PERSONAL PROTECTIVE EQUIPMENT (PPE) FOR FIRST MEDICAL RESPONDERS IN DISASTERS

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PERSONAL PROTECTIVE EQUIPMENT

Background

Natural and man-made (both intentional and unintentional) disasters can involve a wide range of hazardous substances – from industrial chemicals to military grade chemical or biological weapons agents to radiological/nuclear materials. Transportation and treatment of patients, whether at the scene of such an emergency or at a medical care facility, can put healthcare providers at risk of occupational exposures to hazardous materials of all kinds. Having appropriate personal protective equipment (PPE) is essential in order for healthcare providers to perform their life-saving duties providing care to the injured while protecting themselves and the facilities in which they work.

Healthcare providers' need for PPE during patient care was demonstrated in the wake of the 1995 sarin nerve gas attack in the Tokyo subway system. Off-gassing from patients during and after transport to hospitals added 135 pre-hospital providers and over 100 medical providers to the list of victims (Okumura, 2000). This event also illustrated the need for decontamination capabilities and comprehensive medical response planning, training, and preparedness efforts within the healthcare community. Almost 14 years after the Tokyo attack, much of the PPE in use by healthcare providers remains incompatible with delivering patient care.

Medical personnel must wear proper PPE when working in an area known or suspected to be contaminated, or when handling patients who are or may be contaminated. Experience has shown that hospitals will receive not only those patients transported by emergency medical services (EMS). In addition, hospitals – especially those closest to the scene of the emergency – will receive a large number of self-referred casualties. In many cases, these walk-in casualties will not have undergone any field decontamination, making the need for PPE at the hospital even more acute.

This report will discuss current understandings and common uses of PPE, present a matrix of the specific PPE needs of various healthcare personnel, and identify current medical response models – both on-scene and at medical care facilities – for incidents involving hazardous materials.

Current Personal Protective Equipment

The PPE ensembles that are currently available to healthcare providers were developed for use in the chemical and hazardous materials industries and have been adopted for use in the healthcare setting. In practice, this means that the PPE in use is often not

suited to the tasks that healthcare providers must accomplish while wearing it, and at times severely limits their ability to provide appropriate medical care.

PPE is designed to protect the respiratory system, skin, eyes, and mucous membranes from dangerous exposures. In order to provide the protection needed, the proper type of suit and fabric must be selected, along with appropriate respiratory and eye protection, gloves and boots. Each component must be able to protect the wearer from the hazards of concern.

There is no one suit, glove, or boot fabric or material that will protect the wearer from all hazardous materials. PPE ensembles that provide protection against chemicals, biological agents and radiological materials do not provide protection against fire or explosion, though some manufacturers are starting to produce chemical protective suits that incorporate some heat and flammability protection into the fabric.

Clothing

Protective suits can be classified by intended use into two categories – limited use garments and reusable garments. Limited use garments are made of protective materials that are designed to be used and then discarded. They are engineered for one or a low number of wearings and are to be discarded when they become damaged or contaminated, eliminating many of the health and safety concerns regarding decontaminating protective clothing and returning it to service. The advantages of limited use garments include lower costs, the ability to stock a larger and more varied protective clothing inventory, and reduced inspection and maintenance requirements. They are often used for support functions, including decontamination, remedial clean-up of identified chemicals, and training (Noll, 2005, pp. 358 - 359).

Reusable garments are designed and fabricated to allow for decontamination and reuse. They tend to be thicker and more durable then limited use garments. Certain exposures require the disposal of this clothing. Reusable garments tend to be significantly more expensive then limited use garments. (Noll, 2005, p. 359)

Respiratory Protection

Inhalation of hazardous materials is the most common exposure route and is often the most damaging. The selection of respiratory protection should be based on a number of factors, including the following:

- The physical form of the contaminant
- Has the contaminant been identified?
- Are the concentrations known or unknown?
- What is the purpose of response operations?

- What will be the duration of response operations?
- What are the operating environment and conditions?
- What type and level of skin protection will be needed?

Respiratory protection can be provided by either air-purifying devices or by atmosphere-supplying respiratory equipment.

Air-purifying devices are respirators that remove particulate matter, gases, or vapors from the ambient air before inhalation. The proper air-purifying cartridge must be used for expected contaminants. There are two basic types of air-purifying devices that can be used for emergency response purposes:

> **Air-Purifying Respirators** (APRs) are respirators with an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element. These are negative pressure respirators that can be found in either full-face or half-face configurations with sorbent, mechanical, or combination cartridges attached. The full-face configuration is typically the respirator of choice for emergency response applications.
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> **Powered Air-Purifying Respirators** (PAPR) are air-purifying respirators that use a blower to force ambient air through air-purifying elements to either a full-face mask or a hood. As a result, there is a slight positive pressure in the face piece that results in an increased protection factor. Whereas an APR has a protection factor of 50:1, a PAPR will have a protection factor of 1000:1 (a protection factor of 1 = no respiratory protection in place. A protection factor of 1000 means that the concentration of a breathed contaminant is reduced by a factor of 1000 from the ambient concentration). PAPRs are used in a wide range of emergency response and post-response applications, including decontamination, patient handling at medical facilities, and investigation of hazardous materials- and terrorism-related crimes.

A number of operational considerations govern the selection and use of APRs and PAPRs:

- Air monitoring must be in place
- Cannot be an Immediately Dangerous to Life and Health (IDLH) or oxygen-deficient atmosphere
- The contaminant must be known; concentration of the contaminant should also be known
- Require fit testing for use

Respiratory protection devices with an air source are called **atmosphere-supplying devices**. These devices provide the highest available protection against airborne

contaminants and oxygen-deficient atmospheres. Only positive pressure devices should be used for emergency response applications. There are two basic types of atmosphere-supplying devices: self-contained breathing apparatus (SCBA) and supplied air respirators (SAR). Positive pressure respirators provide a protection factor of 10000:1.

There are two types of SCBA:

> **Open circuit SCBA** are those where exhaled air is released directly into the ambient atmosphere. It is the predominant type of SCBA used in emergency response.
>
> **Closed Circuit SCBA** are those where exhaled air is recycled by removing the carbon dioxide with an alkaline scrubber and replenishing the consumed oxygen from a solid, liquid, or gaseous oxygen source. Closed circuit SCBA are used for specialized response scenarios where long, extended operations may be required. They are not commonly used with chemical protective clothing and may generate heat, which can add to the heat stress encountered in chemical protective suits.

Supplied air respirators can be used when extended work times are required for entry, decontamination, or remedial clean up operations. They are lighter and less cumbersome than SCBA because the worker does not wear the primary air supply. The components of a SAR include:

1. Source of breathing air: cylinder, cylinder cart, or cascade system
2. Air-line hose up to 300 feet in length
3. Positive pressure respirator
4. Emergency air supply, such as a small escape pack (Noll, 2005, pp. 364 - 368)

PPE Standards

As noted in Roberson (2006) the European Committee for Standardization (CEN) has issued five chemical protective clothing standards. Compliance with these standards are indicated by the “CE” (Conformite Europeenne) marking system. These standards divide chemical protective apparel into six major classifications:

- EN 943-2:2002—CE Type 1, Gas-Tight Clothing
- EN 943-1:2002—CE Type 2, Non-Gas-Tight Clothing
- EN 14605:2005—CE Type 3, Liquid-Tight Clothing; CE Type 4, Spray-Tight Clothing
- ISO 13982 – 1:2004—CE Type 5, Solid Particulate Protective Clothing

- EN 13034:2005—CE Type 6, Limited Liquid Chemical Protective Clothing

In addition to fabric performance standards, the European system includes ensemble testing to ensure that not only the fabric, but also the entire garment provides an effective barrier to a specific chemical. In the absence of ensemble testing or a similar type of classification system, end users often focus on fabric test data when selecting chemical protective clothing. Some incorrectly assume that if the fabric is an effective barrier, garments made from that fabric will also be effective. Seam type, glove, boot, and respirator interfaces, and closure systems frequently are not given proper consideration in the selection process (Roberson, 2006).

In the United States, the standards-writing organizations have focused on protective clothing for emergency response. The National Fire Protection Association (NFPA) Technical Sub Committee on Hazardous Materials Protective Clothing and Equipment has developed three consensus documents that specify minimum documentation, design, and performance criteria, and test methods for chemical protective clothing. These standards often serve as minimum requirements in agency purchase specifications and cover the following:

- NFPA 1991 – Vapor Protective Ensembles for Hazardous Materials Emergencies
- NFPA 1992 – Liquid Splash Protective Ensembles for Hazardous Materials Emergencies
- NFPA 1994 – Protective Ensemble for Chemical/Biological Terrorism Incidents

Each standard requires independent, third party certification to ensure that the protective clothing meets its design, performance, and documentation requirements. Certification agencies, such as Underwriters Laboratories (UL) or the Safety Equipment Institute (SEI), certify the garment performance, not NFPA. Compliant products must carry a product label indicating compliance with the NFPA standard, a technical data package, and user instructions (Noll, 2005, p. 360).

The protection provided to the wearer by all of these garments is ensemble-based and relies on proper use of all the components (suit, gloves, boots, and respirator). Additionally, helmets, hearing protection, and cooling and ventilation equipment may be required.

In addition to the standards listed above, two U.S. regulatory agencies, the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA), have established a four-level system for chemical protection.

Level A provides the highest level of skin, eye, mucous membrane, and respiratory protection. This ensemble includes a positive pressure SCBA worn inside an encapsulating vapor-tight chemical resistant suit, inner and outer chemical resistant gloves, and chemical resistant boots. Level A is the minimum level considered for initial entry into a chemical, biological, or radiological release or suspected release due to a terrorist event. Lower levels of PPE may be utilized once intelligence and metering indicates that it is safe to use lower levels of protection.

Level B provides the highest level of respiratory protection, but a lower level of skin, eye, and mucous membrane protection. It is the minimum level recommended for initial site entries until the hazards have been further identified and defined by monitoring, sampling, and other reliable methods of analysis. The ensemble includes a positive pressure SCBA, a chemical splash suit, inner and outer chemical resistant gloves, and chemical resistant boots.

Level C provides lower levels of both respiratory and skin protection, and should be used when the type of airborne substance is known, the concentration is measured, the criteria for wearing an APR is met, and skin and eye exposure is unlikely. The ensemble consists of a full-face APR or PAPR, chemical resistant splash suit, inner and outer chemical resistant gloves, and chemical resistant boots. **Level C has been determined through research to be appropriate protection for hospital-based personnel caring for patients from an incident scene involving chemicals, biological materials, or radiological materials**.

Level D is primarily a work uniform and does not provide any measureable chemical protection and as such should not be worn on any site where respiratory or skin hazards exist.

The protective clothing and equipment discussed above, while designed to provide protection from chemicals, also provides adequate protection from both biological and some radiological agents.

With respect to radioactive hazards, alpha and beta particles are of primary concern. Gamma radiation can be reduced only through the use of shielding materials such as lead, but it does not present a contamination hazard when treating patients since it is not transmitted via particles. Alpha and beta particles can be found on patients or their clothing (AFFRI, 2006, pp. 9 - 10). The minimum level of PPE for medical responders and receivers treating patients thought or known to be exposed to radiation is CE Type 5 with a HEPA mask or APR/PAPR (Europe) or OSHA Level C (U.S.).

In the case of biological agents, standard precautions, including gloves, goggles, mask (N-95), gowns or other appropriate barriers, and the washing of hands, provide the best

measure of protection and should be utilized as a minimum (Keyes, 2005, p. 290). However, as in the case of patients exposed to radiation, CE Type 5 with a HEPA mask or APR/PAPR or OSHA Level C protection would also be appropriate.

The European and American PPE standards are not interchangeable because of significant differences in test methods, regulations, and the standards themselves. The most contentious of these differences centers around the determination of chemical permeation and penetration. To remedy this incompatibility, two organizations, the International Safety Equipment Association (ISEA) and the International Organization for Standardization (ISO), are working to develop U.S. standards that are modeled after the European system (Roberson, 2006).

The Limitations of PPE

While both the European and American systems are designed to aid in the selection of appropriate protective garments, these classification systems set only minimum requirements for chemical challenges based on a specified physical state and quantity of a given chemical. The standards and classification systems do not indicate the suitability of PPE for use against any chemical or material other than that required to verify minimum fabric performance. End users – typically industrial concerns – are left to develop or acquire chemical barrier data for the specific chemical(s) to which their employees will be exposed.

Beyond the question of matching PPE protection to anticipated hazards, there are four primary limitations that apply to all PPE. These limitations are heat stress, mobility, visibility, and communications problems. Heat stress is a major concern with all types of protective clothing but is extremely prominent in chemical PPE. The chemical ensembles are designed to keep chemicals outside, away from the body, but in doing so they also keep heat and moisture inside, limiting the body's ability to cool itself. Anyone wearing PPE must be monitored for the signs of dehydration and heat stress, which can progress from heat cramps to heat exhaustion to heat stroke, if not carefully monitored (Hawley, 2008, pp. 131 - 133).

The second limitation of PPE is mobility. The more layers of protection that are added to a PPE ensemble, the more mobility is lost, placing increasing stress on the body and the mind. Loss of mobility is of particular concern to healthcare providers, as it can degrade the level of medical care that they can provide. Current PPE ensembles do not permit fine manual dexterity and also inhibit the ability to feel by touch. The gloves that are in wide use provide adequate protection but do not let users feel for things as fine as a beating pulse or a vein, for example, should an intravenous intervention be necessary. One way to reduce the impact of this limitation is to select PPE based not

only on the hazard, but also on the mission of the person that will be wearing the PPE (Hawley, 2008, p. 133).

Visibility is the third limitation that PPE presents to the wearer. Several types of ensembles provide only a narrow opening for vision in the face piece of the self contained breathing apparatus (SCBA) or air purifying respirator (APR). These openings are often prone to fogging, which further reduces visibility (anti-fog wipes can mitigate this problem). Additional visibility issues are presented when the PPE is too large for the wearer. In this case the face shield of the suit might not move when the wearer turns his/her head, which then requires holding the face shield and manually turning it along with the head in order to see (Hawley, 2008, p. 133).

The fourth limitation of PPE is communications. The ability to communicate through respiratory protection, especially SCBA, is difficult at best and gets worse when a suit is placed over top of the face piece. In order to overcome these issues, hazardous materials teams rely on hand signals and/or radio communications systems based on ear or bone microphones (Hawley, 2008, pp. 133 - 134).

Several factors should inform the choice of the appropriate level of PPE for a given incident. Choosing wisely can reduce the impact of the limitations presented above. These factors include the following:

- Type of Hazard – flammability, corrosivity, toxicity, and/or radioactivity
- Explosive risk
- Vapor pressure of the chemical
- Contamination possibility
- Time on task
- Type of task/mission
- Temperature

The Use of PPE by Healthcare Providers

The protective clothing and equipment used to protect healthcare providers was developed for use in the chemical industry and the hazardous materials response field. This has led to a variety of differing opinions and the adoption of differing protection levels throughout the healthcare community. In recent years, the US Army Center for Health Promotion and Preventive Medicine (USACHPPM) and OSHA released (separate) guidance documents for the healthcare community with regards to the use of chemical protective equipment. The OSHA document is specifically for hospital personnel (“first receivers”). The USACHPPM document addresses both hospital and emergency medical services (EMS) personnel transporting patients to the hospital.

EMS personnel operating at the scene of a real or suspected hazardous materials release would have the same requirements as the other responders operating at the site.

Based on available data and research, it has been determined that the quantity of contaminant that healthcare workers might encounter can be dramatically smaller than the amount to which patients are exposed or that is originally deposited on the patients. Gas or vapor releases can expose victims to toxic concentrations, but tend to evaporate and dissipate quickly. Fedele (2003) determined that 100 grams of most moderately to highly volatile substances that might be sprayed on a victim during a mass casualty incident would evaporate within five minutes of the time the exposure occurred.

The OSHA document does not spell out different PPE levels for the different roles that hospital personnel play. However, OSHA has concluded that a Level C ensemble with a PAPR, nitrile inner gloves and butyl outer gloves and chemical resistant boots will provide adequate protection for hospital personnel for the majority of chemical incidents that they are likely to face (Occupational Safety and Health Administration (OSHA), 2005).

USACHPPM Technical Guide 275 is specific to weapons of mass destruction and terrorist events, and provides detailed and specific PPE recommendations. The recommendations are broken down based on the mission and role of providers, relating to the type and class of agent involved (USACHPPM, 2003).

The following matrices were adapted from USACHPPM Technical Guide 275 and modified in order to make them applicable to civilian responders. Modifications are indicated by *italics*.

Table 1: Personnel Performing Decontamination or Life-Saving Procedures on Contaminated Victims at the Medical Treatment Facility – Exposures to Toxic Industrial Chemicals (TICs) or Chemical Warfare Agents (CWAs)

PPE	Advantages	Disadvantages
Level B (with NIOSH-Certified tight-fitting full-face piece atmosphere supplying respirator as either SCBA *or SAR (with escape-only SCBA)*; hood; boot covers and *chemical resistant* boots or one-piece chemical protective overboot; chemical protective splash suit *(or CE type 3)* and gloves (e.g., butyl rubber glove worn over an inner disposable nitrile glove; if advanced medical care (e.g., endotracheal intubation, etc.) is necessary before decon, use 7-mil or 14-mil butyl rubber glove w/o nitrile glove; if sterility is required, double glove with disposable nitrile gloves, changing every ½ hour *or* after physically contacting a contaminated person and between touching patients.	Complies with OSHA when chemicals present an actual or potential inhalation hazard and the air contaminants have not been identified or the air concentrations have not been estimated to justify a lowering to Level C PPE. *Level B Protection* provides the highest level of respiratory protection.	Some medical personnel are concerned that if life-saving procedures need be done before victims are decontaminated, it may be difficult for medical personnel to deliver these procedures in Level B. Airline hoses may pose tripping hazards and may decrease mobility. *There may also be a chemical compatibility issue with the hose.* SCBA air tanks may be heavy and bulky. Air-supply tanks will have to be changed every 30-45 minutes. *All tight-fitting* respirators require fit-testing prior to use.
Level C [with NIOSH-Certified tight-fitting full-face piece PAPR equipped with combination HEPA or P-100 filter and organic and acid gas cartridges/canister; chemical protective splash suit (or CE Type 3); gloves, as above; hood covers; boot covers and rubber boots or one piece chemical protective over boot]	Provides a *greater* level of respiratory protection than a non-powered APR. Even if the battery dies, contaminated air is still filtered and the respirator therefore still provides some protection until a new battery can be installed. Easier to breathe with than a non-powered APR.	Does not comply with OSHA when chemicals present an actual or potential inhalation hazard and the air contaminants have not been identified or the air concentrations have not been estimated to justify a lowering to Level C PPE. Respirator requires fit-testing prior to use.
Level C [with NIOSH-Certified loose fitting helmet/hooded PAPRs equipped with combination HEPA or P-100 filter and organic and acid gas cartridges/canister. The manufacturer should supply data demonstrating an APF equivalent to a tight-fitting PAPR; chemical protective splash suit *(or CE Type 3)*; gloves, as above; boot covers and rubber boots or one-piece chemical protective over boot]	Same as with tight-fitting full-face piece PAPR, in addition to the following: The respirator does not require fit-testing prior to use. May be more comfortable than a tight-fitting full-face piece PAPR or non-powered APR.	Unlike a tight-fitting PAPR, if the battery fails, the respirator provides no protection *and may cause* the user will breathe unfiltered, contaminated air. To prevent this from happening, a rigorous program must be established to ensure that batteries are well maintained and will provide sustained performance during the response. Batteries should include those that are rechargeable (e.g., NiCad) and non-rechargeable with extended shelf life (e.g., Lithium).
Level C [with NIOSH-Certified full-face piece non-powered APR equipped with combination P-100 filter and organic and acid gas cartridges; chemical protective splash suit *(or CE Type 3)*; gloves, as above; boot covers and rubber boots or one piece chemical protective overboot.]	Not as expensive as the respirators indicated above.	Provides less respiratory protection than the respirators indicated above. Respirator requires fit-testing prior to use.

Note 1: The respirators, chemical protective clothing, and gloves must be demonstrated to be effective against CWA and TICs.
Note 2: A minimum of a PAPR is highly recommended for respiratory protection, and it is likely that PAPRs may prove to be the best overall procurement choice. However, any of the indicated respirators may be used.

Table 2: Personnel Performing Decontamination or Life-Saving Procedures on Contaminated Victims at the Medical Treatment Facility – Exposures to Biological Warfare Agents (BWAs) (after an overt attack) or Nuclear/Radiological Materials

PPE	Advantages	Disadvantages
The PPE recommended in Table 1 for TICs and CWA can also be used for protection against BWA and nuclear/radiological materials.	Procuring and using the same PPE for all terrorist agents simplifies things, and ensures the proper PPE is always used. It may be impractical and perhaps result in confusion to have one set of PPE available for TICs/CWAs and another for BWAs/radiological/nuclear materials.	If only BWA or nuclear/radiological materials are involved, using PPE that is also effective against TICs and CWA may be unnecessarily protective and costly.
Level C [with NIOSH-Certified tight-fitting full-face piece PAPR equipped with HEPA or P-100 filter; rubber gloves; Tyvek or equivalent garments; head and boot covers, etc.] *or CE Type 4*	Provides a very high level of respiratory protection, possibly as high as an airline respirator in some circumstances and greater than a non-powered APR. Even if the battery dies, contaminated air is still filtered and the respirator therefore still provides some protection until a new battery can be installed. Easier to breathe with than a non-powered APR.	Respirator requires fit-testing prior to use.
Level C [with NIOSH-Certified loose-fitting helmet/hooded PAPRs equipped with HEPA or P-100 filter (the manufacturer should supply data demonstrating an APF equivalent to a tight-fitting PAPR); rubber gloves; Tyvek or equivalent garments; boot covers, etc.] *or CE Type 4*	Same as with tight-fitting full-face piece PAPR, with the addition of the following: The respirator does not require fit-testing prior to use. May be more comfortable than a tight-fitting full-face piece PAPR or non-powered APR.	Unlike a tight-fitting PAPR, if the battery fails, the respirator provides no protection and the user will breathe unfiltered, contaminated air. To prevent this from happening, a rigorous program must be established to ensure that batteries are well maintained and will provide sustained performance during the response. Batteries should include those that are rechargeable (e.g., NiCad) and non-rechargeable with extended shelf life (e.g., Lithium)
Level C [with NIOSH-Certified full-face piece non-powered APR equipped with P-100 filter; rubber gloves; Tyvek or equivalent garments; hood and boot covers.] *or CE Type 4*	Not as expensive as the respirators indicated above.	Provides less respiratory protection than the respirators indicated above. Respirator requires fit-testing prior to use.

Note 1: A minimum of a PAPR is preferred for respiratory protection, and it is likely that PAPRs may prove to be the best overall procurement choice. However, a full-face piece non-powered APR is acceptable.
Note 2: For T-2 mycotoxins, use the PPE as described in Table 1 for CWAs and TICs.

Table 3: Triage and Perimeter Security Personnel at Medical Treatment Facility – Exposures to TICs and CWAs

Triage Category, Terrorist Agent, And PPE	Advantages	Disadvantages
Primary Triage and Perimeter Security		
Level C with PAPR (as described in Table 1) is preferred, if possible.	See Table 1	See Table 1
Level C [with NIOSH-Certified full-face piece non-powered APR equipped with combination P-100 filter and organic and acid gas cartridges; chemical protective clothing and gloves, boot covers and rubber boots or one-piece chemical protective overboot.] *or CE Type 4*	Not as expensive as a PAPR and is likely to offer enough protection in most situations.	Provides less respiratory protection than a PAPR. May not be as comfortable to wear as a PAPR. Respirator requires fit-testing prior to use.
Secondary Triage – TICs and CWAs		
Use of Level C PPE as recommended for Primary Triage personnel is discretionary for Secondary Triage personnel, unless circumstances and monitoring dictate otherwise. Except for the Standard Precaution PPE, no other special PPE is likely necessary, but may depend on the situation. The assumption made herein is that patients have been adequately decontaminated and pose no significant health hazard to secondary triage personnel, they are upwind from the decontamination area, and contaminated clothing is removed and contained upwind.		

Note 1: the respirators, CPC, and gloves must be demonstrated to be effective against CWA and TICs.
Note 2: It may be prudent to procure Level C PPE for secondary triage personnel, to be accessible should circumstances and monitoring indicate it is necessary.

Table 4: Triage and Perimeter Security Personnel at Medical Treatment Facility – Exposures to BWAs (after overt attack) and Radiological/Nuclear Materials

Triage Category, Terrorist Agent, and PPE	Advantages	Disadvantages
Primary Triage and Perimeter Security		
The PPE recommended in Table 3 for TICs and CWA can also be used for protection against BWA and nuclear/radiological materials.	Procuring and using the same PPE for all terrorist agents simplifies things, and ensures the proper PPE is always used. It may be impractical and perhaps result in confusion to have one set of PPE available for TICs/CWA and another for BWAs/radiological/nuclear materials.	If only BWA or nuclear/radiological materials are involved, using PPE that is also effective against TICs and CWA may be unnecessarily protective and costly.
Level C with a PAPR (as described in Table 2) is preferred, if possible. However, a non-powered APR as described below is acceptable. If procuring Level C with a PAPR, it may be wiser to procure one with the filters and cartridges as described for PAPRs in Table 1, since it would also protect against TICs and CWAs.	See Table 1 and Table 2	See Table 1 and Table 2
Level C [with NIOSH-Certified full-face piece non-powered APR equipped with P-100 filter; Tyvek or equivalent garments; hood and boot covers; rubber gloves.] *or CE Type 4*	Not as expensive as a PAPR and is likely to provide sufficient protection in most situations.	Provides less respiratory protection than a PAPR. Respirator requires fit testing prior to use.
Secondary Triage		
Use of Level C PPE as recommended for Primary Triage personnel is discretionary for Secondary Triage personnel, unless circumstances and monitoring dictate otherwise. Except for the Standard Precaution PPE, no other special PPE is likely necessary, but may depend on the situation. The assumption made herein is that patients have been adequately decontaminated and pose no significant health hazard to secondary triage personnel, they are upwind from the decontamination area, and contaminated clothing is removed and contained upwind.		

Note 1: It may be prudent to procure Level C PPE for secondary triage personnel, to be accessible should circumstances and monitoring indicate it is necessary.
Note 2: For T-2 mycotoxins, use the PPE as described in Table 3 for CWAs and TICs.

Table 5: Personnel Transporting (e.g., in ambulance) Victims to the Medical Treatment Facility – Exposures to TICs or CWAs

PPE	Advantages	Disadvantages
Patients grossly and secondarily decontaminated or not requiring decontamination:		
Standard Precaution PPE		
Contaminated patients that have undergone gross but not secondary decontamination.		
Level C with a PAPR (as described in Table 4) is preferred, if possible *or CE Type 3*.	See Table 1	See Table 1
Level C [with NIOSH-Certified full-face piece non-powered APR equipped with combination P-100 filter and organic and acid gas cartridges; chemical protective splash suit *or CE Type 3* and gloves (e.g., butyl rubber glove over an inner disposable nitrile glove); hood; boot covers and rubber boots or one piece chemical protective overboot.]	Not as expensive as a PAPR and is likely to offer enough protection in most situations.	Provides less respiratory protection than a PAPR. May not be as comfortable to wear as a PAPR. Respirator requires fit-testing prior to use.

Note 1: The respirators, chemical protective clothing, and gloves must be demonstrated to be effective against CWA and TICs.
Note 2: Ensure there is good fresh air ventilation inside the ambulance to minimize the vapor concentration.
Note 3: It is highly recommended that victims contaminated with CWA be thoroughly decontaminated (gross and secondary decontamination) before they are allowed to enter the ambulance, for the protection of both the ambulance crew and the contaminated victim.
Note 4: Victims contaminated with TICs should have undergone gross decontamination, at a minimum, before they are allowed to enter the ambulance.

Table 6: Personnel Transporting (e.g. in ambulance) Victims to Medical Treatment Facility – Exposures to BWAs (after an overt attack) and Radiological/Nuclear Materials

PPE	Advantages	Disadvantages
Patients grossly and secondarily decontaminated or not requiring decontamination:		
Standard Precaution PPE		
Contaminated patients that have undergone gross but not secondary decontamination.		
The PPE recommended in Table 5 for TICs and CWA can also be used for protection against nuclear/radiological materials.	Procuring and using the same PPE for all terrorist agents simplifies things, and ensures the proper PPE is always used. It may be impractical and perhaps result in confusion to have one set of PPE available for TICs/CWA and another for BWAs/radiological/nuclear materials.	If only BWA or nuclear/radiological materials are involved, using PPE that is also effective against TICs and CWA may be unnecessarily protective and costly.
Level C with a PAPR is preferred. However, a non-powered APR as indicated below is acceptable. If procuring Level C with a PAPR, it may be wiser to procure one with the filters and cartridges (as described for PAPRs in Table 1), since it would also protect against TICs and CWAs.	See Table 1 and Table 2	See Table 1 and Table 2
Level C [with NIOSH-Certified full-face piece non-powered APR equipped with P-100 filter; Tyvek or equivalent garments; hood and boot covers; rubber gloves.]	Not as expensive as a PAPR and is likely to provide sufficient protection in most situations.	Provides less respiratory protection than a PAPR. Respirator requires fit-testing prior to use.

Note: For T-2 mycotoxins, use PPE as described in Table 5.

Table 7: Incident Site – Hot Zone (or Exclusion Area)

CWA	TIC	BWA	Radiological/Nuclear
Level A encapsulating suit or *CE Type1* (initially) with NIOSH-Certified SCBA. The PPE level may be lowered if air monitoring indicates it is safe to do so.	Level A or B or *CE Type 1 or 3* (initially) with a NIOSH-Certified SCBA, the level depending on the chemical or situation. The PPE level may be lowered if air monitoring indicates it is safe to do so.	Level A or Level B or *CE Type 1 or 3*(with NIOSH Certified SCBA), or Level C or *CE Type 4 or 5* (with NIOSH-Certified PAPR, equipped with HEPA filters) or Level C (with NIOSH Certified full-face piece APR, equipped with P-100 filter), depending on situation.	Short-duration exposure: Level C or *CE Type 5* with a NIOSH-Certified full-face piece non-powered APR equipped with combination P-100 filter and organic vapor and acid gas cartridges/canister is acceptable, but a PAPR equipped with combination HEPA or P-100 filter and organic vapor and acid gas cartridges/canister is preferred; gloves; Tyvek or equivalent garments; hood and boot covers. Extended-duration exposure (days, weeks, months): Level B or Level C (*CE Type* 5) with a PAPR equipped with HEPA or P-100 filter and organic vapor and acid gas cartridges/canister, depending; gloves; Tyvek or equivalent garments; hood and boot covers.

Note: When responding to fires or entering buildings on fire, structural firefighting gear should be worn – including helmet, SCBA, and turnout gear (thermally insulated coat, pants, and boots.)

Table 8: Incident Site – Decontamination Zone (or Warm Zone) and Support Zone (or Cold Zone)

CWA	**TIC**	**BWA**	**Radiological/Nuclear**
Decontamination Zone (or Warm Zone)	*Decontamination Zone (or Warm Zone)*	*Decontamination Zone (or Warm Zone)*	*Decontamination Zone (or Warm Zone)*
Same PPE level as that used in the Hot Zone or one PPE Level lower than that used in the Hot Zone if professional judgment or air monitoring indicates it is safe to do so.	Same PPE level as that used in the Hot Zone or one PPE level lower than that used in the Hot Zone if professional judgment or air monitoring indicates it is safe to do so.	One PPE level lower than that used in the Hot Zone.	Same PPE level as used during short-duration exposure in the Hot Zone
Support Zone (or Cold Zone)	*Support Zone (or Cold Zone)*	*Support Zone (or Cold Zone)*	*Support Zone (or Cold Zone)*
Standard Precaution PPE	Standard Precaution PPE	Standard Precaution PPE	Standard Precaution PPE

(USACHPPM, 2003, pp. 36 - 44)

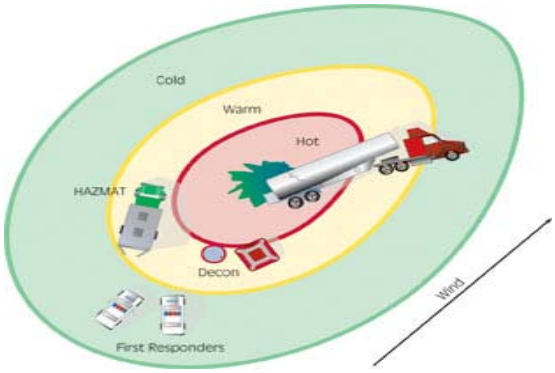
Response Models for the Field and Hospital

Currently there is only one medical response model recommended by U.S. regulatory agencies (OSHA and EPA) and taught in emergency responder training programs for use at the site of a hazardous materials release. This model is recommended in NFPA 472 (Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents) and NFPA 473 (Standard for Emergency Medical Services Personnel Responding to Hazardous Materials/ Weapons of Mass Destruction Incidents). This model also has been adopted for use by some hospitals.

The model calls for the establishment of three zones at an incident site. The first zone is known as the **exclusion zone** or **hot zone**. It is usually represented by the color red and indicates the area of the highest danger/contamination. The hot zone is the area immediately around the release, and is considered to have an atmosphere that is Immediately Dangerous to Life and Health (IDLH). Only personnel trained and equipped to the appropriate levels are permitted entry into the hot zone. At a hospital, this is any area where contaminated patients have gone prior to being decontaminated.

The **contamination reduction zone** or **warm zone** is an area adjacent to the hot zone that may become contaminated once victims or responders start to exit the hot zone. This zone is ideally located upwind, uphill, and upstream from the release. This zone may become contaminated by a wind shift or catastrophic protection failure. In many situations, the decontamination corridor can be set up by personnel prior to donning their PPE because this area does not become contaminated until persons (victims or responders) start to exit the hot zone. Adjacent to the decontamination corridor is an entry corridor for team members to pass into the hot zone to perform their assigned missions.

The **support zone** or **cold zone** is the area of least danger. This is the zone in which the Incident Command Post (ICP) is established along with all support operations such as the EMS treatment sector. The first responding personnel and equipment are staged here as well. Even though the cold zone is considered a safe area, it is not an area that the public is permitted to enter.

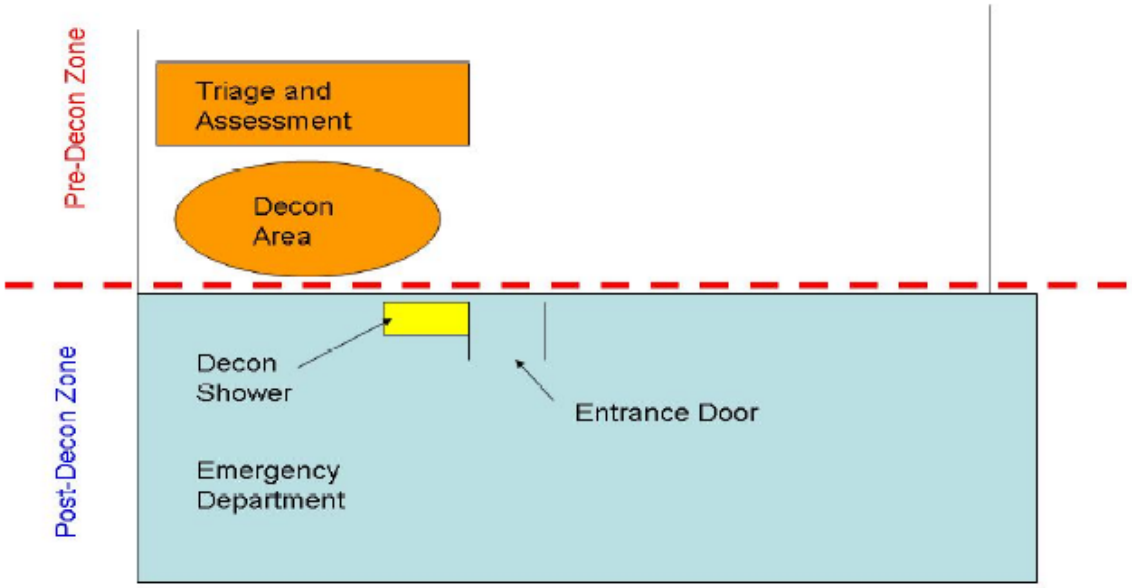


Arrangement of Zones at Incident Scene (Hawley, 2008, p. 149)

Based on research and reference data OSHA has determined that hospitals require a two-zone model for decontamination activities – *if the hospital is not the site of the release*.

The **Hospital Decontamination Zone** includes any areas where the type and quantity of the hazardous substance are unknown and where contaminated victims, equipment, and waste may be present. It is reasonably anticipated that staff members in this zone might be exposed to contaminated victims and their belongings, equipment, and waste. This zone includes, but is not limited to, areas where initial triage and/or medical stabilization of potentially contaminated victims occur, pre-decontamination waiting areas for victims, the actual decontamination area, and the post-decontamination victim inspection area. This area typically will begin at the patient drop-off area and end at the emergency department doors. This is also considered the warm zone.

The **Hospital Post-Decontamination Zone** is an area that is considered uncontaminated. Equipment and personnel are not expected to become contaminated in this area. At a hospital receiving contaminated victims, the Hospital Post-Decontamination Zone includes the emergency department (unless contaminated). This is also considered the cold zone.



Notional Layout of Hospital Decontamination Activities

Conclusion

Much of the PPE that is available and currently marketed to healthcare providers was designed for use in the chemical industry and at the scene of a hazardous materials release by those charged with stopping and cleaning up the release. Its use in healthcare was not considered during its design. Nevertheless, healthcare providers must be protected from exposure to hazardous materials.

Though many of the suit fabrics are becoming thinner and lighter, while offering increased protection from chemical hazards, much of the PPE on the market does not lend itself to providing medical care to patients. Providers must adopt ensembles that will provide them with current state of the art protection while constantly looking out for new and improved systems that will better facilitate delivery of medical services and protect wearers from potential exposure and/or contamination.

PPE must be used in conjunction with an appropriate response model that will enhance the protection provided by the PPE and also protect the facility itself. No protection will be possible without a commitment to 1) training those who will be expected to perform during emergencies as well as those who are expected to take a leadership role and guide the response; 2) developing plans for hazardous materials and other types of emergencies; and 3) exercising regularly to ensure familiarity with both plans and equipment and to identify their limitations before an emergency.

Works Cited

AFFRI, A. F. (2006). Medical Effects of Ionizing Radiation., (pp. 9-10). King of Prussia, PA.

Council of the European Communities. (1989, December 21). *Council Directive 89/686/EEC of 21 December 1989 on the approximation of the laws of the Member States relating to personal protective equipment.* Retrieved February 23, 2009, from http://ec.europa.eu/enterprise/mechan_equipment/ppe/dir89-686.htm

Council of the European Communities. (2008, July 3). *PPE Guidelines.* Retrieved February 23, 2009, from http://ec.europa.eu/enterprise/mechan_equipment/ppe/ppe_guidelines.pdf

European Commission. (n.d.). *Personal Protective Equipment.* Retrieved February 23, 2009, from http://ec.europa.eu/enterprise/mechan_equipment/ppe/index.htm

Fedele, P. G. (2003). *Inhospital Response to External Chemical Emergencies: Personal Protective Equipment, Training, Site Operations Planning and Medical Programs.* Washington DC: US Army Soldier and Biological Chemical Command, Environmental and Occupational Health Sciences Institute and Vetrans Health Administration.

Hawley, C. (2008). *Hazardous Materials Incidents, 3rd Ed.* Clifton Park, NY: Thompson Delmar.

Keyes, D. B. (2005). *Medical Response to Terrorism: Preparedness and Clinical Practice.* Philadelphia, Pa.: Lippincott, Williams, & Wilkins.

National Fire Protection Association (NFPA). (n.d.). *List of NFPA Codes and Standards*. Retrieved from http://www.nfpa.org/aboutthecodes/list_of_codes_and_standards.asp

Noll, G. H. (2005). *Hazardous Materials: Manageing the Incident 3rd Ed.* Chester, MD.: Red Hat.

Occupational Safety and Health Administration (OSHA). (2005, January). *OSHA Best Practices for Hospital Based First Receivers from Mass Casualty Incidents Involving the Release of Hazardous Substances.* Retrieved from http://www.osha.gov/dts/osta/bestpractices/firstreceivers_hospital.pdf

Okumura, T. S. (2000). Lessons Learned from the Tokyo Subway Sarin Attack. *Prehospital Disaster Medicine* , 30.

Roberson, C. (2006, August). ISEA vs. ISO: Apparel Standards Examined. *Occuaptional Health and Safety* .

USACHPPM. (2003). *Personnel ProtectiveEquipment Guide for Military Treatment Facility Personnel Handling Casualties from Weapons of Mass Destruction and Terrorism Events.* Retrieved from http://chppm-www.apgea.army.mil/documents/TG/TECHGUID/TG275new.pdf