

# BNL Handbook on Personal Protective Equipment (PPE) Selection and Use



# ***BNL Handbook on PPE Selection and Use***

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# Introduction

This document is an accompanying reference to the Personal Protective Equipment Subject Area. It provides information for selecting PPE for generic and some specific work scenarios at BNL. The recommendations in this handbook are based on historical experience, professional judgment of the Personal Protective Equipment Subject Matter Expert, and published references.

Personal Protective Equipment is a component of the “hierarchy of controls” used to eliminate or reduce hazards in the workplace. The order in which the controls should be evaluated and used is as follows:

1. **Eliminate the hazard**, examples
  - Use a different, less dangerous piece of equipment.
  - Fix faulty machinery.
  - Redesign the workplace.
  - Use safer materials or chemicals.
2. **Engineering Controls** (isolate the hazard from the people), examples
  - Use guards around moving parts.
  - Remove dust or fumes with an exhaust system.
  - Use lifting equipment.
3. **Administrative Controls** (change the way the job is done), examples
  - Rotate workers to shorten the time of exposure to any one employee.
  - Spread the work out over more days to lessen the daily exposure.
  - Provide training, information and signs.
4. **Personal Protective Equipment (PPE)**
  - Wear PPE to isolate the worker from the hazard while other controls are being implemented.
  - Wear PPE to isolate the worker from the hazard when other controls are not feasible.

The least desirable and usually the least effective method of controlling a risk is the wearing of PPE. This method relies on employees wearing the equipment and then on the equipment always being available in good condition. Because the hazard has typically not been removed, the employee may be exposed to the potential danger if the PPE fails or is improperly used.

# 1. Body Protection

If you have any questions about the appropriate type of body protection required for your work activity, contact your Supervisor or the Facility Support Representative, Industrial Hygiene (IH) Representative, or ESH Coordinator assigned to your organization.

For guidance on selection of suit material, see Polymer selection guidance in *Section 5. Hand Protection*. For specific applications of the various equipment types to particular work situations, see the exhibits [Generic Hazard Assessments](#) and [Specific Hazard Assessments](#) in the [Personal Protective Equipment](#) Subject Area.

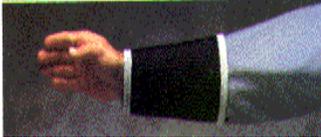
## 1A: Types of Protective Equipment

| Equipment Title                       | Description   | Illustration  |
|---------------------------------------|---|---|
| <b>Casual dress clothing</b>          | Short pants, short sleeve shirt, short dresses, etc. Exposed parts of body are arms and legs. Offers very minimal to no protection level for incidental exposure hazards.   |   |
| <b>Low-hazard protective clothing</b> | Provides a minimum protection level for incidental exposure hazards. Consists of long pants and long or short sleeve shirt. Also meeting this category is a long dress or skirt to the ankles.<br><br>Long sleeves or lab coat are <b>needed</b> when <b>corrosive or high hazard</b> chemicals are handled.  |  |
| <b>Lab coat</b>                       | Cotton or synthetic fiber long sleeve coat, open at the collar, covering to knee length. Provides initial splash protection, minimal thermal protection, and some abrasion protection. Must be removed immediately if contact with a hazardous substance occurs that can transmit the hazard to the underlying skin.<br><br>Lab coats with red collars <b>and yellow colored lab coats</b> are reserved for work with radiological hazards. |  |

## 1A: Types of Protective Equipment

| Equipment Title                         | Description   | Illustration  |
|---|---|---|
| <b>Coveralls</b>                        | Reusable or disposable one-piece suit. Provides initial splash protection, some thermal protection, and some abrasion protection.   |    |
| <b>Encapsulating Suit Level B, C, D</b> | Reusable or disposable one-piece suit. Typically disposable suits are coated with polymer to increase chemical permeation resistance. Provides splash and some sustained chemical contact protection, some thermal protection, and some abrasion protection. Reusable suits provide sustained chemical resistance when the polymer of construction is appropriately selected.                               |    |
| <b>Total Encapsulating Suit Level A</b> | Reusable or disposable one-piece suit. Always coated with polymer or constructed of polymer. Provides maximum degree of chemical permeation resistance. Provides some thermal protection and abrasion protection. The suit is airtight thus requiring breathing-grade supplied air to be provided into the suit.  |   |
| <b>Laboratory apron</b>                 | Apron provides protection from abrasion and splash to front of body, where the maximum potential for exposure occurs. Should be used in conjunction with a lab coat, coverall, or other protection for unprotected areas of the body. Typically manufactured in polyethylene (low cost), vinyl (flexibility and resistance to chemicals, fats, oils, grease, etc.), and rubberized fabric (acid resistant). |  |

## 1A: Types of Protective Equipment

| Equipment Title                        | Description   | Illustration  |
|--|---|---|
| <p><b>Flame-resistant clothing</b></p> | <p>Suit worn for minor electrical operations for protection from accident hazards that create a hot metal. Protective clothing includes shirts, pants, coveralls, jackets, and parkas worn routinely by workers who, under normal working conditions, are exposed to momentary electric arc and related thermal hazards. Arc and flame resistant rainwear worn in inclement weather are included in this category of clothing. Layering of flame-resistant and natural fiber garments is used for added protection. A typical layering system may include an undershirt, a shirt and trouser and coverall. Loose-fitting clothing provides additional thermal insulation due to air spaces. See the Electrical Safety Subject Area for BNL PPE requirements.</p> <ul style="list-style-type: none"> <li>• Do not apply DEET insect repellent (K70766) to Flame Resistant Clothing. Use Permethrin Clothing Spray (K70764) if needed.</li> </ul> |    |
| <p><b>Electrical flash suit</b></p>    | <p>Suit worn by electricians for protection from electrical flash accidents hazards that create a large fireball, sending hot metal flying through the air. ASTM F1506-00 is used to assign the garment with an arc rating. Face shields made of polycarbonate material are more appropriate for use in situations with relatively low radiation exposure. See the Electrical Safety Subject Area for BNL PPE requirements.</p> <ul style="list-style-type: none"> <li>• Do not apply DEET insect repellent (K70766) to Flame Resistant Clothing. Use Permethrin Clothing Spray (K70764) if needed.</li> </ul>  |   |
| <p><b>Gauntlets/ sleeves</b></p>       | <p>Gauntlets provide protection from abrasion to the forearms, for uses where the maximum potential for exposure occurs in that area. Typical uses are chain saws and knife cutting operations.</p>   |  |

## 2. Eye and Face Protection

If you have any questions about the appropriate type of protection required for your work activity, contact your Supervisor or the Facility Support Representative, Industrial Hygiene (IH) Representative, or ESH Coordinator assigned to your organization.

For specific applications of the various equipment types to particular work situations, see the exhibits [Generic Hazard Assessments](#) and [Specific Hazard Assessments](#) in the [Personal Protective Equipment](#) Subject Area.

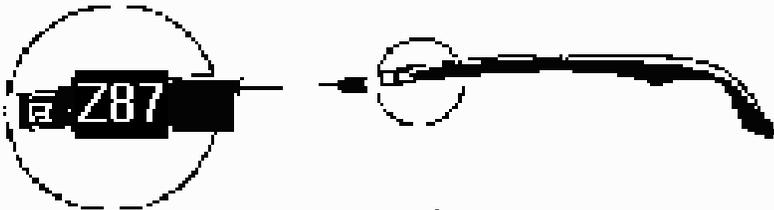
### 2A: Types of Eye Protective Equipment

| Equipment Title   | Description  | Illustration  |
|---|--|---|
| <b>Non-safety eyeglasses</b>                              | Includes any glasses without impact resistance lenses and safety design features. Lenses insert into frame from the face (eye) side to minimize the thickness of the frame viewed by others or lenses attach to frame with minimal anchoring mechanisms. Because of these features to enhance the cosmetic appearance, on impact, the lens may disengage from the frame and move toward eye causing injury. The lens is less impact resistant and may fragment on impact causing eye injuries. |    |
| <b>Impact resistant safety glasses with side shields</b>  | Lenses insert into frame from the outside with a solid rim on the inner side of frame smaller than the lens. Design may include the lens and frame as one piece. On impact with a flying object, the lens will not disengage toward eye. The material of the lens meets impact resistant standards with built in or add-on clear side shield that guard against impact of flying objects entering from the side of the face. Marked as meeting ANSI Z87.1 standards.                           |  |
| <b>Prescription lens safety glasses with side shields</b> | Same as above with corrective prescription lenses.   |  |
| <b>Add-on side shields</b>                                | Add-on clear side shield that guard against impact of flying objects entering from the side of the face. Marked as meeting ANSI Z87.1 standards.   |  |
| <b>Visitor glasses</b>                                    | Impact-resistant safety glasses designed to fit over non-safety glasses. (Red frames glasses in picture are the visitor glasses). Marked as meeting ANSI Z87.1 standards.  |  |
| <b>Vented goggles</b>                                     | Frame makes full contact with the face at all points. Vents in frame allow perspiration to vent reducing fogging. The material of the lens meets impact resistant standards. Marked as meeting ANSI Z87.1 standards.   |  |

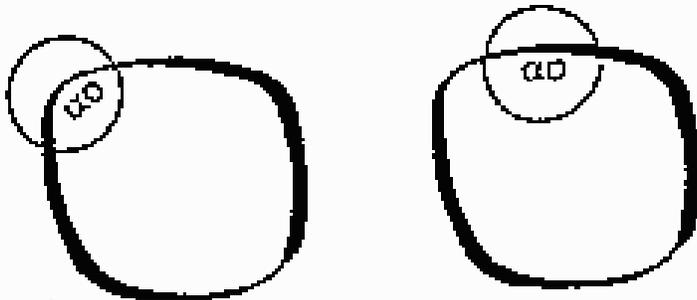
## 2A: Types of Eye Protective Equipment

| Equipment Title                                  | Description  | Illustration  |
|--|--|---|
| <b>Non-vented goggles</b>                        | Frame makes full contact with the face at all points. No vents in frame prevent entry of hazardous vapors, mists, fumes or aerosols. The material of the lens meets impact resistant standards. Marked as meeting ANSI Z87.1 standards.  |    |
| <b>Face shield</b>                               | Face shield has impact resistant crown and window for protection from flying particles. Marked as meeting ANSI Z87.1 standards.  |    |
| <b>Full-face respirator</b>                      | Face piece makes full contact with the face at all points. No vents in face piece prevent entry of hazardous vapors, mists, fumes or aerosols. The material of the lens meets impact resistant standards. Marked as meeting ANSI Z87.1 standards. See the <a href="#">Respiratory Protection</a> Subject Area.<br><br>Acceptable for uses requiring safety glasses, face shield, and non-vented or vented goggles. |   |
| <b>Biohazard face masks</b>                      | Shield provides droplet barrier for added security against bloodborne pathogens.<br><br>Provides protection from biohazard splashes as well as both inhaled and exhaled microorganisms. Filters particulate matter at greater than 95% efficiency.   |  |
| <b>Welding helmet</b>                            | Provides multiple types of protection (eye and face protection). Acceptable for uses requiring safety glasses or face shield.  |  |
| <b>Combo hard hat and face shield respirator</b> | Provides multiple types of protection (head, respiratory, and face protection). Acceptable for uses requiring safety glasses or face shield.   |  |
| <b>Electrical Flash Eye Protection</b>           | Safety glasses and goggles provide lesser protection, but in low risk tasks they may be justified if the task involves substantial physical work in combination with good visual requirements. Eye protection (safety glasses or goggles) is worn under face shields or hoods.   |   |

## 2B. Markings for ANSI-Compliant Eye Protection



ANSI-Required Frame Marking



ANSI-required lens marking (manufacturer's insignia)



ANSI-required side shield marking

## 2C. Filter Lenses for Protection Against Radiant Energy

| Type of Operation                                   | Electric Size<br>1/32 in. | Arc Current<br>(Amp) | Minimum<br>Protective<br>Shade <sup>(a)</sup> |
|---|---------------------------|----------------------|---|
| Shield metal arc welding                            | Less than 3               | Less than 60         | 7   |
|   | 3 to 5                    | 60 to 160            | 8   |
|   | 5 to 8                    | 160 to 250           | 10  |
|   | More than 8               | 250 to 500           | 11  |
|   |                           |                      |   |
| Gas metal arc welding and<br>flux cored arc welding |                           | Less than 60         | 7   |
|   |                           | 60 to 160            | 10  |
|   |                           | 160 to 250           | 10  |
|   |                           | 250 to 500           | 10  |
| Gas tungsten arc welding                            |                           | Less than 50         | 8   |
|   |                           | 65 to 150            | 8   |
|   |                           | 150 to 500           | 10  |
| Air carbon<br>arc cutting                           | (light)                   | Less than 500        | 10  |
|   | (heavy)                   | 500 to 1000          | 11  |
| Plasma arc welding                                  |                           | Less than 20         | 6   |
|   |                           | 20 to 100            | 8   |
|   |                           | 100 to 400           | 10  |
|   |                           | 400 to 800           | 11  |
| Plasma arc cutting                                  | Light <sup>(b)</sup>      | Less than 300        | 8   |
|   | Medium <sup>(b)</sup>     | 300 to 400           | 9   |
|   | Heavy <sup>(b)</sup>      | 400 to 800           | 10  |
| Torch brazing                                       |                           | NA                   | 3   |
| Torch soldering                                     |                           | NA                   | 2   |
| Carbon arc welding                                  |                           | NA                   | 14  |

| Type of Operation | Plate Thickness |             | Minimum Protective Shade <sup>(a)</sup> |
|-------------------|-----------------|-------------|---|
|                   | Inches          | Mm          |   |
| Gas welding       |                 |             |   |
| Light             | Under 1/8       | Under 3.2   | 4                                       |
| Medium            | 1/8 to 1/2      | 3.2 to 12.7 | 5                                       |
| Heavy             | Over 1/2        | Over 12.7   | 6                                       |
| Oxygen Cutting    |                 |             |   |
| Light             | Under 1         | Under 25    | 3                                       |
| Medium            | 1 to 6          | 25 to 150   | 4                                       |
| Heavy             | Over 6          | Over 150    | 5                                       |

Source: OSHA 29 CFR 1910.133 Personal Protective Equipment, Eye and face protection

(a) As a rule of thumb, start with a shade that is too dark to see the weld zone. Then, go to a lighter shade that gives a sufficient view of the weld zone without going below the minimum. In oxyfuel gas welding or cutting where the torch produces a high yellow light, it is desirable to use a filter lens that absorbs the yellow or sodium line in the visible light of the (spectrum) operation.

(b) These values apply where the actual arc is clearly seen. Experience has shown that lighter filters may be used when the arc is hidden by the workpiece.

|                         |   |
|-------------------------|---|
| <b>Laser Operations</b> | See the <a href="#">Laser Safety</a> Subject Area |
|-------------------------|---|

# 3. Fall Protection

If you have any questions about the appropriate type of body protection required for your work activity, contact your Supervisor or the Facility Support Representative, Industrial Hygiene (IH) Representative, or ESH Coordinator assigned to your organization.

For specific applications of the various equipment types to particular work situations, see the exhibits [Generic Hazard Assessments](#) and [Specific Hazard Assessments](#) in the [Personal Protective Equipment](#) Subject Area.

*Employees who work on elevated surfaces or scaffolding are required to utilize a method of fall protection. Fall protection may include railings, barrier markings, or personal fall-arrest systems. Employees who use personal fall-arrest systems such as body harnesses, lanyards, and hoists should be trained in the proper usage of this equipment.*

- **A fall-restraint system** is the equipment used to keep a worker from reaching a potential fall point. Fall restraint includes the use of perimeter cables, guardrails, floor opening covers, scaffolds or work platforms with standard guardrails, or the utilization of a safety harness and lanyard secured to an anchorage point restricting the worker from a fall hazard.
- **A fall-arrest system** is the equipment used to protect a worker from falling more than six feet or from striking a lower object in the event of a fall. This equipment always includes a full-body harness.

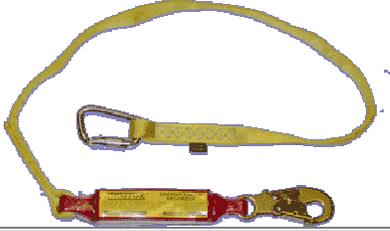
*Before starting work above any elevation greater than 6 feet, it is recommended that a fall-protection work plan be developed. Use fall protection at any elevation greater than 6 feet.*

| 3A: Types of Protective Equipment         |   |   |
|---|---|---|
| Equipment Title                           | Description   | Illustration  |
| <b>Harness with front D-rings</b>         | A full-body harness distributes the forces generated during a fall over at least the thighs, pelvis, chest, and shoulders. Front D-ring for ladder climbing, positioning, suspension, rescue, or restraint.   |  |
| <b>Harness with back and side D-rings</b> | A full-body harnesses distribute the forces generated during a fall over at least the thighs, pelvis, chest, and shoulders. The standard sliding back D-ring helps to suspend a fallen worker in an upright position after the fall. Must meet or exceed all OSHA and ANSI standards including ANSI Z359. |  |

## 3A: Types of Protective Equipment

| Equipment Title                    | Description   | Illustration  |
|------------------------------------|---|---|
| <b>Fall-protection coveralls</b>   | OSHA compliant full-body harness permanently incorporated into coverall. The coveralls come in a range of sizes and since the harnesses is sized to the coverall, no adjustment or adjusting hardware is needed. Inside the coverall, there are no loose straps, making donning fast and simple. A chest pocket holds the lanyard when not in use.  |    |
| <b>Fall-protection overalls</b>    | Overall is lightweight enough to be worn in almost any climate and features the fall protection of an OSHA compliant polyester full-body harness. The overall is available in a range of sizes and requires only minimal adjustment since the harness is sized to fit the overall. Quick connect buckles at the shoulder straps makes donning fast and simple. The energy-absorbing lanyard fits in a specially designed pocket at the center of the wearer's back. A chest pocket holds the snap hook and web lanyard when not in use. |    |
| <b>Wristlets with yoke lanyard</b> | Wristlets and yoke lanyard are designed for use in confined spaces or tanks with narrow openings where the worker may have to be withdrawn. Each wristlet has a permanently attached 1" wide x 6' long (3' each leg) polyester web yoke lanyard with a D-ring in the center.  |   |
| <b>Rope grab system</b>            | Rope grab system includes lifeline, rope grab, flexible counterweight, shock absorbing lanyard and tie-off adapter.   |  |
| <b>Self-retracting lifeline</b>    | Housing with lifeline. Swiveling anchorage loop to prevent twisting of lifeline. Swiveling self-locking snap hook with impact indicator.  |  |

### 3A: Types of Protective Equipment

| Equipment Title            | Description   | Illustration  |
|----------------------------|---|---|
| <b>Tie-back lanyard</b>    | Energy absorber with dual layer polyester web tie-back lanyard. An integral locking snap hook for attachment to your full-body harness and a captive automatic locking carabiner is fitted at the opposite end for attaching to a suitable anchor. Designed to reduce the possibility of serious injury by reducing the arresting force on a worker to less than 900 lbs. |  |
| <b>Decelerator lanyard</b> | An energy absorbing inner core made of polyester absorbs the arresting forces in the case of a fall while the nylon outer shell protects the core from damage and acts as backup.   |  |

# 4. Foot Protection

If you have any questions about the appropriate type of body protection required for your work activity, contact your Supervisor or the Facility Support Representative, Industrial Hygiene (IH) Representative, or ESH Coordinator assigned to your organization.

For specific applications of the various equipment types to particular work situations, see the exhibits [Generic Hazard Assessments](#) and [Specific Hazard Assessments](#) in the [Personal Protective Equipment](#) Subject Area.

| 4A: Types of Protective Equipment                 |  |   |
|---|--|---|
| Equipment Title                                   | Description  | Illustration  |
| <b>Casual, open-toed footwear</b>                 | No impact resistance. None to minimal protection from contact, providing little to no protection from initial brief contact with chemicals and hot objects.  |     |
|   |  |   |
| <b>Enclosed footwear (substantial)</b>            | No impact resistance. Minimal protection from contact- providing some protection from initial brief contact with chemicals and hot objects. Worn with socks.<br><br>Not for use in impact potential areas or for material handling.  |   |
| <b>Safety shoe (impact resistant, safety toe)</b> | Structured steel cap capable of withstanding 2,500 lbs. of compression. ANSI I-75 for absorbing impact and C-75 for compression. Typically full-grain leather or vinyl uppers, durable nonmarking slip-resistant outsole. Cut, falling object, and impact protection. Worn with socks. |  |
| <b>Metatarsal protection</b>                      | High impact and falling object protection. Provides protection for front and bridge of foot. Worn with socks.  |  |

## 4A: Types of Protective Equipment

| Equipment Title                                 | Description   | Illustration  |
|---|---|---|
| <b>Dielectric boot</b>                          | Dielectric – typically 20,000-volt overshoe with adjustable side lace, pole climbing reinforcement patch, antiskid bar tread and heel. Uninsulated. Ideal for utility, power transmission, and horizontal drilling applications. Worn with socks.                   |    |
| <b>Conductive sole shoe</b>                     | Resistance range typically under 10,000 ohms for compliance with the ANSI Z41-1999 CD Type 1 standard for conductive shoes.   |    |
| <b>Conductive shoe covers</b>                   | Antistatic covers for footwear.   |    |
| <b>Shoe cover</b>                               | Contaminant protection worn over “enclosed footwear” or safety toe shoe, as appropriate.  |   |
| <b>Disposable boot</b>                          | Boot cover with elastic top, used for particulates including asbestos, lead dust and radioactive dusts. Worn over “enclosed footwear” or safety toe shoe, as appropriate.   |  |
| <b>Chemical-resistant overboot</b>              | Offers protection for hazardous and non-hazardous materials. Seamless waterproof covers provide added layer of chemical and wear protection. Worn over “enclosed footwear” or safety toe shoe, as appropriate.  |  |
| <b>Chemical-resistant boots with safety toe</b> | Neoprene or other polymer boots are seamless with suction gripping tread pattern for slick floors, cushion insoles. Good against the broadest variety of animal and vegetable fats and fluids as well as the harshest of petrochemical substances. Worn with socks. |  |

## 4A: Types of Protective Equipment

| Equipment Title                         | Description  | Illustration  |
|---|--|---|
| <b>Electrical flash foot protection</b> | Heavy-duty leather work shoes normally provide a significant degree of protection to the feet. |  |

# 5. Hand Protection

If you have any questions about the appropriate type of **hand** protection required for your work activity, contact your Supervisor or the Facility Support Representative, Industrial Hygiene (IH) Representative, or ESH Coordinator assigned to your organization.

For specific applications of the various equipment types to particular work situations, see the exhibits [Generic Hazard Assessments](#) and [Specific Hazard Assessments](#) in the [Personal Protective Equipment](#) Subject Area.

## 5A: Types of Protective Equipment

| Equipment Title                              | Description  | Illustration  |
|--|--|---|
| <b>Splash glove</b>                          | Disposable, nitrile, or natural rubber, ambidextrous gloves are resistant to a broad range of chemicals for brief periods. BNL policy is to dispose of immediately on contact with liquid unless manufacturer rates for sustained contact.   |   |
| <b>Sustained contact and immersion glove</b> | Superior chemical and abrasion resistance. For harsh cleaners and solvents, embossed grip, typically flocked or fabric lined, usually 10 to 20-mil thick. Material of construction must be impervious to the challenge chemical. See Table 5C.   |  |
| <b>Cryogen glove</b>                         | Asbestos-free and water-resistant, gloves protect against injury from both cryogenic and hot materials from -160° to 150°C (-260° to 300°F). Abrasion- and cut-resistant gloves let you confidently handle rough and sharp objects. Machine washable/dryable. Not for immersion in liquid nitrogen. Lighter in weight and more durable than comparable gloves. |  |

## 5A: Types of Protective Equipment

| Equipment Title                                | Description  | Illustration   |
|--|--|--|
| <b>Thermal burn-protection glove</b>           | <p>Woven fiberglass gloves withstand very low to very high (-70° to 600°C). Gloves are soft, flexible, and water resistant. Wool lining enhances user comfort. Aluminized gloves for extra heat reflectivity and molten-splash resistance.</p> <p>Ultra-high temperature Zetex® gloves offer the ultimate protection from intense, concentrated heat.</p> <p>Can also be used for cryogen liquid handling.</p> |   |
| <b>Abrasion resistance (a.k.a. work glove)</b> | <p>Typically a split leather palm, leather index finger and thumb and a leather knuckle strap. Cotton safety cuff.</p>   |   |
| <b>Cut-resistant glove</b>                     | <p>Heavyweight Kevlar® blend knitted gloves offer greater cut resistance than regular knit gloves</p>  |  |
| <b>Electrical flash hand protection</b>        | <p>Gloves made from layers of flame resistant material provide the highest level of hand protection. Heavy-duty leather gloves also provide good protection. Where voltage-rated gloves are used, leather protectors should be worn over the rubber gloves. The leather protectors also provide good arc-flash protection for the hands.</p>   |  |

## 5B. Gloves and Suit Selection Process

The table below provides guidance in the selection of Chemical Protective Equipment for:

- SHSD IH Group;
- RCD Facility Support Group;
- ESH Coordinators and ESH professional in BNL organizations;
- Scientists, Principal Investigators, and Workers (with competency in this area).

Steps in selecting an appropriate glove or suit

|    |  |
|----|--|
| 1  | <p>Choose PPE only after alternative controls have been explored:</p> <ul style="list-style-type: none"> <li>• Substitute a less hazardous chemical (if practical)</li> <li>• Use hoods, glove boxes, capture ventilation to control vapors, mists, liquids</li> </ul>   |
| 2. | <p>Evaluate the job and type of exposure:</p> <ol style="list-style-type: none"> <li>Chemical(s) involved (example: benzene)</li> <li>Duration of exposure (example: 20 minutes in constant contact with liquid)           <ul style="list-style-type: none"> <li>• How long will contact be in routine use and emergencies? Will the contact be immersion for long periods, splash, or incidental contact?</li> <li>• Chemical(s) attack on the glove (breakthrough time, permeation rate, degradation) must be shorter than the breakthrough time. Be sure to include cumulative time on re-used gloves. Refer to a Chemical-Resistant Table from the manufacturer or Table 5C for chemical-resistance ratings.               <ul style="list-style-type: none"> <li>• <b>Breakthrough Time:</b> The elapsed time between initial contact of the chemical on the glove surface and the analytical detection on the inside of the glove. When expressed with a greater than symbol (&gt;), the test was run for "n" minutes and then stopped.</li> <li>• <b>Degradation:</b> A change in one or more of the physical properties of a glove due to contact with a chemical. Can appear as a swelling, softening, shrinkage or cracking of the material. A rating of "E" for excellent, means the glove has little or no signs of degradation when exposed to the challenge chemical. <b>A favorable degradation rating does not guarantee an acceptable breakthrough time.</b></li> <li>• <b>Permeation Rate:</b> The rate at which a chemical passes through a glove material. This process involves absorption on the glove surface, the diffusion of the chemical through the material, and the desorption on the glove's inside surface. This measurement is given is <math>\mu\text{g}/\text{cm}^2/\text{minute}</math>, but is sometimes expressed as "E" to "P" for excellent to poor.</li> </ul> </li> </ul> </li> </ol> |

|    |  |
|----|--|
| 3  | <p>Evaluate the material handling aspects of the job: The nature of the job being performed will greatly influence the selection and features of protective clothing. For example, analyzing samples in a laboratory may require light-duty gloves (&lt;10 mils in thickness) that are flexible and have good manual dexterity; while a maintenance project, such as repairing a pump line, may require thicker gloves that are rugged and durable.</p> <p><b>Glove Dexterity</b> - Will a bulky glove cause drops, accidents or slips? Are small intricate parts handled?</p> <p><b>Select the appropriate glove thickness</b> (example: single use disposable glove vs. reusable gloves)</p> <ul style="list-style-type: none"> <li>• Select a thinner, unsupported glove when you require extra dexterity and tactile sensitivity. When a high degree of manual dexterity is needed with a hazardous substance, use of thin glove with limited protection time may be acceptable <i>if the gloves are changed with sufficient frequency.</i></li> <li>• Select a heavier-gauge unsupported glove for greater protection and wear. Consider a flock-lined, unsupported glove for extra comfort, insulation and wear.</li> </ul> <p><b>Choose the finish</b> you need for the grip for your application: rough, smooth, wrinkle, embossed, bisque, etc.</p> |
| 4. | <p>Evaluate the physical conditions the gloves will be subjected to and determine which types of resistance are important: abrasion, cut, puncture, temperature, etc. Physical conditions can influence chemical resistance. When possible, choose a supported or cut-and-sewn glove for added cut, snag, puncture or abrasion resistance.</p>   |
| 5  | <p>Size the glove:</p> <ul style="list-style-type: none"> <li>• Select glove length by determining the depth to which your hand and arm will be immersed in a solution and the extent to which you need splash protection.</li> <li>• Select the hand size that gives you the right fit, dexterity and comfort. To determine your size, measure the circumference around the palm area. This is your glove size. For example, 7" is equal to a size 7 glove. (XS = 6-7, S = 7-8, M = 8-9, L = 9-10, XL = 10-11)</li> </ul>   |
| 6  | <p>Factor in the following</p> <ul style="list-style-type: none"> <li>• Cost of the glove (e.g., Viton® is very expensive). Does a cheaper glove have adequate properties?</li> <li>• Reuse of the glove. Can many cheaper disposable gloves be used in place of a more expensive reusable glove?</li> <li>• Storage and decontamination. Storing an exposed glove between uses can shorten the life of protection. Use of disposable gloves and clothing is often preferred because proper decontamination of reusable items is often difficult.</li> </ul>   |
| 7. | <p>Document the selection via</p> <ul style="list-style-type: none"> <li>• Protective Clothing Selection Form;</li> <li>• SOP;</li> <li>• Work planning documentation;</li> <li>• Other Department-/Division-developed mechanism.</li> </ul>   |

## 5C. Polymer Selection Tables

The BNL [Safety & Health Services Industrial Hygiene](#) web page provides links to several manufacturer's websites that provide polymer selection and ordering information.

The following table provides guidance for selecting the appropriate glove to be worn in situations involving chemical hazards. This table is not intended to be all-inclusive. If you have any questions about the appropriate type of glove required for your work activity, contact your immediate manager, Facility Support Representative, or the Personal Protective Equipment SME.

(Next page is landscape format)

## Recommended Glove Material for common BNL laboratory chemicals

| Chemical Name                        | Splash Protection<br>(disposable, exam style) |                                |          | Immersion & Sustained Contact                                |    |    |     |                    |      | Reusable<br>(typically flocked or fabric support)               |
|--------------------------------------|---|--------------------------------|----------|--|----|----|-----|--------------------|------|---|
|                                      | Nitrile (N-Dex,<br>Purple Knight)             | Natural Rubber<br>(Latex Exam) | PVC      | Disposable<br>Nitrile (N-Dex)<br>(unflocked and unsupported) |    |    |     |                    |      |   |
|                                      |   |                                |          | DEGRADATION (MIN)  |    |    |     | PERMEATION (MIN)   |      |   |
|                                      |   |                                |          | 5  | 30 | 60 | 240 | Break-thru<br>time | Rate |   |
| <b>Acetonitrile</b>                  | p   | NR                             | NR       | P  | P  | P  | P   | 4                  |      | E= Butyl, Teflon, 4H  |
| <b>Acetic anhydride</b>              | NR  | NR                             | NR       | NR   | NR | NR | NR  | NR                 | NR   | E= butyl, Teflon, 4H  |
| <b>ACIDS, dilute</b>                 | E   | F                              | F        | E  | E  | E  | E   |                    |      | Butyl, Nat Rubber, Neoprene, Nitrile, PVC, Teflon, Viton, 4H    |
| Hydrochloric Acid 37%                | E   | F                              | F        | E  | E  | E  | E   | ND                 | ND   | E= Butyl, Nat Rubber, Neoprene, Nitrile, PVC, Teflon, Viton, 4H |
| Phosphoric Acid 85%                  | E   | F                              | F        | E  | E  | E  | E   | ND                 | ND   | E= Butyl, Nat Rubber, Neoprene, Nitrile, PVC, Viton, 4H         |
| Nitric Acid 30-70%                   | G   | NR                             | F        | G  | P  | NR | NR  | NR                 | NR   | E= Butyl, Neoprene, Viton, 4H                                   |
| Nitric Red Fuming                    | NR  | NR                             | NR       |  |    |    |     |                    |      | E= Teflon   |
| Sulfuric Acid 97%                    | G   | NR                             | F        | G  | P  | NR | NR  | NR                 | NR   | E= Butyl, Teflon, 4H, Viton                                     |
| Acetic Acid 84%                      | E   | F 1-4 HR                       | F 1-4 HR | E  | P  | P  | NR  | NR                 | NR   | E= Butyl, Neoprene, Viton, 4H                                   |
| <b>ALKALI, dilute</b>                | G   | F                              | F        | F  | F  | F  | F   |                    |      | Butyl, Nat Rubber, Neoprene, Nitrile, PVC, Teflon, Viton, 4H    |
| Ammonium Hydroxide 30-70%            | G   | NR                             | P        |  |    |    |     |                    |      | E= Butyl, Neoprene, Nitrile, Teflon                             |
| Potassium Hydroxide (KOH) 45%        | E   | F                              | F        | E  | E  | E  | E   | ND                 | ND   | E= Butyl, Nat Rubber, Neoprene, Nitrile, PVC, Teflon, Viton, 4H |
| Sodium Hydroxide (NaOH) 50%          | E   | F                              | F        | E  | E  | E  | E   | ND                 | ND   | E= Butyl, Nat Rubber, Neoprene, Nitrile, PVC, Teflon, Viton, 4H |
| <b>ALCOHOLS</b>                      | G   | F                              | G        |  |    |    |     |                    |      | Butyl, Nat Rubber, Neoprene, Nitrile, PVC, Teflon, Viton, 4H    |
| Ethanol                              | E   | NR                             | NR       | E  | E  | E  | G   | 7                  | 12   | E= Butyl, Neoprene, Viton, 4H; F= Nitrile                       |
| Iso-propanol (2-propanol)            | E   | NR                             | F        | E  | E  | E  | E   | 15                 | 29   | E= Butyl, Neoprene, Nitrile, Teflon, Viton, 4H                  |
| Methanol                             | E   | NR                             | NR       | E  | G  | G  | F   | NR                 | NR   | E = Butyl, Neoprene, Nitrile, Teflon, Viton, 4H                 |
| n-Propanol                           | G   | NR                             | F        | G  | F  | P  | P   | 7                  | 42   | E = Butyl, Teflon, Viton, 4H                                    |
| <b>ALDEHYDES</b>                     |   |                                |          |  |    |    |     |                    |      |   |
| Acetaldehyde                         | NR  | NR                             | NR       | NR   | NR | NR | NR  | NR                 | NR   | E= Butyl, 4H, Teflon  |
| Benzaldehyde                         | NR  | NR                             | NR       | NR   | NR | NR | NR  | NR                 | NR   | E= Butyl, PVA, Viton, 4H  |
| Formaldehyde                         | E   | NR                             | F        | E  | E  | E  | E   | ND                 | ND   | E= Butyl, Nitrile, Viton, 4H                                    |
| <b>Ammonia</b>                       | NR  | NT                             | NR       | NR   | NR | NR | NR  | NR                 | NR   | E= Butyl, Nitrile, Teflon, Viton                                |
| <b>AROMATICS</b>                     | F   | NR                             | NR       | NR   | NR | NR | NR  | NR                 | NR   | PVA, Viton, 4H  |
| Benzene                              | NR  | NR                             | NR       | NR   | NR | NR | NR  | NR                 | NR   | E= PVA, Teflon, Viton, 4H                                       |
| Toluene                              | F   | NR                             | NR       | NR   | NR | NR | NR  | NR                 | NR   | E= PVA, Teflon, Viton, 4H                                       |
| Xylene                               | F   | NR                             | NR       | NR   | NR | NR | NR  | NR                 | NR   | E= PVA, Teflon, Viton, 4H                                       |
| <b>CHLORINATED HYDROCARBONS</b>      | P   | NR                             | NR       | NR   | NR | NR | NR  | NR                 | NR   | Butyl, Nitrile, PVA, Teflon, Viton, 4H                          |
| Carbon tetrachloride                 | F   | NR                             | NR       | NR   | NR | NR | NR  | NR                 | NR   | E= PVA, Viton, 4H   |
| Chloroform                           | P   | NR                             | NR       | NR   | NR | NR | NR  | NR                 | NR   | E= PVA, Viton, 4H, Teflon                                       |
| Methylene Chloride (dichloromethane) | F   | NR                             | NR       | NR   | NR | NR | NR  | NR                 | NR   | E= PVA, Teflon, 4H  |
| Trichloroethane, 1,1,1-              | F   | NR                             | NR       | NR   | NR | NR | NR  | NR                 | NR   | E= Butyl, PVA, Viton, 4H  |

| Chemical Name                          | Splash Protection<br>(disposable, exam style) |                                |     | Immersion & Sustained Contact                                |    |    |     |                  |      | Reusable<br>(typically flocked or fabric support)        |
|--|---|--------------------------------|-----|--|----|----|-----|------------------|------|--|
|  | Nitrile (N-Dex,<br>Purple Knight)             | Natural Rubber<br>(Latex Exam) | PVC | Disposable<br>Nitrile (N-Dex)<br>(unflocked and unsupported) |    |    |     |                  |      |  |
|  |   |                                |     | DEGRADATION (MIN)  |    |    |     | PERMEATION (MIN) |      |  |
|  |   |                                |     | 5  | 30 | 60 | 240 | Break-thru time  | Rate |  |
| Trichloroethylene                      | F   | NR                             | NR  | NR   | NR | NR | NR  | NR               | NR   | E = PVA, Viton, 4H                                       |
| DMF                                    | P   | NR                             | NR  | NR   | NR | NR | NR  | NR               | NR   | E= Butyl, Teflon, 4H                                     |
| DMSO                                   | E   | NR                             | NR  | E  | G  | F  | P   | 23               | 84   | E= Butyl, Neoprene, Teflon, 4H                           |
| EPOXY RESINS                           | G   | P                              | F   |  |    |    |     |                  |      | Butyl, Neoprene, Nitrile, PVC, Teflon, Viton, 4H         |
| Ethyl ether                            | G   | NR                             | NR  | G  | G  | G  | G   | 2                | 495  | E= PVA, 4H, Teflon                                       |
| ESTERS                                 | P   | NR                             | NR  | NR   | NR | NR | NR  |                  |      | Butyl  |
| Ethyl Acetate                          | P   | NR                             | NR  | NT   | NT | NT | NT  | NT               | NT   | E= PVA, Teflon, 4H; F= Butyl                             |
| Hydrazine                              | NT  | F                              | G   |  |    |    |     |                  |      | E= Butyl, Neoprene, Nitrile, PVC                         |
| HYDROCARBONS/<br>PETROLEUM DISTILLATES | G   | F                              | F   |  |    |    |     |                  |      | E= Butyl, Neoprene, Nitrile, PVC, PVA, Teflon, Viton, 4H |
| Hexane                                 | E   | NR                             | NR  | E  | E  | E  | E   | 11               | 8    | E= Nitrile, PVA, Teflon, Viton, 4H                       |
| Hydrogen Peroxide 30-70%               | G   | G                              | G   |  |    |    |     |                  |      | Butyl, Nitrile, PVA, Viton, 4H                           |
| KETONES                                |   |                                |     |  |    |    |     |                  |      | Butyl, 4H  |
| Acetone                                | NR  | NR                             | NR  | NR   | NR | NR | NR  | NR               | NR   | E= Butyl, Teflon, 4H                                     |
| Methyl Ethyl ketone                    | F   | NR                             | NR  | NR   | NR | NR | NR  | NR               | NR   | E= Butyl, Viton, 4H                                      |
| Mercury                                | G   | G                              | G   | NT   | NT | NT | NT  | NT               | NT   | E = 4H <b>Note:</b> most gloves afford good protection   |
| OILS, GREASE                           | E   | E                              | E   |  |    |    |     |                  |      | E= Butyl, Neoprene, Nitrile, PVC, PVA, Teflon, Viton, 4H |
| PCBs                                   | F   | NR                             | NR  |  |    |    |     |                  |      | E = Viton  |
| Tetrahydrofuran                        | F   | NR                             | NR  | NR   | NR | NR | NR  | NR               | NR   | E= Teflon, 4H  |

|   |  |  |   |
|---|--|--|---|
| <b>NR</b> = not recommended<br><b>ND</b> = none detectable (permeation)<br><b>NT</b> = not tested<br><b>NA</b> = not applicable | <b>E</b> = excellent<br><b>G</b> = good<br><b>F</b> = fair<br><b>P</b> =poor | Butyl = butylenes/isoprene copolymer<br>4H = Silvershield = (polyethylene/ethylene vinyl alcohol copolymer)<br>Natural rubber = isoprene from <i>gutta percha</i><br>Neoprene = DuPont trademark for chloroprene | PVA= tradename of Ansell for polyvinyl alcohol<br>PVC= polyvinyl chloride<br>Teflon = DuPont trademark for polytetrafluoroethylene (PTFE)<br>Viton = DuPont trademark for hexafluoropropylene/vinylidene fluoride copolymer |
|---|--|--|---|

Source: Best Glove 4/98 Degradation/Permeation Table: Forsberg, Krister, & Mansdorf, S. Z. (1997). *Quick Selection Guide to Chemical Protective Clothing* (3rd ed.). New York: Van Nostrand Reinhold.

## 5D. BNL Guidance on “Splash Protection & Incidental Contact” for laboratory and fine detail work

**Background:** When selecting chemical protective gloves, a choice must be made regarding thickness and length. Thicker gloves have better chemical resistance than thinner gloves. However, thinner gloves offer better touch sensitivity and flexibility.

Glove thickness is stated in either mils or gauge. A 10-gauge glove equals 10 mils, or 0.010 inches. When choosing your glove, look for the stated thickness on the manufacturer's test data

Thin gloves sacrifice chemical resistance. Generally, doubling the thickness of a glove quadruples the breakthrough time of the chemical (more protective). Because surgical gloves are so thin, the material is easily stretched over the hand, allowing better sensitivity. But this stretching also leaves larger spaces in the glove material polymer. These larger spaces allow many chemicals to permeate through quickly, limiting the amount of time the glove can be worn. Some surgical gloves offer limited splash protection from some chemicals. But almost always, these gloves are not intended for complete immersion in chemicals, and should only be used for a very limited time period. Check the glove manufacturer's recommendations in regards to usage with your chemical.

### BNL GUIDANCE

This BNL Guidance is applicable for gloves used in “fine detail” laboratory work for SPLASH PROTECTION & INCIDENTAL CONTACT (i.e., procedures where no contact or very little actual contact with a chemical in use is anticipated ). It is NOT applicable where immersion is a factor.

1. Select the best disposable glove polymer - Nitrile, PVC, or natural rubber (Latex). When test data is not available, Nitrile is almost always the best choice.
2. If the glove has a “recommended” rating by the manufacturer (fair/good/excellent) for use with the chemical, use the glove within the guidelines provided by the manufacturer.
3. If breakthrough time (BT) is known, whenever the chemical is contacted always remove the glove sooner than the BT.
4. If BT is not known or the glove does not have a manufacturer's approval, wear the disposable glove with strong adherence to this policy:

“REMOVE THE GLOVE **INSTANTLY** WHEN CONTACTED BY A SPLASH or with RESIDUES of the chemical”.

# 6. Head Protection

If you have any questions about the appropriate type of body protection required for your work activity, contact your Supervisor or the Facility Support Representative, Industrial Hygiene (IH) Representative, or ESH Coordinator assigned to your organization.

For specific applications of the various equipment types to particular work situations, see the exhibits [Generic Hazard Assessments](#) and [Specific Hazard Assessments](#) in the [Personal Protective Equipment](#) Subject Area.

| 6A: Types of Protective Equipment |   |   |
|-----------------------------------|---|---|
| Equipment Title                   | Description   | Illustration  |
| <b>Bump cap</b>                   | Bump cap is extremely light in weight and features a replaceable suspension and sweatband. Popular where the possibility of a head bump or laceration is possible. Ideal for those working in areas with low head clearance. Four-point easily adjustable plastic suspension with perforated vinyl sweatband. |   |
| <b>Hard hat</b>                   | A safety cap adjusts from head with 4 to 6-point nylon web suspension system. Hearing, welding, and face shield accessories should be able to be snapped into universal slots. Must meet or exceed OSHA and ANSI Z89.1 standards.   |  |
| <b>Helmet respirator</b>          | Combination of PAPR respirator built into a safety cap adjusts from head with 4 to 6-point suspension system. Must meet or exceed OSHA and ANSI Z89.1 standards.  |  |

## 7. Hearing Protection

If you have any questions about the appropriate type of hearing protection required for your work activity, contact your Supervisor or the Facility Support Representative, Industrial Hygiene (IH) Representative, or ESH Coordinator assigned to your organization.

Two main types of hearing protection devices are used to protect workers' hearing from noise in the workplace:

- 1) **earplugs** that are inserted into the ear canal and
- 2)  **earmuffs** that are worn over the head to cover the outer ear.

The ability of the hearing protection devices to attenuate (reduce) noise is expressed as a *Noise Reduction Rating (NRR)*. The higher the NRR, the more protection the device provides.

The NRR is a theoretical value. OSHA recommends adjusting the NRR to account for variability in the fitting of the devices to the individual. The formula for calculation of the adjusted NRR is:

$$\frac{(NRR_{(EPA)} - 7 \text{ db})}{2} = NRR_{(BNL)}$$

Example:

NRR on box of ear muffs is 29 dB

$$\frac{(29\text{dB} - 7\text{db})}{2} = \frac{22}{2} = 11 \text{ NRR}_{(BNL)}$$

Example: If a noise area is 93 dBA  
Then: 93 dBA – **11 dBA NRR** = 82 dBA

## 7A: Types of Protective Equipment

| Equipment Title                        | Description  | Illustration  |
|--|--|---|
| <p><b>Earplugs</b></p>                 | <p>Soft, smooth foam is molded for maximum comfort, Tapered design with rounded tip aids insertion, typically NRR to about 29 dB (field use NRR = 11 dB).</p> <p>Fit into and seal the ear canal; generally treated as "disposable" after each use.</p>  |    |
| <p><b>Banded plugs</b></p>             | <p>High visibility headband for easy compliance checks, typically to NRR 22 dB (field use NRR = 8 dB).</p>   |   |
| <p><b>Earmuffs</b></p>                 | <p>Soft ear cushions improve comfort, typically Dielectric design for use around electrical hazards, Noise Reduction Rating typically range for NRR 20 to 30 (field use NRR = 7 to 12 dB), tested in accordance with ANSI S3.19.</p> <p>Use when frequent removal and replacement of hearing protection is necessary.</p>  |  |
| <p><b>Noise cancellation muffs</b></p> | <p>Headphones that use a small microphone mounted in each earpiece to monitor the outside noise getting to the ear. A special electronic circuit then creates a signal perfectly opposite to the outside noise so as to cancel it out before it reaches the ear.</p> <p>Typically they are only able to reduce noise by about 10 dB over a limited frequency range. They cancel low frequencies best and typically do not cancel high frequencies effectively.</p> |  |

## 8. Respiratory Protection

See the [Respiratory Protection](#) Subject Area for program requirements and required procedures.

For selection of Respiratory Protective Equipment, issuance of equipment, and cleaning and maintenance, contact the [RCD Facility Support Representative](#).

### 8A: Types of Respiratory Protective Equipment

| Equipment Title                                     | Description  | Illustration  |
|---|--|---|
| <b>Disposable dust masks (filtering face piece)</b> | <p>The filtering media forms the facepiece to face seal. Used for nonhazardous dusts or worker convenience and comfort.</p> <p><b>Note:</b> Not permitted for use at BNL in any situation in which a respirator is needed unless written consent is granted by the BNL Respiratory Protection Program Administrator (see the Point of Contact in the <a href="#">Respiratory Protection</a> Subject Area).</p> |   |
| <b>Minimal use dust filtering mask</b>              | <p>Used for nonhazardous dusts or worker convenience and comfort. Polymer sealing surface fits user face.</p> <p><b>Note:</b> Use is limited to operations with written consent is granted by the BNL Respiratory Protection Program Administrator (see the Point of Contact in the <a href="#">Respiratory Protection</a> Subject Area).</p>  |  |
| <b>APR half-face</b>                                | <p>Air Purifying Respirator (APR) - Minimum level of protection at BNL for hazardous situations. Relies on cartridge media to clean the air that will be breathed.</p>   |  |

## 8A: Types of Respiratory Protective Equipment

| Equipment Title          | Description   | Illustration  |
|--------------------------|---|---|
| <b>APR - full face</b>   | Air Purifying Respirator (APR) - Moderate level of protection at BNL for hazardous situations. Relies on cartridge media to clean the air that will be breathed.  |    |
| <b>PAPR - full face</b>  | Powered Air Purifying Respirator (PAPR) - higher level of protection than APR. Relies on cartridge media to clean the air that will be breathed. Air is pressurized by a blower into the mask. Selection of accompanying cartridge is made only by BNL Authorized Issuer. |    |
| <b>Welding helmet</b>    | Combines air purification with eye protection from the shaded lenses.   |    |
| <b>Military mask</b>     | This mask is only for use by the Safeguards and Security Division at BNL.   |   |
| <b>Gas mask</b>          | APR with high volume canister instead of a cartridge(s).  |  |
| <b>PAPR helmet</b>       | Provides the minimum level of protection, only for particulates. Does not require a fit test.   |  |
| <b>Supplied air hood</b> | Provides clean air from a compressed air source-- either a bottle of Grade D breathing air or a compressor tested to provide Grade D breathing air. Does not require a fit test.  |  |

## 8A: Types of Respiratory Protective Equipment

| Equipment Title                 | Description   | Illustration  |
|---------------------------------|---|---|
| <b>Supplied air - full face</b> | Provides clean air from a compressed air source-- either a bottle of Grade D breathing air or a compressor tested to provide Grade D breathing air.   |  |
| <b>SCBA</b>                     | <p>Provides clean air from a compressed air bottle worn by the user.</p> <p>Permitted for use at BNL in situations in which an emergency device is needed. Use is limited to Emergency Services Division Fire Rescue Personnel and other allied organization in emergency response.</p> |  |
| <b>Escape-bottled air pack</b>  | Provides a minimal amount of clean air from a compressed air bottle worn by the user. Used for escape only. Can be used for escape from oxygen-deficient areas.   |  |