

## Personal Protective Equipment (PPE)

- [Need for PPE](#)
- [PPE Selection](#)
- [Levels of PPE](#)
- [Types of Protection](#)
- [Elements of a PPE Management Program](#)
- [Limitations of PPE](#)
- [Medical Management](#)
  - [Levels of Clearance](#)
- [References and Additional Resources](#)

---

### Need for PPE

Personal protective equipment, or PPE, is designed to provide protection from serious injuries or illnesses resulting from contact with chemical, radiological, physical, electrical, mechanical, or other hazards. Careful selection and use of adequate PPE should protect individuals involved in chemical emergencies from hazards effecting the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing. No single combination of protective equipment and clothing is capable of protecting against all hazards. Thus PPE should be used in conjunction with other protective methods, including exposure control procedures and equipment.

[top of page](#)

---

### PPE Selection

The onsite incident commander will define the PPE ensemble required based on the conditions at the scene. For first receivers and hospitals, PPE selection is based on the institution's chemical emergency procedures.

- Guidance used for selecting appropriate PPE for chemical emergencies is available.
  - For First Responder - [OSHA/NIOSH Interim Guidance: Chemical - Biological - Radiological - Nuclear \(CBRN\) Personal Protective Equipment \(PPE\) Selection Matrix for Emergency Responders](#) (OSHA, NIOSH, April 2005)
  - For Hospital Providers - [OSHA Best Practices for Hospital-Based First Receivers of Victims from Mass Casualty Incidents Involving the Release of Hazardous Substances](#) (PDF - 1.93 MB) (OSHA, January 2005)

[top of page](#)

---

## Levels of PPE

Personal protective equipment is divided into four categories based on the degree of protection afforded.

- **Level A** protection should be worn when the highest level of respiratory, skin, eye and mucous membrane protection is needed. A typical Level A ensemble includes:
  - Positive pressure (pressure demand), self contained breathing apparatus (SCBA) (NIOSH approved), or positive-pressure supplied air respirator with escape SCBA.
  - Fully encapsulating chemical protective suit.
  - Gloves, inner, chemical resistant.
  - Gloves, outer, chemical resistant.
  - Boots, chemical resistant, steel toe and shank; (depending on suit boot construction, worn over or under suit boot.)
- **Level B** protection should be selected when the highest level of respiratory protection is needed, but a lesser level of skin and eye protection is needed. Level B protection is the minimum level recommended on initial site entries until the hazards have been further identified and defined by monitoring, sampling, and other reliable methods of analysis, and equipment corresponding with those findings utilized. A typical Level B ensemble includes:

- Positive-pressure (pressure-demand), self-contained breathing apparatus (NIOSH approved), or positive-pressure supplied air respirator with escape SCBA.
- Chemical resistant clothing (overalls and long-sleeved jacket, coveralls, hooded two-piece chemical splash suit, disposable chemical resistant coveralls.)
- Gloves, outer, chemical resistant.
- Gloves, inner, chemical resistant.
- Boots, outer, chemical resistant, steel toe and shank.
- **Level C** protection should be selected when the type of airborne substance is known, concentration measured, criteria for using air-purifying respirators met, and skin and eye exposure is unlikely. Periodic monitoring of the air must be performed. A typical Level C ensemble includes:
  - Full-face or half-mask, air-purifying respirator (NIOSH approved).
  - Chemical resistant clothing (one piece coverall, hooded two piece chemical splash suit, chemical resistant hood and apron, disposable chemical resistant coveralls.)
  - Gloves, outer, chemical resistant.
  - Gloves, inner, chemical resistant.
  - Boots, steel toe and shank, chemical resistant.
- **Level D** protection is primarily a work uniform and is used for nuisance contamination only. It requires only coveralls and safety shoes/boots. Other PPE is based upon the situation (types of gloves, etc.). It should not be worn on any site where respiratory or skin hazards exist.

[top of page](#)

---

## Types of Protection

There are many types of protective equipment, each with specific applications and use requirements. Information on common elements of the PPE ensemble include:

- **Respiratory**

- Responders should use appropriate respirators to protect against adverse health effects caused by breathing contaminated air.
  - [NIOSH Respirators Guidance](#) (CDC/NIOSH)
- **Eye & Face**
  - Eye and face protection should protect responders from the hazards of flying fragments, hot sparks, and chemical splashes.
    - [NIOSH Eye Safety Guidance](#) (CDC/NIOSH)
- **Skin**
  - Skin protection should be used when responders may be exposed to harmful substances.
    - [NIOSH Protective Clothing & Ensembles Guidance](#) (CDC/NIOSH)
- **Noise**
  - Earplugs or earmuffs can help prevent damage to hearing. Exposure to high noise levels can cause irreversible hearing loss or impairment as well as physical and psychological stress.
    - [NIOSH Noise and Hearing Loss Prevention Guidance](#) (CDC/NIOSH)

[top of page](#)

---

## Elements of a PPE Management Program

PPE use requires the implementation of a management program. Some elements of an effective program include:

- Respirator Use Certification and Fit Testing
  - [OSHA respirator fit testing](#) (OSHA)
- Training - [OSHA Training Information](#) (OSHA)
  - Proper donning of PPE
  - Limitations of PPE
  - Maintenance and Care of PPE
  - Useful life of PPE, disposal

[top of page](#)

---

## Limitations of PPE

Decisions about PPE use must consider its limitations.

- Safety Hazards
  - Restricted movement due to weight
  - Restricted vision due to visual field limitations
  - Difficulty communicating due to face protection
- Physiological/Psychological stressors
  - Psychological stress resulting from confining nature of full suits
  - [Heat stress](#) and risk of dehydration
  - The highest levels of PPE generally cannot be worn continuously for more than 30 minutes
- Management Requirements
  - Need for a management program that ensures effective use of PPE
    - Facial hair interferes with proper fit of masks
    - Improper use, penetration/tears are potentially hazardous

[top of page](#)

---

## Medical Management

Because of the psychological and physiological stresses involved, PPE use requires medical surveillance and clearance.

- [OSHA Medical Clearance Questionnaire](#) (OSHA)
- **Levels of PPE Clearance**
  - Level 1 - Escape devices only
  - Level 2 - Air purifying only (with dermal protection)

- Screening- occupational and medical history, vital signs including (BP), EKG, PE of cardio/pulmonary systems, spirometry, hearing and vision screening
  - Level 3 - Full spectrum of PPE
    - Screening - Level 2 evaluation plus Exercise tolerance test (dependent upon and CV evaluation)
- **Medical Monitoring for use scenarios**
  - **Pre-entry**
    - Record weight, vital signs
    - Record recent medical history
    - Compare to individuals baseline information per institution policy
    - Report any concerns to physician
    - Place identification tape with name and role on the back of the responder
    - Complete safety check by a second person
    - Record the starting time PPE is put on
  - **During the event**
    - Monitor staff time in PPE
    - Have second team preparing to relieve first team in PPE
  - **Post-entry**
    - [Decontamination](#)
    - Record amount of time in PPE (general guideline is 30 minutes)
    - Record weight, vital signs
    - Ensure hydration

[top of page](#)

## References

1. [Rhode Island Department of Environmental Management. Personal Protection Equipment](#) (PDF - 96 KB) (Rhode Island Department of Environmental Management)
2. [Fact Sheet: Personal Protection Equipment](#) (PDF - 52 KB) (OSHA, 2006)
3. [Personal Protection Equipment](#) (PDF - 629 KB) (OSHA, 2003)
4. [Safety and Health Topics: Personal Protection Equipment](#) (OSHA)

## Additional Resources

1. [Personal Protection Equipment](#) (OSHA)
2. [U.S. Department of Transportation. Emergency Response Guidebook \(ERG\)](#) (DOT)
3. [Personal Protection Equipment Training](#) (DHS)

## Basic Decontamination

### Set up Considerations

- Use pictorial and written posted instructions for victims to self decon when able, use locale-appropriate multilingual signage.
- Double bag contaminated clothing etc. (place hearing aids, valuables in small bag). Place bag in container by showers.
- Victims who are able may assist with their own decontamination.
- **Children and the elderly are at increased risk for hypothermia - provide warm showers, blankets.**
- Privacy must be considered, if possible.
- The decontamination system should be designed for use in children of all ages, by parentless children, the non-ambulatory child, the child with special needs, and also **allow families to stay together.**
- Use step-by-step child friendly instructions that explain to the children and parents what they need to do, why they are doing it, and what to expect.
- Take into consideration that infants when wet are slippery and will need a way to get them through the decontamination process - i.e. plastic buckets, car seats, stretchers...
- Designate a holding area and provide staff to support and supervise the children.
- Recommended age appropriate staffing ratios for untended children:
  - 1 adult to 4 infants
  - 1 adult to 10 preschool children
  - 1 adult to 20 school-age children

### Washing Instructions

- If there will be significant delay to decontamination, have the victims disrobe (disposable clothing kits should be available).

- Remove all clothing (at least down to their undergarments) and place the clothing in a labeled durable 6-mil polyethylene bag (removal of clothing, at least to the undergarment level will reduce victim's contamination by 85 %).
- **If exposure to liquid agent is suspected**, cut and remove all clothing and wash skin immediately with soap and water.
- **If exposure to vapor only is certain**, remove outer clothing and wash exposed skin with soap and water.
- The eyes must be decontaminated within minutes of exposure to liquid nerve agent to limit injury. Flush the eyes immediately with water for about 5 to 10 minutes by tilting the head to the side, pulling eyelids apart with fingers, and pouring water slowly into eyes. There is no need to flush the eyes following exposure to nerve agent vapor. Remove contact lenses if easily removable without additional trauma to the eye.
- If clothes have been exposed to contamination, then extreme care must be taken when undressing to avoid transferring chemical agents to the skin - i.e. any clothing that has to be pulled over your head should be cut off instead of being pulled over your head.
- Scraping with a wooden stick, i.e. a tongue depressor or popsicle stick, can remove bulk agent.
- Cover all open wounds with plastic wrap prior to performing head to toe decontamination (particular attention should be made to open wounds because cyanide is readily absorbed through abraded skin).
- Flush the exposed skin and hair with plain water for 2 to 3 minutes then wash twice with mild soap. Rinse thoroughly with water. Be careful not to break the patient/victim's skin during the decontamination process.
- **Caution - many people shower as they as they do it at home rather than conducting a rapid decontamination of their bodies. Too aggressive scrubbing can lead to further damage to skin and open wounds.**
- Irrigate exposed or irritated eyes with plain water or saline for 5 minutes. Continue eye irrigation during other basic care or transport. Remove contact lenses if easily removable without additional trauma to the eye.
- Utilizing large amounts of water by itself is very effective (limit pressure in infants).
- If water supplies are limited, and showers are not available an alternative form of decontamination is to use 0.5 % sodium hypochlorite solution, or absorbent powders such as flour, talcum powder, or Fuller's earth.



- **Sodium hypochlorite is not recommended for use in infants and young children.**
- **Certification of decontamination is accomplished by any of the following: processing through the decontamination facility; M9 tape; M256A1 ticket; or by the Chemical Agent Monitor (CAM).**
- If still contaminated repeat shower procedure.

In cases of ingestion, do not induce emesis. If the victim is alert, asymptomatic, and has a gag reflex, administer slurry of activated charcoal (administer at 1 gm/kg, usual adult dose 60-90 g, child dose 25-50 g). A soda can and a straw may be of assistance when offering charcoal to a child (consider naso-gastric tube - if possible contact ED prior to use of NG tube in infants and children [risk vs. benefit of inducing emesis with NG tube placement]).

### **Decontamination of First Responder**

- Begin washing PPE of the first responder using soap and water solution and a soft brush. Always move in a downward motion (from head to toe). Make sure to get into all areas, especially folds in the clothing. Wash and rinse (using cold or warm water) until the contaminant is thoroughly removed.
- Remove PPE by rolling downward (from head to toe) and avoid pulling PPE off over the head. Remove the SCBA after other PPE has been removed.
- Place all PPE in labeled durable 6-mil polyethylene bags.

### **Decontamination of Infants and Children**

- Video: Decontamination of Infants and Children (HHS/AHRQ, Children's Hospital Boston) ([Watch video](#))
  - [Decontamination of Children](#) (HHS/AHRO) provides a step-by-step decontamination demonstration in real time, and trains clinicians about the nuances of treating infants and children, who require special attention during decontamination.

### **Wound Management**

- Link to [Wound Management](#)

### **References**

1. Medical Management of Chemical Casualties Handbook, 2nd edition, September, 1995
2. Braue EH, Boardman CH. Decontamination of Chemical Casualties
3. Jagminas L. CBRNE - Chemical Decontamination (eMedicine)

## Nerve Agents Wound Management

- Following total body decontamination the plastic wrap is removed and the wounds are flushed. Bandages are replaced only if bleeding reoccurs. Tourniquets are replaced with clean tourniquets and the sites of the original tourniquets are decontaminated. Splints are thoroughly decontaminated (removed only by a physician).
- The new dressings are removed in the operating room and submerged in a 5% solution of hypochlorite or placed in a plastic bag and sealed
- The blood and necrotic tissue of the wound "buffers" the nerve agents. Nerve agent that reaches viable tissue is rapidly absorbed. The potential risk from contaminated wounds arises from chemical agent in the wound and from thickened agents combined with the debridement process.
- Wound contamination assessment - The Chemical Agent Monitor (CAM) can be used to locate contaminated objects within a wound (30 seconds are required to achieve a bar reading). The CAM detects vapor, but may not detect a thickened agent or liquid on a foreign body.
- **Thickened Agents**
  - Thickened agents are chemical agents that have been mixed with another substance (commonly an acrylate) to increase their persistency.
  - They do not dissolve as quickly in biological fluids, nor are they absorbed as rapidly by tissue as other similar agents.
  - Though the vapor hazard to surgical personnel is extremely low, contact hazard does remain.
- **Off-Gassing**
  - The risk from vapor off-gassing from chemically contaminated shrapnel and cloth in wounds is low and not significant.
  - There is no vapor release from contaminated wounds without foreign bodies.
  - Off-gassing from a wound during surgical exploration will be negligible.
  - No eye injury will occur from any of the agents (a chemical-protective mask is not required for surgical personnel)
- **Wound Exploration/Debridement**
  - No single glove material protects against every substance. Butyl rubber gloves generally provide better protection against chemical warfare agents

and most toxic industrial chemicals (but not all) than nitrile gloves, which are generally better than latex surgical gloves.

- Surgeons and assistants are advised to wear two pair of gloves: a nitrile (latex if nitrile is not available) inner pair covered by a butyl rubber outer pair.
- Thicker gloves provide better protection but less dexterity. Latex and nitrile gloves are generally 4 to 5 mils thick (1 mil = 1/1,000 of an inch). The recommended butyl rubber glove is 14 mils thick; if greater dexterity is needed a 7-mil butyl glove may be worn. A study at the US Army Soldier and Biological Chemical Command showed breakthrough times for distilled mustard (HD) and sarin (GB) depended on glove material and thickness. N-Dex (Best Manufacturing, Menlo, GA) nitrile gloves (4 mil) had a breakthrough time of 53 minutes for HD and 51 minutes for GB. North (North Safety Products, Cranston, RI) butyl gloves (30 mil) had a breakthrough time of over 1,440 minutes for both HD and GB. The safety standard operating procedure at USAMRICD for working with neat (referring to a chemical's neat means it's full-concentration, undiluted state) agents requires a maximum wear time of 74 minutes for HD and 360 minutes for G agents (volatile nerve agents) and VX (a low volatility nerve agent) when wearing 7-mil butyl rubber gloves over 4-mil N-Dex nitrile gloves. Wearing this glove combination is recommended until users ascertain that no foreign bodies or thickened agents are in the wound [2].
- Double latex surgical gloves have no breakthrough for 29 minutes in an aqueous medium; they should be changed every 20 minutes (changing gloves is especially important when puncture is likely because of the presence of bone spicules or metal fragments).
- The wound should be explored with surgical instruments rather than with fingers.
- Superficial wounds should be subjected to thorough wiping with 0.5% hypochlorite and subsequent irrigation with normal saline or irrigation with saline or water for an additional 5- 10 minutes [3]
- Removed fragments of tissue, pieces of cloth and associated debris must not be examined closely, and quickly disposed of in a container of 5% hypochlorite.
- Bulky tissue such as an amputated limb should be placed in a plastic or rubber bag (chemical proof) which is then sealed.

- The wound can then be checked with the CAM which may direct the surgeon to further retained material. It takes about 30 seconds to get a stable reading from the CAM. A rapid pass over the wound will not detect remaining contamination.
- The wound is debrided and excised as normal, maintaining a no-touch technique.
- Hypochlorite solution (0.5%) may be instilled into deep non-cavity wounds following the removal of contaminated cloth. This solution should be removed by suction to an appropriate disposal container. Within a short time, i.e., 5 minutes, this contaminated solution will be neutralized and nonhazardous. Subsequent irrigation with saline or other surgical solutions should be performed.
- Penetrating abdominal wounds caused by large fragments or containing large pieces of contaminated cloth chemically contaminated cloth will be uncommon.
- Surgical practices should be effective for the majority of wounds in identifying and removing the focus of remaining agent within the peritoneum. When possible the CAM may be used to assist.
- Saline, hydrogen peroxide, or other irrigating solutions do not necessarily decontaminate agents, but may dislodge material for recovery by aspiration with a large bore sucker. The irrigation solution should not be swabbed out manually with surgical sponges. The risk to patients and medical attendants is minuscule. However, safe practice suggests that any irrigation solution should be considered potentially contaminated.
- Following aspiration by suction the suction apparatus and the solution should be disposed of in a solution of 5% hypochlorite.
- Instruments that have come into contact with possible contamination should be placed in 5% hypochlorite for 10 minutes prior to normal cleansing and sterilization.
- Reusable linen should be checked with the CAM, M-8 paper, or M-9 tape for contamination. If found to be contaminated it should be disposed of in a 5-10% hypochlorite solution.

[top of page](#)

## References

1. Medical Management of Chemical Casualties Handbook, 2nd edition, September, 1995
2. Braue EH, Boardman CH. Decontamination of Chemical Casualties
3. Jagminas L. CBRNE - Chemical Decontamination (eMedicine)