it should be stored in an air-tight plastic bag. The bagged respirator should be stored loosely so that it does not become deformed. Do not hang unprotected respirators by their straps from hooks, and ensure that the respirator is protected from crushing or other mechanical damage. Full-facepiece respirators should be stored with their head harness and straps in a relaxed position.

#### 7.0 Recordkeeping and Documentation

Rigorous recordkeeping, which is necessary to document compliance with the written program, is also an invaluable

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management tool. The program administrator should maintain records of the following:

- Training
- Medical evaluations
- Fit-testing
- Maintenance
- Written respiratory protection program and pertinent amendments
- Standard operating procedures (SOPs) for specific routine and foreseeable use situations, and pertinent amendments

## Attachment E3-1: Fit-Testing Procedures

### Part I. OSHA-Accepted Fit-Test Protocols

#### A. Fit-Testing Procedures--General Requirements

The employer shall conduct fit-testing using the following procedures. The requirements in this attachment apply to all OSHA-accepted fit-test methods, both qualitative fit-testing (QLFT) and quantitative fit-testing (QNFT).

1. The test subject shall be allowed to pick the most acceptable respirator from a sufficient number of respirator models and sizes so that the respirator is acceptable to, and correctly fits, the user.
2. Prior to the selection process, the test subject shall be shown how to put on a respirator, how it should be positioned on the face, how to set strap tension, and how to determine an acceptable fit. A mirror shall be available to assist the subject in evaluating the fit and positioning of the respirator. This instruction may not constitute the subject's formal training on respirator use, because it is only a review.
3. The test subject shall be informed that he/she is being asked to select the respirator that provides the most acceptable fit. Each respirator represents a different size and shape, and, if fitted and used properly, will provide adequate protection.
4. The test subject shall be instructed to hold each chosen facepiece up to the face and eliminate those that obviously do not give an acceptable fit.
5. The more acceptable facepieces are noted in case the one selected proves unacceptable; the most comfortable mask is donned and worn at least five minutes to assess comfort. Assistance in assessing comfort can be given by discussing the points in the following item A.6. If the test subject is not familiar with using a particular respirator, the test subject shall be directed to don the mask several times and to adjust the straps each time to become adept at setting proper tension on the straps.
6. Assessment of comfort shall include a review of the following points with the test subject and shall allow the test subject adequate time to determine the comfort of the respirator:
  - (a) Position of the mask on the nose
  - (b) Room for eye protection
  - (c) Room to talk
  - (d) Position of mask on face and cheeks
7. The following criteria shall be used to help determine the adequacy of the respirator fit:
  - (a) Proper chin placement
  - (b) Adequate strap tension, not overly tightened
  - (c) Proper fit across nose bridge
  - (d) Proper respirator size (to span distance from nose to chin)

## Attachment E3-1: Fit-Testing Procedures (continued)

- (e) Tendency of respirator to slip
  - (f) Self-observation in mirror to evaluate fit and respirator position
8. The test subject shall conduct a user seal check; either the negative- and positive-pressure seal checks described in Attachment B-1 of this section or those recommended by the respirator manufacturer if they provide protection equivalent to the procedures in Attachment B-1. Before conducting the negative- and positive-pressure checks, the subject shall be told to seat the mask on the face by slowly moving the head from side to side and up and down while taking in a few slow deep breaths. Another facepiece shall be selected and retested if the test subject fails the user seal check tests.
  9. The test shall not be conducted if there is any hair growth (such as stubble beard growth, beard, mustache, or sideburns) between the skin and the facepiece sealing surface, which crosses the respirator sealing surface. Any type of apparel that interferes with a satisfactory fit shall be altered or removed.
  10. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician or other licensed health care professional, as appropriate, to determine whether the test subject can wear a respirator while performing her or his duties.
  11. If the employee finds the fit of the respirator unacceptable, the test subject shall be given the opportunity to select a different respirator and to be retested.
  12. Exercise regimen: Prior to the commencement of the fit-test, the test subject shall be given a description of the fit-test and the test subject's responsibilities during the test procedure. The description of the process shall include a description of the test exercises that the subject will be performing. The respirator to be tested shall be worn for at least 5 minutes before the start of the fit-test.
  13. The fit-test shall be performed while the test subject is wearing any applicable safety equipment that may be worn during actual respirator use which could interfere with respirator fit.
  14. Test Exercises: The following test exercises are to be performed for all fit-testing methods prescribed in this attachment, except for the controlled negative pressure (CNP) method. A separate fit-testing exercise regimen is contained in the CNP protocol. The test subject shall perform exercises, in the test environment, in the following manner:
    - (a) Normal breathing: In a normal standing position, without talking, the subject shall breathe normally.
    - (b) Deep breathing: In a normal standing position, the subject shall breathe slowly and deeply, taking caution so as not to hyperventilate.

## Attachment E3-1: Fit-Testing Procedures (continued)

- (c) Turning head side to side: Standing in place, the subject shall slowly turn his/her head from side to side between the extreme positions on each side. The head shall be held at each extreme momentarily so the subject can inhale at each side.
- (d) Moving head up and down: Standing in place, the subject shall slowly move his/her head up and down. The subject shall be instructed to inhale in the up position (i.e., when looking toward the ceiling).
- (e) Talking: The subject shall talk out loud slowly and loud enough so as to be heard clearly by the test conductor. The subject can read from a prepared text such as the Rainbow Passage below, count backward from 100, or recite a memorized poem or song.

### *Rainbow Passage*

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond reach, his friends say he is looking for the pot of gold at the end of the rainbow.

- (f) Grimace: The test subject shall grimace by smiling or frowning. (This applies only to QNFT testing; it is not performed for QLFT)
- (g) Bending over: The test subject shall bend at the waist as if he/she were to touch his/her toes. Jogging in place shall be substituted for this exercise in those test environments such as shroud type QNFT or QLFT units that do not permit bending over at the waist.
- (h) Normal breathing: Same as exercise (1).
  - (1) Each test exercise shall be performed for one minute, except for the grimace exercise, which shall be performed for 15 seconds. The test subject shall be questioned by the test conductor regarding the comfort of the respirator upon completion of the protocol. If it has become unacceptable, another model of respirator shall be tried. The respirator shall not be adjusted once the fit-test exercises begin. Any adjustment voids the test, and the fit-test must be repeated.

## Attachment E3-1: Fit-Testing Procedures (continued)

### B. Qualitative Fit-Test (QLFT) Protocols

#### 1. General

- (a) The employer shall ensure that persons administering QLFT are able to prepare test solutions, calibrate equipment and perform tests properly, recognize invalid tests, and ensure that test equipment is in proper working order.
- (b) The employer shall ensure that QLFT equipment is kept clean and well maintained so as to operate within the parameters for which it was designed.

#### 2. Isoamyl Acetate Protocol

*Note: This protocol is not appropriate to use for the fit-testing of particulate respirators. If used to fit-test particulate respirators, the respirator must be equipped with an organic vapor filter.*

##### (a) Odor Threshold Screening

Odor threshold screening, performed without wearing a respirator, is intended to determine if the individual tested can detect the odor of isoamyl acetate at low levels.

- (1) Three 1-liter glass jars with metal lids are required.
- (2) Odor-free water (e.g., distilled or spring water) at approximately 25°C (77°F) shall be used for the solutions.
- (3) The isoamyl acetate (IAA) (also known as isopentyl acetate) stock solution is prepared by adding 1 ml of pure IAA to 800 ml of odor-free water in a 1-liter jar, closing the lid and shaking for 30 seconds. A new solution shall be prepared at least weekly.
- (4) The screening test shall be conducted in a room separate from the room used for actual fit-testing. The two rooms shall be well-ventilated to prevent the odor of IAA from becoming evident in the general room air where testing takes place.
- (5) The odor test solution is prepared in a second jar by placing 0.4 ml of the stock solution into 500 ml of odor-free water using a clean dropper or pipette. The solution shall be shaken for 30 seconds and allowed to stand for two to three minutes so that the IAA concentration above the liquid may reach equilibrium. This solution shall be used for only one day.
- (6) A test blank shall be prepared in a third jar by adding 500 cc of odor-free water.

## Attachment E3-1: Fit-Testing Procedures (continued)

- (7) The odor test and test blank jar lids shall be labeled (e.g., 1 and 2) for jar identification. Labels shall be placed on the lids so that they can be peeled off periodically and switched to maintain the integrity of the test.
  - (8) The following instruction shall be typed on a card and placed on the table in front of the two test jars (i.e., 1 and 2): “The purpose of this test is to determine if you can smell banana oil at a low concentration. The two bottles in front of you contain water. One of these bottles also contains a small amount of banana oil. Be sure the covers are on tight, then shake each bottle for two seconds. Unscrew the lid of each bottle, one at a time, and sniff at the mouth of the bottle. Indicate to the test conductor which bottle contains banana oil.”
  - (9) The mixtures used in the IAA odor detection test shall be prepared in an area separate from where the test is performed, in order to prevent olfactory fatigue in the subject.
  - (10) If the test subject is unable to correctly identify the jar containing the odor test solution, the IAA qualitative fit-test shall not be performed.
  - (11) If the test subject correctly identifies the jar containing the odor test solution, the test subject may proceed to respirator selection and fit-testing.
- (b) Isoamyl Acetate Fit-Test
- (1) The fit-test chamber shall be a clear 55-gallon drum liner suspended inverted over a 2-foot diameter frame so that the top of the chamber is about 6 inches above the test subject’s head. If no drum liner is available, a similar chamber shall be constructed using plastic sheeting. The inside top center of the chamber shall have a small hook attached.
  - (2) Each respirator used for the fitting and fit-testing shall be equipped with organic vapor cartridges or offer protection against organic vapors.
  - (3) After selecting, donning, and properly adjusting a respirator, the test subject shall wear it to the fit-testing room. This room shall be separate from the room used for odor threshold screening and respirator selection, and shall be well-ventilated, as by an exhaust fan or lab hood, to prevent general room contamination.
  - (4) A copy of the test exercises and any prepared text from which the subject is to read shall be taped to the inside of the test chamber.
  - (5) Upon entering the test chamber, the test subject shall be given a 6-inch-by-5-inch piece of paper towel, or other porous, absorbent, single-ply material, folded in half and wetted with 0.75 ml of pure IAA. The test subject shall hang



## Attachment E3-1: Fit-Testing Procedures (continued)

the wet towel on the hook at the top of the chamber. An IAA test swab or ampule may be substituted for the IAA wetted paper towel, provided it has been demonstrated that the alternative IAA source will generate an IAA test atmosphere with a concentration equivalent to that generated by the paper towel method.

- (6) Allow two minutes for the IAA test concentration to stabilize before starting the fit-test exercises. This would be an appropriate time to talk with the test subject; to explain the fit-test, the importance of his/her cooperation, and the purpose for the test exercises; or to demonstrate some of the exercises.
- (7) If at any time during the test, the subject detects the banana-like odor of IAA, the test is failed. The subject shall quickly exit from the test chamber and leave the test area to avoid olfactory fatigue.
- (8) If the test is failed, the subject shall return to the selection room and remove the respirator. The test subject shall repeat the odor sensitivity test, select and put on another respirator, return to the test area and again begin the fit-test procedure described in (b)(1) through (7) above. The process continues until a respirator that fits well has been found. Should the odor sensitivity test be failed, the subject shall wait at least 5 minutes before retesting. Odor sensitivity will usually have returned by this time.
- (9) If the subject passes the test, the efficiency of the test procedure shall be demonstrated by having the subject break the respirator face seal and take a breath before exiting the chamber.
- (10) When the test subject leaves the chamber, the subject shall remove the saturated towel and return it to the person conducting the test, so that there is no significant IAA concentration buildup in the chamber during subsequent tests. The used towels shall be kept in a self-sealing plastic bag to keep the test area from being contaminated.

### 3. Saccharin Solution Aerosol Protocol

The entire screening and testing procedure shall be explained to the test subject prior to the conduct of the screening test.

- (a) Taste threshold screening: The saccharin taste threshold screening, performed without wearing a respirator, is intended to determine whether the individual being tested can detect the taste of saccharin.
  - (1) During threshold screening as well as during fit-testing, subjects shall wear an enclosure about the head and shoulders that is approximately 12 inches in diameter by 14 inches tall with at least the front portion clear and that allows

## Attachment E3-1: Fit-Testing Procedures (continued)

free movements of the head when a respirator is worn. An enclosure substantially similar to the 3M hood assembly, parts # FT 14 and # FT 15 combined, is adequate.

- (2) The test enclosure shall have a  $\frac{3}{4}$ -inch (1.9 cm) hole in front of the test subject's nose and mouth area to accommodate the nebulizer nozzle.
- (3) The test subject shall don the test enclosure. Throughout the threshold screening test, the test subject shall breathe through his/her slightly open mouth with tongue extended. The subject is instructed to report when he/she detects a sweet taste.
- (4) Using a DeVilbiss Model 40 Inhalation Medication Nebulizer or equivalent, the test conductor shall spray the threshold check solution into the enclosure. The nozzle is directed away from the nose and mouth of the person. This nebulizer shall be clearly marked to distinguish it from the fit-test solution nebulizer.
- (5) The threshold check solution is prepared by dissolving 0.83 gram of sodium saccharin USP in 100 ml of warm water. It can be prepared by putting 1 ml of the fit-test solution (see (b)(5) below) in 100 ml of distilled water.
- (6) To produce the aerosol, the nebulizer bulb is firmly squeezed so that it collapses completely, then released and allowed to fully expand.
- (7) Ten squeezes are repeated rapidly and then the test subject is asked whether the saccharin can be tasted. If the test subject reports tasting the sweet taste during the ten squeezes, the screening test is completed. The taste threshold is noted as 10 regardless of the number of squeezes actually completed.
- (8) If the first response is negative, 10 more squeezes are repeated rapidly and the test subject is again asked whether the saccharin is tasted. If the test subject reports tasting the sweet taste during the second 10 squeezes, the screening test is completed. The taste threshold is noted as 20 regardless of the number of squeezes actually completed.
- (9) If the second response is negative, 10 more squeezes are repeated rapidly and the test subject is again asked whether the saccharin is tasted. If the test subject reports tasting the sweet taste during the third set of 10 squeezes, the screening test is completed. The taste threshold is noted as 30 regardless of the number of squeezes actually completed.
- (10) The test conductor will take note of the number of squeezes required to solicit a taste response.

## Attachment E3-1: Fit-Testing Procedures (continued)

- (11) If the saccharin is not tasted after 30 squeezes (step 10), the test subject is unable to taste saccharin and may not perform the saccharin fit-test.

*Note to paragraph 3.(a): If the test subject eats or drinks something sweet before the screening test, he/she may be unable to taste the weak saccharin solution.*

- (12) If a taste response is elicited, the test subject shall be asked to take note of the taste for reference in the fit-test.
  - (13) Correct use of the nebulizer means that approximately 1 ml of liquid is used at a time in the nebulizer body.
  - (14) The nebulizer shall be thoroughly rinsed in water, shaken dry, and refilled at least each morning and afternoon or at least every four hours.
- (b) Saccharin solution aerosol fit-test procedure:
- (1) The test subject may not eat, drink (except plain water), smoke, or chew gum for 15 minutes before the test.
  - (2) The fit-test uses the same enclosure described in 3.(a) above.
  - (3) The test subject shall don the enclosure while wearing the respirator selected in part I.A. of this attachment. The respirator shall be properly adjusted and equipped with a particulate filter(s).
  - (4) A second DeVilbiss Model 40 Inhalation Medication Nebulizer or equivalent is used to spray the fit-test solution into the enclosure. This nebulizer shall be clearly marked to distinguish it from the screening test solution nebulizer.
  - (5) The fit-test solution is prepared by adding 83 grams of sodium saccharin to 100 ml of warm water.
  - (6) As before, the test subject shall breathe through the slightly open mouth with tongue extended, and report if he/she tastes the sweet taste of saccharin.
  - (7) The nebulizer is inserted into the hole in the front of the enclosure and an initial concentration of saccharin fit-test solution is sprayed into the enclosure using the same number of squeezes (either 10, 20 or 30 squeezes) based on the number of squeezes required to elicit a taste response as noted during the screening test. A minimum of 10 squeezes is required.
  - (8) After generating the aerosol, the test subject shall be instructed to perform the exercises in part I.A.14. of this attachment.

## Attachment E3-1: Fit-Testing Procedures (continued)

- (9) Every 30 seconds the aerosol concentration shall be replenished using one half the original number of squeezes used initially (e.g., 5, 10, or 15).
- (10) The test subject shall indicate to the test conductor if at any time during the fit-test the taste of saccharin is detected. If the test subject does not report tasting the saccharin, the test is passed.
- (11) If the taste of saccharin is detected, the fit is deemed unsatisfactory and the test is failed. A different respirator shall be tried and the entire test procedure is repeated (taste threshold screening and fit-testing).
- (12) Since the nebulizer has a tendency to clog during use, the test operator must make periodic checks of the nebulizer to ensure that it is not clogged. If clogging is found at the end of the test session, the test is invalid.

### 4. Bitrex™ (Denatonium Benzoate) Solution Aerosol Protocol

The Bitrex™ (Denatonium benzoate) solution aerosol QLFT protocol uses the published saccharin test protocol because that protocol is widely accepted. Bitrex™ is routinely used as a taste aversion agent in household liquids that children should not be drinking, and it is endorsed by the American Medical Association, the National Safety Council, and the American Association of Poison Control Centers. The entire screening and testing procedure shall be explained to the test subject prior to the conduct of the screening test.

#### (a) Taste Threshold Screening:

The Bitrex™ taste threshold screening, performed without wearing a respirator, is intended to determine whether the individual being tested can detect the taste of Bitrex™.

- (1) During threshold screening as well as during fit-testing, subjects shall wear an enclosure about the head and shoulders that is approximately 12 inches (30.5 cm) in diameter by 14 inches (35.6 cm) tall. The front portion of the enclosure shall be clear from the respirator and allow free movement of the head when a respirator is worn. An enclosure substantially similar to the 3M hood assembly, parts #14 and #15 combined, is adequate.
- (2) The test enclosure shall have a 3/4-inch (1.9 cm) hole in front of the test subject's nose and mouth area to accommodate the nebulizer nozzle.
- (3) The test subject shall don the test enclosure. Throughout the threshold screening test, the test subject shall breathe through his or her slightly open mouth with tongue extended. The subject is instructed to report when he/she detects a bitter taste.

### Attachment E3-1: Fit-Testing Procedures (continued)

- (4) Using a DeVilbiss Model 40 Inhalation Medication Nebulizer or equivalent, the test conductor shall spray the Threshold Check Solution into the enclosure. This nebulizer shall be clearly marked to distinguish it from the fit-test solution nebulizer.
- (5) The Threshold Check Solution is prepared by adding 13.5 milligrams of Bitrex™ to 100 ml of 5 percent salt (NaCl) solution in distilled water.
- (6) To produce the aerosol, the nebulizer bulb is firmly squeezed so that the bulb collapses completely, and is then released and allowed to fully expand.
- (7) An initial 10 squeezes are repeated rapidly and then the test subject is asked whether the Bitrex™ can be tasted. If the test subject reports tasting the bitter taste during the 10 squeezes, the screening test is completed. The taste threshold is noted as 10 regardless of the number of squeezes actually completed.
- (8) If the first response is negative, 10 more squeezes are repeated rapidly and the test subject is again asked whether the Bitrex™ is tasted. If the test subject reports tasting the bitter taste during the second 10 squeezes, the screening test is completed. The taste threshold is noted as 20 regardless of the number of squeezes actually completed.
- (9) If the second response is negative, 10 more squeezes are repeated rapidly and the test subject is again asked whether the Bitrex™ is tasted. If the test subject reports tasting the bitter taste during the third set of 10 squeezes, the screening test is completed. The taste threshold is noted as 30 regardless of the number of squeezes actually completed.
- (10) The test conductor will take note of the number of squeezes required to solicit a taste response.
- (11) If the Bitrex™ is not tasted after 30 squeezes (step 10), the test subject is unable to taste Bitrex™ and may not perform the Bitrex™ fit-test.
- (12) If a taste response is elicited, the test subject shall be asked to take note of the taste for reference in the fit-test.
- (13) Correct use of the nebulizer means that approximately 1 ml of liquid is used at a time in the nebulizer body.
- (14) The nebulizer shall be thoroughly rinsed in water, shaken to dry, and refilled at least each morning and afternoon or at least every four hours.

## Attachment E3-1: Fit-Testing Procedures (continued)

### (b) Bitrex™ Solution Aerosol Fit-Test Procedure:

- (1) The test subject may not eat, drink (except plain water), smoke, or chew gum for 15 minutes before the test.
- (2) The fit-test uses the same enclosure as described in 4.(a) above.
- (3) The test subject shall don the enclosure while wearing the respirator selected according to part I.A. of this attachment. The respirator shall be properly adjusted and equipped with any type particulate filter(s).
- (4) A second DeVilbiss Model 40 Inhalation Medication Nebulizer or equivalent is used to spray the fit-test solution into the enclosure. This nebulizer shall be clearly marked to distinguish it from the screening test solution nebulizer.
- (5) The fit-test solution is prepared by adding 337.5 mg of Bitrex™ to 200 ml of a 5 percent salt (NaCl) solution in warm water.
- (6) As before, the test subject shall breathe through his or her slightly open mouth with tongue extended, and be instructed to report if he/she tastes the bitter taste of Bitrex™.
- (7) The nebulizer is inserted into the hole in the front of the enclosure and an initial concentration of the fit-test solution is sprayed into the enclosure using the same number of squeezes (either 10, 20, or 30 squeezes) based on the number of squeezes required to elicit a taste response as noted during the screening test.
- (8) After generating the aerosol, the test subject shall be instructed to perform the exercises in part I.A.14. of this attachment.
- (9) Every 30 seconds the aerosol concentration shall be replenished using one half the number of squeezes used initially (e.g., 5, 10, or 15).
- (10) The test subject shall indicate to the test conductor if at any time during the fit-test the taste of Bitrex™ is detected. If the test subject does not report tasting the Bitrex™, the test is passed.
- (11) If the taste of Bitrex™ is detected, the fit is deemed unsatisfactory and the test is failed. A different respirator shall be tried and the entire test procedure is repeated (taste threshold screening and fit-testing).

## Attachment E3-1: Fit-Testing Procedures (continued)

### 5. Irritant Smoke (Stannic Chloride) Protocol

This qualitative fit-test uses a person's response to the irritating chemicals released in the "smoke" produced by a stannic chloride ventilation smoke tube to detect leakage into the respirator.

#### (a) General Requirements and Precautions:

- (1) The respirator to be tested shall be equipped with high-efficiency particulate air (HEPA) or P100 series filter(s).
- (2) Only stannic chloride smoke tubes shall be used for this protocol.
- (3) No form of test enclosure or hood for the test subject shall be used.
- (4) Since the smoke can be irritating to the eyes, lungs, and nasal passages, the test conductor shall take precautions to minimize the test subject's exposure to irritant smoke. Sensitivity varies, and certain individuals may respond to a greater degree to irritant smoke. Care shall be taken when performing the sensitivity screening checks that determine whether the test subject can detect irritant smoke to use only the minimum amount of smoke necessary to elicit a response from the test subject.
- (5) The fit-test shall be performed in an area with adequate ventilation to prevent exposure of the person conducting the fit-test or the build-up of irritant smoke in the general atmosphere.

#### (b) Sensitivity Screening Check:

The person to be tested must demonstrate his or her ability to detect a weak concentration of the irritant smoke.

- (1) The test operator shall break both ends of a ventilation smoke tube containing stannic chloride, and attach one end of the smoke tube to a low-flow air pump set to deliver 200 mL per minute, or an aspirator squeeze bulb. The test operator shall cover the other end of the smoke tube with a short piece of tubing to prevent potential injury from the jagged end of the smoke tube.
- (2) The test operator shall advise the test subject that the smoke can be irritating to the eyes, lungs, and nasal passages and instruct the subject to keep his/her eyes closed while the test is performed.



## Attachment E3-1: Fit-Testing Procedures (continued)

- (3) Before the respirator is donned, the test subject shall be allowed to smell a weak concentration of the irritant smoke to become familiar with its irritating properties and to determine if he/she can detect the irritating properties of the smoke. The test operator shall carefully direct a small amount of the irritant smoke in the test subject's direction to determine if he/she can detect it.

### (c) Irritant Smoke Fit-Test Procedure:

- (1) The person being fit-tested shall don the respirator without assistance, and perform the required user seal check(s).
- (2) The test subject shall be instructed to keep his/her eyes closed.
- (3) The test operator shall direct the stream of irritant smoke from the smoke tube toward the face seal area of the test subject, using the low-flow pump or the squeeze bulb. The test operator shall begin at least 12 inches from the facepiece and move the smoke stream around the whole perimeter of the mask. The operator shall gradually make two more passes around the perimeter of the mask, moving to within six inches of the respirator.
- (4) If the person being tested has not had an involuntary response and/or detected the irritant smoke, proceed with the test exercises.
- (5) The exercises identified in part I.A.14. of this attachment shall be performed by the test subject while the respirator seal is being continually challenged by the smoke, directed around the perimeter of the respirator at a distance of six inches.
- (6) If the person being fit-tested reports detecting the irritant smoke at any time, the test is failed. The person being retested must repeat the entire sensitivity check and fit-test procedure.
- (7) Each test subject passing the irritant smoke test without evidence of a response (e.g., involuntary cough, irritation) shall be given a second sensitivity screening check, with the smoke from the same smoke tube used during the fit-test, once the respirator has been removed, to determine whether he/she still reacts to the smoke. Failure to evoke a response shall void the fit-test.
- (8) If a response is produced during this second sensitivity check, then the fit-test is passed.

## Attachment E3-1: Fit-Testing Procedures (continued)

### C. Quantitative Fit-Test (QNFT) Protocols

The following quantitative fit-testing procedures have been demonstrated to be acceptable:

- Quantitative fit-testing using a non-hazardous test aerosol (e.g., corn oil, polyethylene glycol 400 [PEG 400], di-2-ethyl hexyl sebacate [DEHS], or sodium chloride) generated in a test chamber, and employing instrumentation to quantify the fit of the respirator
- Quantitative fit-testing using ambient aerosol as the test agent and appropriate instrumentation (e.g., condensation nuclei counter) to quantify the respirator fit
- Quantitative fit-testing using controlled negative pressure and appropriate instrumentation to measure the volumetric leak rate of a facepiece to quantify the respirator fit

#### 1. General

- (a) The employer shall ensure that persons administering QNFT are able to calibrate equipment and perform tests properly, recognize invalid tests, calculate fit-factors properly and ensure that test equipment is in proper working order.
- (b) The employer shall ensure that QNFT equipment is kept clean, and is maintained and calibrated according to the manufacturer's instructions so as to operate at the parameters for which it was designed.

#### 2. Generated Aerosol Protocol

- (a) Apparatus:
  - (1) *Instrumentation:* Aerosol generation, dilution, and measurement systems using particulates (e.g., corn oil, polyethylene glycol 400 [PEG 400], di-2-ethyl hexyl sebacate [DEHS] or sodium chloride) as test aerosols shall be used for quantitative fit-testing.
  - (2) *Test chamber:* The test chamber shall be large enough to permit all test subjects to perform freely all required exercises without disturbing the test agent concentration or the measurement apparatus. The test chamber shall be equipped and constructed so that the test agent is effectively isolated from the ambient air, yet uniform in concentration throughout the chamber.
  - (3) When testing air-purifying respirators, the normal filter or cartridge element shall be replaced with a HEPA or P100 series filter supplied by the same manufacturer.
  - (4) The sampling instrument shall be selected so that a computer record or strip chart record may be made of the test showing the rise and fall of the test agent concentration with each inspiration and expiration at fit-factors of at least

## Attachment E3-1: Fit-Testing Procedures (continued)

2,000. Integrators or computers that integrate the amount of test agent penetration leakage into the respirator for each exercise may be used, provided a record of the readings is made.

- (5) The combination of substitute air-purifying elements with the test agent and test agent concentration shall be such that the test subject is not exposed in excess of an established exposure limit for the test agent at any time during the testing process, based on the length of the exposure and the exposure limit duration.
- (6) The sampling port on the test specimen respirator shall be placed and constructed so that no leakage occurs around the port (e.g., where the respirator is probed), a free air flow is allowed into the sampling line at all times, and there is no interference with the fit or performance of the respirator. The in-mask sampling device (probe) shall be designed and used so that the air sample is drawn from the breathing zone of the test subject, midway between the nose and mouth and with the probe extending into the facepiece cavity at least  $\frac{1}{4}$  inch.
- (7) The test setup shall permit the person administering the test to observe the test subject inside the chamber during the test.
- (8) The equipment generating the test atmosphere shall maintain the concentration of test agent constant to within a 10 percent variation for the duration of the test.
- (9) The time lag (i.e., interval between an event and the recording of the event on the strip chart or computer or integrator) shall be kept to a minimum. There shall be a clear association between the occurrence of an event and its being recorded.
- (10) The sampling line tubing for the test chamber atmosphere and for the respirator sampling port shall be of equal diameter and of the same material. The length of the two lines shall be equal.
- (11) The exhaust flow from the test chamber shall pass through an appropriate filter (i.e., high-efficiency particulate or P100 series filter) before release.
- (12) When sodium chloride aerosol is used, the relative humidity inside the test chamber shall not exceed 50 percent.
- (13) The limitations of instrument detection shall be taken into account when determining the fit-factor.

## Attachment E3-1: Fit-Testing Procedures (continued)

- (14) Test respirators shall be maintained in proper working order and be inspected regularly for deficiencies such as cracks or missing valves and gaskets.

(b) Procedural Requirements:

- (1) When performing the initial user seal check using a positive- or negative-pressure check, the sampling line shall be crimped closed in order to avoid air pressure leakage during either of these pressure checks.
- (2) The use of an abbreviated screening QLFT test is optional. Such a test may be used to quickly identify poor-fitting respirators that passed the positive- and/or negative-pressure test and reduce the amount of QNFT time. The use of the contamination nuclei counter (CNC) QNFT instrument in the count mode is another optional method to obtain a quick estimate of fit and eliminate poor-fitting respirators before going on to perform a full QNFT.
- (3) A reasonably stable test agent concentration shall be measured in the test chamber prior to testing. For canopy or shower curtain types of test units, the determination of the test agent's stability may be established after the test subject has entered the test environment.
- (4) Immediately after the subject enters the test chamber, the test agent concentration inside the respirator shall be measured to ensure that the peak penetration does not exceed 5 percent for a half mask or 1 percent for a full facepiece respirator.
- (5) A stable test agent concentration shall be obtained prior to the actual start of testing.
- (6) Respirator restraining straps shall not be over-tightened for testing. The straps shall be adjusted by the wearer without assistance from other persons to give a reasonably comfortable fit typical of normal use. The respirator shall not be adjusted once the fit-test exercises begin.
- (7) The test shall be terminated whenever any single peak penetration exceeds 5 percent for half masks and 1 percent for full facepiece respirators. The test subject shall be refitted and retested.
- (8) Fit-factors shall be calculated.
  - (I) The fit-factor shall be determined for the quantitative fit-test by taking the ratio of the average chamber concentration to the concentration measured inside the respirator for each test exercise except the grimace exercise.

## Attachment E3-1: Fit-Testing Procedures (continued)

- (ii) The average test chamber concentration shall be calculated as the arithmetic average of the concentration measured before and after each test (i.e., 7 exercises) or the arithmetic average of the concentration measured before and after each exercise or the true average measured continuously during the respirator sample.
- (iii) The concentration of the challenge agent inside the respirator shall be determined by one of the following methods:
  - (a) Average peak penetration: the method of determining test agent penetration into the respirator using a strip chart recorder, integrator, or computer. The agent penetration is determined by an average of the peak heights on the graph or by computer integration, for each exercise except the grimace exercise. Integrators or computers that calculate the actual test agent penetration into the respirator for each exercise will also be considered to meet the requirements of the average peak penetration method.
  - (b) Maximum peak penetration: the method of determining test agent penetration in the respirator as determined by strip chart recordings of the test. The highest peak penetration for a given exercise is taken to be representative of average penetration into the respirator for that exercise.
  - (c) Integration by calculation of the area under the individual peak for each exercise except the grimace exercise. This includes computerized integration.
  - (d) The calculation of the overall fit-factor using individual exercise fit-factors involves first converting the exercise fit-factors to penetration values, determining the average, and then converting that result back to a fit-factor.
- (9) The test subject shall not be permitted to wear a half mask or quarter facepiece respirator unless a minimum fit-factor of 100 is obtained, or a full facepiece respirator unless a minimum fit-factor of 500 is obtained.
- (10) Filters used for quantitative fit-testing shall be replaced whenever increased breathing resistance is encountered, or when the test agent has altered the integrity of the filter media.

**3. Ambient Aerosol Condensation Nuclei Counter (CNC) Protocol.**

The ambient aerosol CNC quantitative fit-testing (Portacount™) protocol quantitatively fit-tests respirators with the use of a probe. The probed respirator is only used for quantitative fit-tests. A probed respirator has a special sampling device, installed on the respirator, that allows the probe to sample the air from inside the mask. A probed respirator is required for each make, style, model, and size that the employer uses and can be obtained from the respirator manufacturer or distributor. The CNC instrument manufacturer, TSI Inc., also provides probe attachments (e.g., TSI sampling adapters) that permit fit-testing in an employee's own respirator. A minimum fit-factor pass level of at least 100 is necessary for a half-mask respirator and a minimum fit-factor pass level of at least 500 is required for a full-facepiece negative-pressure respirator. The entire screening and testing procedure shall be explained to the test subject prior to performing the screening test.

(a) Portacount™ Fit-Test Requirements:

- (1) Check the respirator to make sure it is fitted with a high-efficiency filter and that the sampling probe and line are properly attached to the facepiece.
- (2) Instruct the test subject to don the respirator for five minutes before the fit-test starts. This purges the ambient particles trapped inside the respirator and permits the wearer to make certain the respirator is comfortable. This individual shall already have been trained on how to wear the respirator properly.
- (3) Check the following conditions for the adequacy of the respirator fit: chin properly placed; adequate strap tension, not overly tightened; proper fit across nose bridge; respirator of proper size to span distance from nose to chin; tendency of the respirator to slip; self-observation in a mirror to evaluate fit and respirator position.
- (4) Have the person wearing the respirator do a user seal check. If leakage is detected, determine the cause. If leakage is from a poorly-fitting facepiece, try another size of the same model respirator, or another model of respirator.
- (5) Follow the manufacturer's instructions for operating the Portacount™ and proceed with the test.
- (6) The test subject shall be instructed to perform the exercises in part I.A.14. of this attachment.

## Attachment E3-1: Fit-Testing Procedures (continued)

- (7) After the test exercises, the test subject shall be questioned by the test conductor regarding the comfort of the respirator upon completion of the protocol. If it has become unacceptable, another model of respirator shall be tried.

(b) Portacount™ Test Instrument:

- (1) The Portacount™ will automatically stop and calculate the overall fit-factor for the entire set of exercises. The overall fit-factor is what counts. The pass or fail message will indicate whether or not the test was successful. If the test was a pass, the fit-test is over.
- (2) Since the pass or fail criteria of the Portacount™ are user programmable, the test operator shall ensure that the pass or fail criteria meet the requirements for minimum respirator performance in this attachment.
- (3) A record of the test needs to be kept on file, assuming the fit-test was successful. The record must contain the test subject's name; overall fit-factor; make, model, style, and size of respirator used; and date tested.

### 4. Controlled Negative Pressure (CNP) Protocol

The CNP protocol provides an alternative to aerosol fit-test methods. The CNP fit-test method technology is based on exhausting air from a temporarily sealed respirator facepiece to generate and then maintain a constant negative pressure inside the facepiece. The rate of air exhaust is controlled so that a constant negative pressure is maintained in the respirator during the fit-test. The level of pressure is selected to replicate the mean inspiratory pressure that causes leakage into the respirator under normal use conditions. With pressure held constant, air flow out of the respirator is equal to air flow into the respirator. Therefore, measurement of the exhaust stream that is required to hold the pressure in the temporarily sealed respirator yields a direct measure of leakage air flow into the respirator.

The CNP fit-test method measures leak rates through the facepiece as a method for determining the facepiece fit for negative-pressure respirators. The CNP instrument manufacturer Dynatech Nevada also provides attachments (e.g., sampling manifolds) that replace the filter cartridges to permit fit-testing in an employee's own respirator. To perform the test, the test subject closes his mouth and holds his breath, after which an air pump removes air from the respirator facepiece at a pre-selected constant pressure. The facepiece fit is expressed as the leak rate through the facepiece, expressed as milliliters per minute. The quality and validity of the CNP fit-tests are determined by the degree to which the in-mask pressure tracks the test pressure during the system measurement time of approximately five seconds. Instantaneous feedback in the form of a real-time pressure trace of the in-mask pressure is provided and used to determine test validity and quality.



## Attachment E3-1: Fit-Testing Procedures (continued)

A minimum fit-factor pass level of 100 is necessary for a half-mask respirator and a minimum fit-factor of at least 500 is required for a full face-piece respirator. The entire screening and testing procedure shall be explained to the test subject prior to the conduct of the screening test.

### (a) CNP Fit-Test Requirements:

- (1) The instrument shall have a non-adjustable test pressure of 15.0 mm water pressure.
- (2) The CNP system defaults selected for test pressure shall be set at  $-1.5$  mm of water ( $-0.58$  inches of water) and the modeled inspiratory flow rate shall be 53.8 liters per minute for performing fit-tests.

*(Note: CNP systems have built-in capability to conduct fit-testing that is specific to unique work rate, mask, and gender situations that might apply in a specific workplace. Use of system default values, which were selected to represent respirator wear with medium cartridge resistance at a low-moderate work rate, will allow inter-test comparison of the respirator fit.)*

- (3) The individual who conducts the CNP fit-testing shall be thoroughly trained to perform the test.
- (4) The respirator filter or cartridge needs to be replaced with the CNP test manifold. The inhalation valve downstream from the manifold either needs to be temporarily removed or propped open.
- (5) The test subject shall be trained to hold his breath for at least 20 seconds.
- (6) The test subject shall don the test respirator without any assistance from the individual who conducts the CNP fit-test.
- (7) The QNFT protocol shall be followed according to part I.C.1. of this attachment, with an exception for the CNP test exercises.

### (b) CNP Test Exercises:

- (1) *Normal breathing:* In a normal standing position, without talking, the subject shall breathe normally for 1 minute. After the *normal breathing* exercise, the subject needs to hold his or her head straight ahead and hold his or her breath for 10 seconds during the test measurement.

## Attachment E3-1: Fit-Testing Procedures (continued)

- (2) *Deep breathing:* In a normal standing position, the subject shall breathe slowly and deeply for 1 minute, being careful not to hyperventilate. After the *deep breathing* exercise, the subject shall hold his or her head straight ahead and hold his or her breath for 10 seconds during test measurement.
- (3) *Turning head side to side:* Standing in place, the subject shall slowly turn his or her head from side to side between the extreme positions on each side for 1 minute. The head shall be held at each extreme momentarily so the subject can inhale at each side. After the *turning head side to side* exercise, the subject needs to hold his or her head full left and hold his or her breath for 10 seconds during test measurement. Next, the subject needs to hold his or her head full right and hold his or her breath for 10 seconds during test measurement.
- (4) *Moving head up and down:* Standing in place, the subject shall slowly move his or her head up and down for 1 minute. The subject shall be instructed to inhale in the up position (i.e., when looking toward the ceiling). After the *moving head up and down* exercise, the subject shall hold his or her head full up and hold his or her breath for 10 seconds during test measurement. Next, the subject shall hold his or her head full down and hold his or her breath for 10 seconds during test measurement.
- (5) *Talking:* The subject shall talk out loud slowly and loud enough so as to be heard clearly by the test conductor. The subject can read from a prepared text such as the Rainbow Passage, count backward from 100, or recite a memorized poem or song for 1 minute. After the talking exercise, the subject shall hold his or her head straight ahead and hold his or her breath for 10 seconds during the test measurement.
- (6) *Grimace:* The test subject shall grimace by smiling or frowning for 15 seconds.
- (7) *Bending Over:* The test subject shall bend at the waist (as if he or she were to touch his or her toes) for 1 minute. Jogging in place shall be substituted for this exercise in those test environments such as shroud-type QNFT units that prohibit bending at the waist. After the *bending over* exercise, the subject shall hold his or her head straight ahead and hold his or her breath for 10 seconds during the test measurement.
- (8) *Normal Breathing:* The test subject shall remove and re-don the respirator within a one-minute period. Then, in a normal standing position, without talking, the subject shall breathe normally for 1 minute. After the *normal breathing* exercise, the subject shall hold his or her head straight ahead and hold his or her breath for 10 seconds during the test measurement. After the test

## Attachment E3-1: Fit-Testing Procedures (continued)

exercises, the test subject shall be questioned by the test conductor regarding the comfort of the respirator upon completion of the protocol. If it has become unacceptable, another model of a respirator shall be tried.

(c) CNP Test Instrument:

- (1) The test instrument shall have an effective audio warning device when the test subject fails to hold his or her breath during the test. The test shall be terminated whenever the test subject failed to hold his or her breath. The test subject may be refitted and retested.
- (2) A record of the test shall be kept on file, assuming the fit-test was successful. The record must contain the test subject's name; overall fit-factor; make, model, style, and size of respirator used; and date tested.

### Part II. New Fit-Test Protocols

- A. Any person may submit an application to OSHA for approval of a new fit-test protocol. If the application meets the following criteria, OSHA will initiate a rulemaking proceeding under section 6(b)(7) of the OSHA Act to determine whether to list the new protocol as an approved protocol.
- B. The application must include a detailed description of the proposed new fit-test protocol. This application must be supported by either:
  1. A test report prepared by an independent government research laboratory (e.g., Lawrence Livermore National Laboratory, Los Alamos National Laboratory, the National Institute for Standards and Technology) stating that the laboratory has tested the protocol and had found it to be accurate and reliable; or
  2. An article that has been published in a peer-reviewed industrial hygiene journal describing the protocol and explaining how test data support the protocol's accuracy and reliability.
- C. If OSHA determines that additional information is required before the Agency commences a rulemaking proceeding under this section, OSHA will so notify the applicant and afford the applicant the opportunity to submit the supplemental information. Initiation of a rulemaking proceeding will be deferred until OSHA has received and evaluated the supplemental information.

### 1.0 Introduction

Accident anticipation and emergency response are among the most critical aspects of an effective laboratory management plan. Laboratories must establish means for responding to accidental eye and body exposure to hazardous materials. Primary protective devices, such as safety glasses and lab coats, are essential to the prevention of accidental exposure to hazardous materials. Eyewashes and safety showers, though not substitutes for protective devices, are critical for an effective response to accidental exposure. For instance, the first few seconds following accidental eye contact with a corrosive chemical is often critical to keeping eye injury to a minimum. It's essential that laboratories locate emergency eyewashes and safety showers in immediately accessible areas, maintain them appropriately, and train employees on the procedures for proper use.

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#### *EPA Program Requirements*

Emergency eyewashes and showers must be located in the immediate area where employees may be exposed to corrosive chemicals, and are recommended in all areas where personnel may have accidental contact with hazardous materials. Each laboratory must ensure that:

- Emergency eyewashes and showers are provided in all required areas
- Emergency eyewashes and showers are immediately accessible and are maintained free of obstructions at all times

- Locations are labeled with a highly visible sign
- Employees are trained in proper use
- Emergency eyewashes and showers are properly maintained and routinely tested

The requirement for suitable facilities for quick drenching or flushing of the eyes and body is contained in the U.S. Occupational Safety and Health Administration (OSHA) standard on Medical Services and First Aid 29 CFR 1910.151. OSHA does not specifically address the operation and maintenance of eyewashes and safety showers, but does accept the guidelines established by the American National Standards Institute (ANSI) for emergency eyewash and shower equipment in ANSI Z358.1-1990 (A new issue, ANSI Z358.1-1998 has recently been released).

ANSI published the first standard for the design, installation, and use of eyewash and shower equipment in 1981. The most recent update of the standard is the 1998 version. The standard provides specifications for equipment design, performance, installation, and maintenance for several types of eyewashes and safety showers, as well as training requirements for the use of this equipment.

#### *Program Administration*

To effectively manage the provision, use, and maintenance of emergency eyewashes and showers, responsibilities should be assigned for:

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- Developing procedures to document the measures for management of eyewashes and showers
- Ensuring that eyewashes and showers are located in all required areas and installed to meet the ANSI specifications
- Training employees on the procedures for proper use
- Periodically activating showers (e.g., weekly) and eyewashes (e.g., daily) to flush the lines and verify proper operation
- Coordinating regular maintenance according to the manufacturer's specifications
- Inspecting eyewash and shower locations to ensure they are free of obstructions at all times

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## 2.0 Types

Several types of eyewash units and safety showers shown below are available for laboratory use. However, any eyewash must be capable of flushing both eyes simultaneously.

## 3.0 Location

Eyewash and shower units should be located throughout the facility as close to the hazard as possible without physically causing a hazard itself (e.g., from protruding fittings). All laboratory employees should know the locations of eyewashes and showers in their areas. Locating equipment on normal access and egress paths in the work area helps reinforce the location to potential users.

The maximum time required to reach the unit should be determined by the potential effect of the chemical. It is recommended

that a consulting physician or appropriate professional be contacted for advice on the proper distance. However, as a rule of thumb, eyewashes and showers should be located with a maximum travel distance of 100 feet so that employees can reach them in no more than 10 seconds, taking into account the fact that individuals may be partially blinded by chemicals. Highly corrosive chemicals may require the installation of eyewashes and showers within 10 to 20 feet from the hazard. Eyewashes and showers must never be located so that employees must open doors to reach them.

A blanket should always be stored close to the safety shower to protect the user from shock or freezing conditions, and to provide privacy. Safety showers should be equipped with a modesty curtain, as well.

Attachment E4-1 of this manual provides a quick reference for the installation specifications of each category of equipment.

## Types of Eyewash Units and Safety Showers



**Plumbed Shower:** A plumbed unit permanently connected to a source of potable water. These units enable the user to have water cascading over the entire body.



**Combination Unit:** A unit combining a shower with an eyewash or eye/face wash, or with a drench hose, or with both, into one common assembly.



**Plumbed Eyewash:** An eyewash unit permanently connected to a source of potable water. These devices are used to irrigate and flush the eyes.



**Hand-Held Drench Hose:** A flexible hose connected to a water supply and used to irrigate and flush eyes, face, and body areas.



**Personal Eyewash:** A supplementary eyewash that supports plumbed units, self-contained units, or both, by delivering immediate flushing liquid. These are not a substitute for self-contained eyewashes.



#### 4.0 Labeling

Each emergency shower and eyewash unit should be identified with a highly visible sign. The area around the units must be well-lighted and highly visible. Instructions and expiration dates, if applicable, should be permanently affixed to the emergency shower/eyewash unit.

#### 5.0 Water Flow and Control

Drenching and flushing facilities must be able to provide copious amounts of water for at least 15 minutes. For most of the equipment, the ANSI standard states that the velocity of the water flow should be low enough so that it is not injurious to the user. Specific flow rates and flow pressures are summarized in Attachment E4-2 of this manual.

Laboratories should provide only potable water in their safety stations and keep the temperature of the water within a comfortable range (27° to 29°C or 80° to 85°F) is the optimum temperature range; 78-92 is considered acceptable.

Except for personal eyewash equipment and hand-held drench hoses, control valves must be designed so the water flow remains on without requiring the use of the operator's hands. The valve must be designed to remain activated until intentionally shut off. The valve must go from "off" to "on" in one second or less.

Nozzles of all emergency showers and eyewashes must be protected from airborne contaminants.

#### 6.0 Use

The laboratory should have written documentation of emergency and first aid procedures, and should communicate these procedures clearly to laboratory personnel. Laboratory personnel should be familiar with the controls and operating devices, as well as with the procedures to assist an injured person. Very often an injured person cannot flush his/her own eyes, and two people are needed—one to hold open the victim's eyes and the other to restrain the victim if the victim is in pain. Laboratory management should introduce their personnel to the appropriate actions required during such an emergency.

People who have been splashed with chemicals may panic and need assistance to find the safety shower or eyewash unit. They may also be in shock and need help washing. Assistance should be provided, but helpers need to wash themselves thoroughly as well.

The following actions should be taken in the event of a chemical splash to the skin:

##### *Safety Showers*

1. Activate the safety showers to get as much of the concentrated chemical off the skin as possible.
2. Remain under the safety shower for a minimum of 15 minutes.
3. When leaving the shower area, wrap yourself in a blanket and seek immediate medical help.



Usually clothing and shoes will need to be removed to reduce or eliminate contact with the chemical. Wet clothing kept on can actually cause more severe damage than if removed because it holds residual chemicals in contact with skin.

The following actions should be taken in the event of a chemical splash to the eyes:

#### *Eyewash Units*

1. Immediately flush eyes at nearest eyewash unit.
2. Roll eyes to allow water to reach all areas.
3. Irrigate eyes and inside lids for a minimum of 15 minutes.
4. When leaving the eyewash area, seek immediate medical help.

Immediate rinsing is essential since a delay of even a few seconds may result in permanent eye damage.

#### **7.0 Inspection and Maintenance**

Safety showers and eyewash units must be inspected on a regular basis. According to the ANSI standard, plumbed eyewashes and safety showers, drench hoses, and combination units should be activated weekly to flush the lines and observe proper pressurization levels. Self-contained and personal eyewashes should be tested and maintained in accordance with manufacturer's instructions. Laboratory management should develop formal procedures for regular testing and inspection.

A frequent water replacement program must be adopted and implemented for self-contained eyewash units to protect against growth of harmful microorganisms. Any stored flushing fluid must be protected as well.

#### **8.0 User Training**

All employees who might be exposed to chemical splash should be instructed in the proper use of emergency showers and eyewash units. The training should cover:

- Location(s) of eyewashes and showers relative to the user
- Importance of immediate drenching and flushing
- Operation of and components of the type of eyewashes and showers in the user's area
- Proper procedures for drenching and flushing, including instructions on how to aid a co-worker
- Testing and maintenance requirements

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Attachment E4-1: Installation Specification for Eyewash Units and Safety Showers

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Safety Equipment	Specifications
Plumbed and self-contained showers	<ul style="list-style-type: none"> <li>• Water column: 82 to 96 inches in height from the surface on which the user stands</li> <li>• Center of spray: greater than 16 inches from any obstruction</li> <li>• Enclosures: unobstructed area greater than 34 inches in diameter</li> <li>• Travel distance: less than 100 feet from hazard</li> </ul>
Plumbed and self-contained eyewashes	<ul style="list-style-type: none"> <li>• Water nozzles: 33 to 34 inches above floor; 6 inches from any obstruction</li> <li>• Travel distance: less than 100 feet from hazard</li> </ul>
Personal eyewash equipment	<ul style="list-style-type: none"> <li>• May be kept in the immediate vicinity of employees working in a potentially hazardous area</li> <li>• Not a substitute for self-contained eyewashes</li> <li>• Follow manufacturers' recommendations for location, use, and expiration periods</li> </ul>
Eye/facewash units	<ul style="list-style-type: none"> <li>• Water nozzles: 33 to 34 inches above floor; 6 inches from any obstruction</li> <li>• Travel distance: less than 100 feet from hazard</li> </ul>
Hand-held drench hoses	<ul style="list-style-type: none"> <li>• Not a substitute for safety shower/eyewash stations</li> </ul>
Combination units	<ul style="list-style-type: none"> <li>• Must meet the requirements for each individual component</li> <li>• Travel distance: less than 100 feet from hazard</li> <li>• Water line at least 1¼ inches in diameter</li> </ul>

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Attachment E4-2: Specifications for Water Flow Control, Eyewash Units & Safety Showers

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Safety Equipment	Specifications
Plumbed and self-contained showers	<ul style="list-style-type: none"><li>• Water column: greater than 20 inches in diameter at 60 inches above the surface</li><li>• Water delivery: greater than 20 gallons per minute (gpm)</li></ul>
Plumbed and self-contained eyewashes	<ul style="list-style-type: none"><li>• Water delivery: greater than 0.4 gpm for 15 min</li><li>• Water pressure: greater than 30 lbs/square inch</li></ul>
Personal eyewash equipment	<ul style="list-style-type: none"><li>• Water delivery: greater than 0.4 gpm for 15 min</li></ul>
Eye/facewash units	<ul style="list-style-type: none"><li>• Water delivery: greater than 3.0 gpm for 15 min</li><li>• Water pressure: greater than 30 lbs/square inch</li></ul>
Hand-held drench hoses	<ul style="list-style-type: none"><li>• Water delivery: greater than 3.0 gpm</li></ul>
Combination units	<ul style="list-style-type: none"><li>• Must meet the requirements for each individual component</li></ul>