Guidelines for Use of Personal Protective Equipment by Law Enforcement Personnel During A Terrorist Chemical Agent Incident

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PREFACE

The fiscal year (FY) 1997 Defense Authorization Bill (P.L. 104-201, Sept 23, 1996), commonly called the Nunn-Lugar-Domenici legislation, funded the Domestic Preparedness initiative. Under this initiative, the Department of Defense (DoD) was charged with enhancing the capability of federal, state, and local emergency responders in incidents involving nuclear, biological, and chemical terrorism. The U.S. Army Soldier and Biological Chemical Command (SBCCOM), Aberdeen Proving Ground, Maryland, was assigned the mission of developing an Improved Response Program (IRP) to identify problems and develop solutions to the tasks associated with responding to such incidents. The Chemical Weapons IRP (CWIRP) was established to deal specifically with terrorist's use of chemical weapons.

The CWIRP subsequently formed the Law Enforcement Functional Group (LEFG) to identify key issues facing the law enforcement community in a chemical terrorist scenario. The Group then developed procedures and recommendations to improve the law enforcement response. The LEFG consisted of experienced personnel from the law enforcement community supported by scientists and engineers assigned by SBCCOM. The law enforcement personnel hailed from agencies and departments from federal, state, and local organizations.

The LEFG used a series of exercises, entitled Baltimore Exercise (BALTEX), workshops, demonstrations, and other sources of information to facilitate the identification of the unique challenges facing law enforcement in situations involving the deliberate use of chemical warfare agents (CWAs). Issues were prioritized and slated for follow-on investigation and analysis. The Group placed particular attention on the operational impact that these agents presented and then focused on formulating recommendations designed to mitigate these challenges.

The LEFG noted that most operational shortcomings facing law enforcement are related to equipment and training required for proper use and application of that equipment. Consequently, this report focused primarily on the range of equipment that, from a practical standpoint, is reasonably available to most departments. **This report attempts to discern the fundamental information that is required to help those responsible for acquisition make sound decisions.** Additional information regarding law enforcement activities and recommendations for responding to acts of domestic chemical terrorism can be found in other related Program publications such as the CWIRP Playbook. These can be obtained from the SBCCOM website at http//hld.sbccom.army.mil/ip/ in the MIRP section.

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Participating Agencies:

Federal

Federal Bureau of Investigation - Baltimore Division
Aberdeen Proving Ground Criminal Investigation Division

State

Maryland State Police
Maryland State Fire Marshall
Maryland Transportation Authority Police Department
Mass Transit Administration Police Force

Local

Anne Arundal County Police Department
Baltimore City Police Department
Baltimore City School Police
Baltimore County Police Department
Harford County Sheriff's Office
Howard County Police Department
Metropolitan Police Department, District of Columbia
Montgomery County Police Department
New York City Police Department Emergency Services Unit
Prince Georges County Police Department

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GUIDELINES FOR MASS USE OF PERSONAL PROTECTIVE EQUIPMENT BY LAW ENFORCEMENT PERSONNEL DURING A TERRORIST CHEMICAL AGENT INCIDENT

1.0 INTRODUCTION AND BACKGROUND

The challenges facing law enforcement officers vary greatly between those of a hazardous materials (HazMat) incident and a deliberate attack using chemical agents. The CWIRP undertook this study to characterize these challenges in terms that are understandable to the law enforcement departments and individuals that may find themselves in these situations. In doing so, the CWIRP has attempted to identify and evaluate various personal protective equipment (PPE) alternatives that law enforcement officials may choose to use based on the types of missions being performed at the incident scene. Primary consideration was given to the protection of patrol officers operating on the perimeters of the incident and performing necessary crowd control and security functions as well as tactical teams that may be called on to perform operations inside of the Warm Zone. Protective clothing options for bomb technicians are basically limited due to the inherent dangers associated with the mission. The CWIRP did not identify any alternative protective ensembles beyond the already available chemical/biological (C/B) bomb suit. It is the Program's intent to provide law enforcement officials with sufficient information to make informed decisions about how to equip their departments for responding to a chemical terrorist attack.

The recommendations made in this report are based on the assumption that officers wearing PPE will have a good understanding of chemical, biological, radiological, and nuclear (CBRN) hazards (awareness and operations training) and be well trained in the use of the equipment. Early recognition and protective measures are essential when dealing with chemical agents otherwise responding officers will only add to the list of victims (the proverbial "blue canary"). Inappropriate, improperly worn, or poorly maintained equipment can be more devastating to an officer's safety than no PPE at all by giving them a false sense of security.

This report is provided to assist departments on PPE acquisition, application, and maintenance decisions. The Program recognizes that there are numerous other factors that will directly influence these decisions such as jurisdictional size, availability of funding, functional responsibilities, capabilities, etc.

The Improved Response Program (IRP) is a component of the Department of Defense Domestic Preparedness Program (DPP) developed to support legislation passed under Title XIV "Defense Against Weapons of Mass Destruction" of the 1997 National Defense Authorization Act. One of the initiatives under this legislation was the establishment of a program to improve the civilian response capability to C/B terrorism. The IRP was developed to identify and improve systemic deficiencies in the ability of a community to effectively respond to a C/B terrorist incident. Because there are major differences between chemical and biological agents and the expected response, a separate program was developed to study each area.

Utilizing the Baltimore – Washington D.C. metropolitan area as its test-bed location the CWIRP conducted a series of exercises and workshops, entitled Baltimore Exercise (BALTEX) to present information regarding the potential impact of a terrorist chemical agent incident and lead discussions into identifying operational, procedural, and equipment shortfalls.

To address these identified shortfalls, the CWIRP established functional working groups comprised of local, state, and federal officials from key response and management positions associated with the consequence management of a chemical terrorist incident. These four groups, Emergency Response, Law Enforcement, Health and Safety, and Emergency Management formed committees to develop solutions and recommendations for improving the civilian response capability.

The Law Enforcement Functional Group (LEFG) met regularly from October 1998 through September 2000 to discuss and evaluate law enforcement missions, responsibilities, and protective equipment requirements for responding to an incident of chemical terrorism. As the Group outlined response procedures and their associated agent hazards, they evaluated various types of PPE available that would afford adequate protection for officers and are consistent with the law enforcement mission.

In determining what protective ensembles to test, the Program focused on equipment that is readily available, easy to maintain, and relatively affordable. In addition, newly designed equipment targeted for emergency responders was considered and evaluated.

THE CWIRP'S INTENT WAS TO IDENTIFY PPE ALTERNATIVES FOR PATROL OFFICERS THAT AFFORDED ADEQUATE CHEMICAL PROTECTION AT A COST OF APPROXIMATELY $200 PER OFFICER.

SBCCOM tested several varieties of PPE using internationally accepted protocols to determine the levels of protection each afforded. An explanation of the test procedure (Man-In-Simulant Test) and the resulting protection afforded (Ensemble Stay-Times) are included in Appendix A and B respectively. Maryland State Police troopers participated in the tests and evaluated the compatibility of the equipment with existing law enforcement tactics and equipment. In addition, several departments provided respiratory equipment that is currently in use by their agencies for evaluation. SBCCOM evaluated the serviceability of these based on current military standards in order to ascertain the level of protection current, off-the-shelf equipment may provide.

In January and September 2000, the CWIRP conducted tabletop exercises to present the Functional Groups' operational recommendations and PPE guidelines to members of the law enforcement community. These exercises, BALTEX X and CRIME 2000 respectively, were designed to validate the procedures and recommendations of the Group. Exercise participants were organized by operational areas and represented a variety of local, state, and federal law enforcement organizations from large metropolitan cities to small rural communities. LEFG members facilitated discussion throughout the scenario and presented the Program's recommendations to the participants. Participants' comments and recommendations were incorporated into the final law enforcement reports and guidelines.

Exercise participants were organized into the following operational groups:

- **Command**
- **Patrol**
- **Communications**
- **Tactical**
- **Bomb**
- **Intelligence/Investigation**
- **Public Information Officer**
- **Aviation**

2.0 OBJECTIVE

The objective of this report is to present law enforcement issues associated with operations in a terrorist chemical agent incident environment and provide information to assist law enforcement organizations formulate policy and procedures that will improve response to such incidents.

3.0 TECHNICAL ASSESSMENT

3.1 General

Respiratory protection represents the single most important piece of chemical agent protection for law enforcement officers.

Respiratory protection represents the single most important piece of chemical agent protection for law enforcement officers. Most chemical agents, and more importantly those with application to a terrorist interests (immediate, widespread casualties), are designed to enter through the respiratory track and mucus membranes. While the recommended PPE for law enforcement officers consists of a complete ensemble (respirator, suit, gloves, and boots), the best protective suit is only as good as the respiratory protection afforded by the mask that is worn.

Respiratory protection is not new to law enforcement departments. It has been used for years as protection from riot control agents, however, there is a clear difference between protection from such agents and chemical warfare agents. The major difference is that a single mask does not offer protection against all chemical agents. Masks that work extremely well against riot control agents may be totally useless against nerve agent. In order to determine if a mask affords proper respiratory protection, an extensive evaluation must be performed. Reference to the standards associated with respiratory protection can be found in Appendix C (Safety Requirements).

The primary protection that officers and/or first responders should use in a chemical incident response is high quality respiratory protection to protect their lungs and respiratory system.

Regardless of the type of respirator used, it is recommended that a chemical protective hood be used in conjunction with it. While skin exposure to riot control agents provides only a slight level of discomfort, CWAs can penetrate through the skin causing agent casualties. A hood attached to the protective mask increases the protection to the neck area that is often left exposed without one. Testing of protective ensembles, as discussed later in this report, reinforces this recommendation.

Also important to the effectiveness of a respirator is the means by which it filters out the chemical agent. Unless a respiratory protective system relies on a bottled air supply (self-contained breathing apparatus) it generally uses a filter or canister to remove chemical agent particles from the air as it passes through the filter system. Therefore, the type of filter/canister used must be certified for protection against the agent in question. Additionally, these types of respiratory systems also require that there be a sufficient level of oxygen in the area to sustain life in order for the respirator to be used.

There are certain requirements for use of respirators with filters/canisters.

- They must be designed for the agent in question
- Be within their serviceability shelf-life
- There must be sufficient oxygen in the atmosphere

Filter/canisters are a shelf-life item that must be periodically rotated. There are generally two shelf-life durations associated with a given filter/canister. The first applies to the filter/canister in its factory package and the second to the duration of its effectiveness once removed from the package. It's imperative that departments using respirators with filters/canisters establish a program whereby they receive standard updates on the effectiveness of the filters in stock.

This section provides departments with a basic knowledge of the types of respirators available, their applicability to the law enforcement mission, the regulatory requirements for use of respirators, and discussion of evaluations conducted on respirators currently in most departments' inventories. The mention of any manufacturer or trade names is solely for clarity and brevity and does not represent any endorsement of such product. Masks are referenced in order of increasing protection afforded and not in any government recommended order.

Currently NIOSH assigned respiratory protection factors for different types of respirators are:
Negative-Pressure: 50
PAPR: 50
SCBA: 10,000

Note. NIOSH has not released revised applied PF for respirators.

3.2 Respiratory Protection

3.2.1 Escape Masks/Hoods

Escape masks with integral hoods, herein referred to as escape masks, are designed to provide short duration respiratory protection in order to evacuate from an area of suspected or known chemical agent contamination. Various types of escape masks are available ranging from simple (charcoal based filters) to complex (short duration bottled air supply).

Members of the LEFG identified that performing the fit test requirements, outlined for "tight-fitting" respirators is difficult for departments to comply with. A discussion of the fit test requirements is included in Appendix D (Fit Testing). Since there are currently no fit test requirements for escape masks, the LEFG examined their suitability for use by officers on the perimeter of a chemical incident. Many escape masks are disposable, one-time use only masks that are unique from tight-fitting respirators since they do not need to be fitted to the wearer's face. These masks are designed to fit snugly around the wearer's neck via an expandable neck dam. Although escape masks do not form a seal around the face like most other respirators, the neck dam must provide a complete seal in order to keep agent from entering the mask around the neck.

> A **tight-fitting respirator** is defined as a respiratory inlet covering (mask face piece) that forms a complete seal with the face.
> OSHA 1910.134

Problems identified with escape masks included:

- Inability to communicate.
- Talking caused fogging of the lens.
- Some systems had nose clips (designed to control breathing through the nose) that fell off causing hoods to collapse around the head.
- Officers were unable to stay in the hood, even though they were familiar with wearing negative-pressure respirators, due to claustrophobia.
- Lack of NIOSH certification standards.

It is expected that some of the problems regarding wear of an escape mask may be overcome with additional training and familiarization of the wearer; however, communication problems limit the appropriateness of these masks for use by law enforcement officers. In addition, these masks are intended for escape purposes only and therefore are not intended for prolonged use such as performing perimeter security operations.

3.2.2 Negative-Pressure Respirators

A negative-pressure respirator is what most people recognize as and often refer to as a gasmask. While negative-pressure respirators come in both full-face and half-face configurations, due to the considerations regarding the possibility of chemical warfare agents penetrating through the eye membranes, this report focuses only on full-face negative-pressure respirators as an alternative for law enforcement operations. A negative-pressure respirator consists of an air-purifying filter or canister, herein referred to as filter, through which the wearer breathes in clean air. Airflow through the filter occurs when the wearer inhales, therefore the name negative-pressure respirator. A full-face respirator forms a seal completely around the wearer's face, which classifies it as a tight-fitting respirator. These types of respirators are the ones that most people can relate to as the military style protective masks and law enforcement riot control masks.

Negative-pressure respirators come in two general styles, singular and bi-ocular vision with either an internal filter or external canister. Singular vision versions often provide greater peripheral vision. Sight alignment is better with this style respirator but the face piece and lens often interfere with placement of the cheek to stock when sighting a shoulder-fired weapon. Bi-ocular versions generally fit closer to the face; as such they provide less interference with shoulder-fired weapons. Sight alignment is not as good as singular vision masks due to the split between the eye lenses. Most masks with an external canister have the capability of placing the canister on either side of the mask. This is critical for officers firing shoulder fired weapons and should be a factor that is looked for in determining what mask to procure.

Hazard Zones as defined in the 2000 Emergency Response Guidebook are:

Hot Zone: Area immediately surrounding a dangerous goods incident that extends far enough to prevent adverse effects from released dangerous goods to personnel outside the zone. This zone is also referred to as exclusion zone, red zone, or restricted zone in other documents.

Warm Zone: Area between Hot and Cold zones where personnel and equipment decontamination and Hot Zone support takes place. It includes control points for the access corridor and thus assists in reducing the spread of contamination. Also referred to as the contamination reduction corridor (CRC), contamination reduction zone (CRZ), yellow zone, or limited access zone in other documents.

Cold Zone: Area where the command post and support functions that are necessary to control the incident are located. This is also referred to as the clean zone, green zone, or support zone in other documents.

Reference – U.S. Department of Transportation, 2000. 2000 Emergency Response Guidebook.

Negative-pressure respirators provide the respiratory protection of Level C personal protection (see Appendix E, OSHA Protection Requirements). This form of respiratory protection is considered adequate for officers operating on the perimeter of the Warm Zone and in the decontamination corridor (area leading from the Warm Zone to the Cold Zone

where decontamination takes place) where live citizens without respiratory protection are found. Negative-pressure respirators are not recommended for use in the Hot Zone unless agent and ambient air quality monitoring has been performed and concentrations of both have been defined. Additionally, there must be a sufficient level of oxygen (19.8 percent) in the atmosphere to sustain life in order to use a negative-pressure respirator.

Any type of respirator hinders both voice and radio communications. Most manufacturers of negative-pressure respirators have voice amplification adaptors that fit over the voicemitters of the masks. These relatively small, lightweight, battery powered adaptors are basically essential for law enforcement operations. As a minimum, departments should consider procuring them for their squad and team leaders who must communicate directions to their personnel.

3.2.3 Powered Air Purifying Respirators (PAPR)

PAPRs generally consist of a full-face, tight-fitting respirator accompanied with a battery-powered generator (blower) that forces air through the filter/canister element into the wearer's face piece. The blower is worn on a belt or can be fitted onto tactical equipment such as a webbed vest and provides air to the filters through a hose.

Advantages that the blower provides in the PAPR are a decrease in the breathing resistance (level of difficulty involved in breathing air in through the respirator filter) from a negative-pressure respirator and the ability to use larger (thicker) filter elements with a greater degree of protection and comfort. The blower supplies a stream of cool air that both assists in reducing heat buildup and provides a form of positive pressure. Disadvantages identified with the use of PAPRs included the following:

- The hose connecting the blower to the filter provided an easy way for someone to pull the mask off of the officer's face.
- The hose can easily become crimped either manually or by additional equipment (especially tactical) thereby reducing or cutting off the oxygen supply.
- The blower is noisy thereby reducing the ability to communicate and virtually rendering the mask unusable for stealth tactical operations. Manufacturers are constantly making improvements on the blower to include the level of noise that it makes.
- The extra bulk and weight of the battery pack and blower was undesirable.

- There was concern that proper maintenance and rotation of batteries would not be performed on a battery-powered device. It is noted here that a PAPR can be used without a functioning blower (turned off, dead batteries, or any other malfunction other than a cut hose line). In this case, the mask operates like a negative-pressure respirator; however, as mentioned in the advantages, if a larger filter element is used, the breathing resistance will be increased without the blower operating.
- Finally, the additional cost above that of a negative-pressure respirator made the mask less desirable from a budget standpoint for outfitting anyone other than specialized teams.

3.2.4 Self-Contained Breathing Apparatus (SCBA)

SCBA provides the greatest level of respiratory protection in a chemical agent environment as it relies on a supply of clean air either through a tank worn by the wearer or through an airline from a stationary air supply source. SCBA is required for Level A and B PPE. These levels of protection are required when entering an area where the agent hazard and concentration are unknown or when there is a danger of an oxygen deficiency in the area.

The FBI is training and equipping their regional HazMat response teams (WMD coordinators) to operate in Level B protection. This is consistent with their mission of investigating the crime scene. SCBA was not considered an option for local law enforcement operations based on the following:

- The types of missions recommended for local law enforcement officers and covered in this report are inconsistent with the use of SCBA.
- SCBA provides for a limited duration of operation based on the air supply. Most portable air tanks provide 30-40 minutes of operation to include time required to suit up and process through decontamination.
- Communication in SCBA is worse than with negative-pressure respirators and/or PAPRs.
- Extensive cost and maintenance requirements make SCBA unsuitable for most departments.

3.2.5 M17 Respirator Evaluations

Many law enforcement agencies have acquired stocks of military M17 series protective masks for use in riot control situations. These are often preferred by agencies because they can be obtained free of charge

from military surplus stocks. The M17 mask served as the standard protective mask for the U.S. Army for almost 3 decades before DoD began phasing them out in 1985. Now, more than 15 years later, they are still in use by some law enforcement agencies as their predominant means of chemical and riot control agent protection.

In order to afford proper agent protection to its wearer, a mask must be in good working order, be outfitted with serviceable parts, and have filter elements that are tested and determined to protect against the agent(s) in question. To put the serviceability issue into context, consider the fact that all materials deteriorate over time and with use. Compare the fact that ballistic vests are replaced on an average of every five years due to changes in the kelvar fiber of the vest and concerns over deterioration of the protection afforded. Now consider that any M17 protective mask in a department's inventory is **at least** 15 years old.

It must be reiterated that a mask that is worn on a gas training range that doesn't leak doesn't directly correlate to providing sufficient protection against chemical warfare agents. Differences in the physical properties of the agent, agent concentration, types of filters, etc. all make for differences in the protection afforded. In particular, filters for the M17 mask are a major issue regarding CWA and riot control protection. There were three different filters produced for the M17. These carried the model numbers (military nomenclature) of M13, M13A1, and M13A2. Of these, only the M13A2 filter was approved for use against CWAs. The M13 and M13A1 filters were strictly considered for protection against riot control agents. In addition, the M13A2 filters generally carried a one-year shelf life once removed from its vacuum-packed storage bag unless the lot number was extended through testing.

The Department of Defense began phasing out the M17 series mask in 1985. M17 masks currently in use by law enforcement agencies that were procured through military surplus are at least 15 years old.

SBCCOM raised concerns regarding the age of these masks based on their prolonged use in the military, the duration that they had been out of military service, and knowledge of the long-term affects on the mask components and materials. As part of the protective equipment analysis conducted for the LEFG, SBCCOM assessed the serviceability of the M17 masks currently in use by the law enforcement community.

Protective masks, like ballistic vests, deteriorate over time reducing the protective qualities of the materials or system.

In order to ensure safety to the user, each mask should be thoroughly inspected and if necessary repaired prior to use. The mask's faceblank and head harness are susceptible to dry rot and tearing. Components such as the inlet and outlet valve disks become brittle and useless over time; and the filter elements must be of the appropriate type and serviceable as referenced above.

SBCCOM conducted an evaluation of a representative sample of M17 masks that were part of a department's operational stockpile of masks. These masks were tested according to current U.S. Army serviceability standards for protective masks and the technical manual for the M17. This testing was done to provide a baseline for departments to understand the fitness of these masks for protection against CWAs versus their current level of use for riot control agents.

SBCCOM tested twenty masks that were provided by a department supporting the CWIRP effort. *It should be noted here that the department providing these masks was not the same department that provided masks for the mask fit test evaluation.* Upon initial inspection, it was found that more than half of the masks had riot control filters, not CWA filters installed. Five of the masks failed a manual inspection according to technical manual standards for dry rot. Areas with particular problems included the area below the voicemitter, the head harness attachment straps and around the eyelens. The remaining 15 were placed on a machine that is used to identify improper faceblank seals and leakage through the mask openings (eyelens, inlet valves, etc.). All 15 of the masks failed the initial test on the machine. These masks were then "rebuilt" with new components (head harness, filters, inlet/outlet disks, etc.) and were retested on the machine. Five of the 15 (33 percent) still failed after being rebuilt.

Evaluations conducted by the CWIRP indicate a clear concern regarding the serviceability of protective masks in law enforcement stocks as well as training and respiratory protection program requirements. It cannot be overstated that high quality respiratory protection is the basis of protecting officers responding to a chemical agent incident.

3.3 Protective Clothing

3.3.1 General

Respirators provide the fundamental protection from chemical agent vapors and aerosols; however, chemical agents also present dangers from absorption through the skin. While absorption of most agents through the skin does not produce agent effects nearly as rapid as respiratory exposure it can be just as deadly. To provide

protection against direct skin contamination, the respiratory protection needs to be supplemented with chemical protective clothing.

The basic components of a chemical protective ensemble include a respirator, chemical protective gloves, footwear, and an overgarment or suit. The remaining components of a chemical protective ensemble are discussed here briefly.

3.3.2 Chemical Protective Gloves

Along with providing chemical agent protection, gloves worn by law enforcement officers as part of an overall protective ensemble must allow for the manual dexterity necessary to perform duties. This includes activities involving firearms (firing, reloading, holstering), handcuffing, and the use of specialized equipment such as tactical equipment. The protective glove worn by officers represents an essential part of the protection against liquid contamination. The chances of officers, performing perimeter security duties, encountering liquid contamination are negligible; however, officers operating in the decontamination corridor and within the Warm Zone are at a much greater risk through the potential for cross-contamination. The potential for cross-contamination exists through direct contact between an officer and a victim with contamination on their clothing. This may be the result of providing physical assistance to someone injured or in distress or in the detention of disorderly persons and/or suspects.

It must be noted that not all gloves provide adequate chemical agent protection. **Latex gloves, the type used for blood-borne pathogens, provide almost no form of protection against CWAs.** Simply providing a barrier between the skin and agent doesn't equate to protection, as the glove must stop the agent from penetrating through the material, which is the problem with latex gloves.

Chemical protective gloves come in a large variety of styles and fabrics from numerous manufacturers. Any glove chosen as part of an officer's ensemble must provide adequate chemical agent protection. While some manufacturers of charcoal impregnated suits offer gloves of similar materials, departments purchasing gloves separately should consider butyl rubber gloves as their primary choice for chemical protection.

The second factor of most importance to the officer is the thickness of the glove. An increase in the thickness of the material will generally increase the protection provided by the glove; however, this comes at an increased loss in dexterity. Concerns with substituting a thinner material in order to gain increased dexterity include a lower level of protection and the threat of the gloves ripping. The

gloves worn by law enforcement officers during the ensemble evaluations conducted by SBCCOM consisted of a seven-mil butyl rubber glove. Officers, understanding that any glove will reduce their dexterity, were generally accepting of the glove; however, when officers wore their ensembles on the firing range they experienced instances of the fingers ripping when reloading pistol magazines. Additionally, officers should avoid contact with any sharp objects to avoid ripping or cutting the gloves.

3.3.3 Chemical Protective Footwear

Chemical protective footwear is essential to limit the chance of agent being absorbed into the normal footwear by walking through liquid contamination. In all instances liquid contamination should be avoided at all costs regardless of the type of protection worn. Just as with gloves, not every boot will provide adequate agent protection.

Protective footwear for chemical agent exposure generally consists of two types. The first are boots that can be worn over shoes or directly over the feet similar to the way one would wear snow boots. The second is booties that are a part of the protective suit being worn. There are distinct considerations for each type of foot protection. Boots provide a higher level of protection and are more durable than the suit bootie but are more costly. In addition, boots must be sized for the wearer. A general rule of thumb for chemical protective boots is that they should be two sizes larger than normal footwear. Booties, as part of the suit, are one-size fits all; however, they generally must be protected from tearing by wearing some form of footwear over them. The secondary cover does not have to provide chemical agent protection since that is provided by the bootie. A typical type of shoe cover designed for wear in rain or snow would perform well.

3.3.4 Chemical Protective Suits

For an explanation of levels of protection and associated PPE requirements refer to Appendix E.

Chemical protective suits complete the overall protective ensemble. While there are a large variety of suit types (one-piece coverall, two-piece, hooded, disposable, etc.), they are manufactured in two major types, these being fully- and non-fully encapsulating. A fully encapsulating suit is the type that is necessary for Level A protection and provides a complete, airtight protection (cocoon) for the wearer. As such, a supplied air respirator such as SCBA must be worn with a fully encapsulating suit. Non-fully encapsulating suits consist of the types worn with Levels B and C protection. More discussion of levels of protection, as they relate to the LEFG PPE recommendations and ensemble tests, is included in section 5.4.

All Level A and B suits are made of impermeable material while Level C suits are made up of a variety of either permeable or impermeable materials. The primary difference between a Level B and C impermeable ensemble is the respiratory protection (Level B requires SCBA). Since the PPE studies conducted by

SBCCOM for use by law enforcement consisted of Level C ensembles, this section will focus primarily on those types of suits. Variations in the Level C suits that are pertinent to a department's decision on what protective equipment to purchase for their officers are discussed below.

Most Level C suits come with an attached hood that provides additional protection to the neck area. Suit hoods generally do not form a closed seal around the mask and face and therefore should not be considered a replacement for the hoods that are designed for the protective mask. Most often the area of the neck under the chin is left exposed. Since chemical agents are also effective through skin absorption it is imperative that complete body protection be provided in order for the protective ensemble to provide protection to the wearer.

These suits generally come as either a one-piece coverall or a two-piece style consisting of a separate top and bottom. A one-piece suit generally provides slightly better protection (based on the quality of the suit) than a two-piece of the same material because an airtight seal is not made between the top and bottom sections of the two-piece suit. Normally, impermeable suits do not come in two-piece configurations.

The final major factor to consider with a Level C type suit is whether it is permeable or impermeable. The importance of permeability of the suit for law enforcement purposes can basically be characterized by the fact that permeable suits should not be worn in areas where there is a danger of it becoming wet such as decontamination corridors. Wetting of a permeable suit decreases the protection afforded and can lead to agent absorbing through the fabric.

Test results of these two types of suits conducted by SBCCOM in support of this initiative demonstrated that the permeable suits provided an increased level of protection to the wearer over the impermeable. Factors associated with each suit that are relevant to law enforcement operations are listed in Table 1 by suit type.

Many manufacturers of charcoal impregnated suits also offer gloves and boots made of similar materials.

IMPERMEABLE SUITS	PERMEABLE SUITS
Predominantly used for HazMat situations where Level A PPE is not required.	Consist of charcoal lined or impregnated suits – standard military style C/B suits.
Generally less expensive than permeable.	Generally more expensive than impermeable.
Disposable, one time use.	Most can be washed and reused according to manufacturer's instructions. Generally accepted practice is not to wash and reuse a suit that was worn in a known contaminated environment. Reuse of a suit would normally be considered if it was worn on a response that proved to be a false alarm (hoax). Shelf life applies once removed from vacuum-sealed package.
Most suits available in hooded versions with attached booties.	Most suits are available in hooded versions, attached boots not a normal characteristic of these types suits.
Increased level of heat buildup inside the suit.	Less heat buildup due to air transfer.
Can be exposed to water making it the preferred type of suit for operations in support of decontamination operations.	Should not be exposed to water.
Smaller and more compact – storage.	Most are available in one- and two-piece configurations.
Most are bright colored fabric making them inappropriate for tactical law enforcement operations. Fabric tends to tear easily under stress and is noisy to operate in.	Dark cloth fabric that is more durable under extreme physical conditions. Supports tactical law enforcement operations well through design, fabric, and durability.

Table 1. Impermeable/Permeable Suit Comparison

4.0 OPERATIONAL CONSIDERATIONS

4.1 GENERAL

Responding to a chemical WMD crime scene is relatively new to law enforcement officers. Trained HazMat technicians normally handle the dangers associated with contamination from a typical HazMat incident. In the case of a deliberate use of chemical agents against persons or property, law enforcement must be involved in both the response and ensuing investigation.

The most immediate factor associated with officer safety is rapid identification of the incident for what it is. Dispatchers and first arriving officers are presented the first signs that an incident may be a chemical incident from their initial observations and information provided in calls for assistance.

This section outlines the basic operational considerations facing law enforcement officers responding to a known or suspected chemical agent incident. It is intended to provide a broad overview of the types of missions confronting officers that may involve exposure to chemical agents.

4.2 Initial Response

When responding to a known or suspected chemical terrorist incident, law enforcement officers must be prepared to meet the challenges associated with the chemical agent hazards. The first step that the LEFG took was to define the roles facing law enforcement officers upon arrival at the incident scene. While firefighters are better equipped and prepared to operate in hazardous environments due to their protective clothing and self-contained breathing apparatus (SCBA), there are clearly defined situations that require a law enforcement presence on the perimeter of the Warm Zone. Firefighters cannot be expected to handle crowd control, detention of suspects, security of downed officers' equipment, etc. just because they are equipped with PPE. These roles are clearly a law enforcement issue, and departments need to evaluate how they will handle operations on the outskirts of the contamination zone. Departments may identify other key roles that must be quickly performed based on their jurisdiction, location of the attack (dignitary protection, security of sensitive equipment, etc.), or departmental procedures.

Firefighters, although equipped with chemical protective equipment, cannot be expected to perform the roles of law enforcement officers.

The first and utmost task for the safety of responding law enforcement officers is early recognition of the event for what it is. First responding officers must be cognizant of the signs/symptoms of the victims and information included in the first reports of the incident. It is essential that dispatchers and communications center operators identify an unusually large volume of calls reporting sick or injured victims as a potential chemical

terrorist incident. Operators should have quick reference sheets (similar to bomb threat sheets) regarding key information that may suggest a chemical agent incident. Departments should also have in place dispatch and notification procedures for alerting responding units of the potential danger of chemical (or other hazardous) agents at the scene. This should include instructions for PPE and response actions to take upon arrival. In many jurisdictions, fire, emergency medical service (EMS), and police departments do not have an interconnecting communications system. As such, initial critical information regarding the hazards at the incident response site may be obtained and passed through only one department's communications. It is essential that jurisdictions develop a method of cross-leveling information between responding elements of each department until a unified command post is established.

It can be expected that terrorist acts performed on U.S. soil will be targeted at large populations and mass gatherings. As statistics provide there "…appears to be evidence of a portentous shift in terrorism, away from its traditional emphasis on discrete, selective attacks toward a mode of violence that is now aimed at inflicting indiscriminate and wanton slaughter".[1] In many of these instances (political gatherings, sporting events, etc.), there will likely be a law enforcement contingent already on the scene at the time of occurrence. Therefore, the greatest communications challenge affecting officer safety will most likely come from a call reporting an officer down at the incident scene. Departments, specifically dispatchers and supervisors, must rapidly identify the incident and have procedures in place for controlling officer's response in such a case.

The Trend of Increasing Terrorist Lethality

There were 273 international terrorist attacks during 1998, a drop from the 304 attacks we recorded the previous year and the lowest annual total since 1971. The total number of persons killed or wounded in terrorist attacks, however, was the highest on record: 741 persons died, and 5,952 persons suffered injuries.
Idem, *Patterns of Global Terrorism 1998* (Washington, D.C.: U.S. Department of State Publication 10610, 1999)

4.3 Scene Security

Scene security will most likely be comprised of two, if not three, levels of control and must take into account not only the physical layout of the crime scene but also the extent of contamination and cross-contamination concerns. These include an outer perimeter, inner perimeter, and possibly an access control in/around a building where an agent has been released. Various factors that will determine the size of the control zones that need to be established include, but are not limited to, the agent release point (inside/outside), the size of the device (estimated amount of agent), type of release

Secondary Devices

The threat of secondary devices targeting emergency responders should never be overlooked.

[1] Advisory Panel et al., (1999). *First Annual Report to The President and The Congress of the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction*. RAND, Washington D.C.

(spray, bursting, evaporating, etc.), and wind direction and speed, as well as other weather related factors (humidity, precipitation, temperature, etc.). The first law enforcement officer arriving on scene should check with the Incident Commander (IC) regarding recommendations on initial perimeter boundaries. It is expected that in most cases the initial IC will be the senior fire department official on the scene. Security boundaries are not circular as may normally be established but elongated due to the airborne contamination hazard.

4.4 Perimeter Security

4.4.1 Outer Perimeter

Given agent dispersal considerations and standard recommendations for protective distances (Emergency Response Guidebook) it can not be expected that law enforcement will have the manpower to establish a complete 360 degree outer perimeter. Outer perimeter security will more than likely consist of controlling traffic (foot and vehicular) at key intersections/roadways leading into and out of the incident location. Barriers and use of non-law enforcement personnel may enhance the outer perimeter security. Since this perimeter is outside of the extent of expected contamination, it does not require complete closure. Officers and other personnel manning points along the outer perimeter should be equipped with Level D PPE. Level D consists of having the protective clothing and equipment necessary for Level C immediately available but not worn. As such, officers can easily don protective gear to assume Level C protection in the case of wind shifts, additional agent releases from the initial site and/or secondary devices. In addition, Level C is available for protection if the need arises to confront a citizen who is suspected of being contaminated.

Cross-Contamination
It should be noted that not all chemical agents are rapid acting and some have very prolonged contact hazards. The thought that everyone who comes in contact with agent will die or be incapacitated within minutes is only true of certain agents.

For the most part, crowd control on the outer perimeter will consist of diverting traffic away from the incident scene and keeping bystanders out of the area. The majority of citizens who were at the incident scene who wanted to leave will have done so prior to the establishment of security perimeters.

4.4.2 Inner Perimeter (Security of the Warm Zone)

The most critical level of security regarding personal protection, both of the officers and the citizens, is on the perimeter of the Warm Zone. This is the boundary between the extent of chemical agent hazard and the clean area, or Cold Zone. The IC should rapidly identify this

area. Everyone inside the zone should be considered potentially contaminated and undergo decontamination prior to being released from the scene.

The Warm Zone also includes the contamination reduction corridors, also known as the decontamination corridors or lines. As a minimum, it can be expected that two separate decontamination corridors will be established, one for the general population and another for emergency responders. A law enforcement presence may be warranted at each of these (see comments under Operations in the Warm Zone below). References throughout this document to operations on the inner perimeter include operating in the decontamination corridors. Officers operating on the inner perimeter are at greater danger to agent exposure due to wind shifts, secondary releases, and cross-contamination from citizens with agent on their clothing and possessions. As such, Level C PPE is required for officers performing this mission.

Officers on the inner perimeter are faced with additional crowd control concerns from those on the outer perimeter. These involve entry of both authorized and unauthorized personnel/responders as well as control of citizens and responders exiting the zone. Entry into and exit from the Warm Zone should be through one controlled entry point to ensure accountability of all personnel in the hazard area, verification that they are wearing appropriate PPE for their mission and operating area (entry), and decontamination of everyone (exit). This calls for a tighter, more secure perimeter that increases the manpower requirements on the department. Also, the detention of citizens who do not desire to go through decontamination must be addressed. It can be considered that the majority of those wanting to leave the area will have done so by the time responders gain control of the scene. Those still remaining, for the most part, can be expected to be cooperative with responders, or be incapacitated. Processing through decontamination takes time and some individuals may either grow tired of waiting or simply refuse decontamination. It is these individuals that pose a compound issue for law enforcement. To what point and under what conditions can/should law enforcement forcibly detain citizens who refuse to go through decontamination? Officers are charged both with protecting the citizens whom they serve from danger, while also upholding the civil rights of each individual. Departments must consider the issues associated with the detention of citizens, local ordnances and policies, and seek advice from their attorney general in establishing their procedures. Other response organizations that may be involved in operations at the incident scene should be aware of departmental policies once they are identified or established.

Departments must consider the issues associated with detention of citizens who may potentially be contaminated.

4.5 Security of Critical Infrastructure

In addition to on-scene security duties, law enforcement can expect that other sites may request a security presence. Departments should evaluate each request based on on-scene manpower requirements, the potential danger to individuals and facilities, and the necessity of the security mission to be performed by sworn law enforcement officers. Hospitals and other medical facilities are expected to be the principle locations requesting security support. These facilities are subject to a large number of self-referring casualties from the scene who will arrive without benefit of decontamination. In order to protect both staff and the facility from contamination and to keep it from being overwhelmed by shear numbers, it is expected that the facility will be locked down in order to create a controlled access to the building. In response to a lock-down and delays in processing due to having to wait for decontamination, citizens may perceive that they are being denied access to care, which could lead to disorderly behavior or civil unrest.

Another security concern that must be considered by law enforcement is other potential targets that may relate to the initial attack. One concern is the potential that the original attack is a diversion for a larger, more deliberate attack, second is the identification of a "theme" associated with the initial attack. In either instance intelligence sources should conduct an evaluation of locations, current events (meetings, exhibits etc.), and daily activities that may present additional targets. Depending on the threat assessment, available resources, and inherent security measures/forces already at an identified potential target, law enforcement may choose to provide a level of assistance or conduct risk-based notifications.

4.6 Operations in the Warm Zone

4.6.1 General

Ideally, law enforcement would like to perform all operations outside of the contamination zone; however, this may not be entirely possible. The LEFG identified several key response areas that require a law enforcement presence in the Warm Zone. These areas are specific to law enforcement duties and for the most part are not expected to be shifted to other agencies (fire, HazMat, EMS, etc.). As such, departments should consider the identified missions and develop response procedures and PPE requirements for performing them.

Based on the studies conducted by SBCCOM and outlined in this report, Level C PPE is considered adequate protection for officers performing these duties on the perimeter of the Warm Zone and in the decontamination corridor.

Departments choosing to conduct operations in the Warm Zone must consider which officers/departments are better suited to perform the missions. Typical missions are outlined in the following paragraphs. For the most part, the missions outlined are consistent with roles that would be performed by patrol officers. When the LEFG considered the increased risk of contamination from operating inside of the zone instead of on its perimeter, they questioned if tactical officers should perform these duties instead. The use of tactical officers has clear advantages and disadvantages as listed in Table 2. Departments should consider the mission, the personnel's level of training, and operating policies and procedures when determining if they would perform such mission and with what resources.

ADVANTAGES	DISADVANTAGES
Tactical officers are better trained for operating with specialized equipment and their equipment is generally better maintained that patrol officers special equipment.	Roles are consistent with patrol officer duties.
Tactical officers often have more time for specialized training.	Use of tactical officers fragments the tactical team.
Outfitting tactical teams with better quality PPE consistent with the increased danger of contamination is easier and more cost effective then outfitting all patrol officers.	Use of tactical officers reduces the ability of rapid deployment to an area/mission requiring a tactical team response.

Table 2. Considerations for Using Tactical Officers to Perform Operations Inside of the Warm Zone

4.6.2 Reconnaissance for Secondary Devices

Under normal operating circumstances (no chemical contamination), someone familiar with the incident location and surroundings would perform a reconnaissance for secondary devices accompanied by a police officer. This may be a security officer, maintenance officer, or any other employee of the area who can identify things that look out of place. However, in a chemical agent incident, the contamination in the immediate area does not permit normal procedures. Safety requirements prohibit departments from giving a mask to a building

employee and escorting them into the area (see Appendix C, Safety Requirements). Therefore, reconnaissance will most likely fall into the hands of the local law enforcement department if they are properly equipped for operating in the Warm Zone. Reconnaissance of the Hot Zone requires personnel to be in Level A protection unless HazMat has fully identified the agent, determined its concentration, and specified that a lower level of protection is acceptable. While officers are not expected to identify "out of place" items with the detail of someone familiar with the area, they can identify certain questionable items and collaborate on them.

Reconnaissance in Level C PPE should be restricted to outdoor areas. Reconnaissance inside of buildings or enclosures may not be possible without higher levels of protection (clothing and respiratory) and the use of chemical agent monitoring devices.

4.6.3 Security of Personal Property

Everyone at the incident site is considered a potential witness to the crime. Victims may have record of events that occurred prior to or during the incident such as videotapes or pictures. Additionally, there exists the possibility that the perpetrator(s) may be among the crowd and seek to escape from the scene along with the victims. Therefore, the personal belongings of the victims are of an interest to law enforcement officers.

The first stage of victim decontamination is to have citizens remove as much clothing as they are willing to. It is estimated that this act performs approximately 80% of the contamination removal. Depending on the magnitude of the incident, firefighters operating decontamination corridors may or may not attempt to segregate (bag and tag) clothing/belongings. Firefighters will be focused on the rescue and decontamination operations and are not expected to be concerned with the security of such items. Therefore law enforcement should be prepared to provide security and control over these items to the extent of their interests as far as personal identification and potential for evidence is concerned.

4.6.4 Security of Police Equipment

As noted earlier, given the nature of terrorists targeting large gatherings, it is likely that law enforcement officers may already be at the location performing routine crowd control/security functions when the incident occurs. It can be expected that some will become casualties or fatalities and that their belongings will be contaminated. Unlike bagging and tagging belongings from the general public, there are

Security of contaminated law enforcement equipment must be considered as part of incident response plans.

important considerations regarding officers' equipment. Badges, radios, uniforms, and most importantly, firearms are sensitive items that are not normally relinquished by officers. However, these items should not be released beyond the decontamination corridor until they have been thoroughly decontaminated with a bleach-based solution and monitored to ensure that no agent hazard exists. Departments need to be prepared to supply replacement equipment for that which is contaminated and left at the incident scene or cannot be thoroughly decontaminated.

Departments should consider security of police equipment when determining response plans and manpower requirements. The LEFG recommends some form of a locking storage container be maintained at the decontamination corridor under supervision of someone from the department to handle the security of such equipment. In addition, most officers will only surrender their equipment, particularly firearms, to individuals from their own department further complicating the issue. Not only may there be multiple law enforcement jurisdictions involved in the response, in many locations jurisdictions share responsibilities for routine operations at large events.

4.6.5 Suspect Arrest and Detention

The final issue involving law enforcement operations inside of the Warm Zone focus on the detention and/or arrest of suspects. The identification of suspects may come from witness reports, individuals presenting themselves in the decontamination corridor with suspicious items (remote detonators, PPE), or individuals claiming involvement that may or may not be intent on surrendering to police.

Regardless of how the suspect(s) is identified, firefighters are not expected to handle the situation. In certain instances, it may be prudent to not take action until the individual passes through the decontamination corridor where law enforcement can approach the situation without regard to chemical agent protection. However, certain circumstances may clearly require that officers confront an individual immediately in order to protect the immediate public.

4.6.6 Investigation/Processing the Crime Scene

The Federal Bureau of Investigation (FBI) is the lead investigating agency for any act involving the use of a weapon of mass destruction (WMD). As such, the FBI assumes primary jurisdiction and will direct all follow-up investigations in association with local law enforcement authorities.[2] The FBI is enhancing its capabilities to

[2] Chemical/Biological Incident Contingency Plan

respond to an act of chemical terrorism by training and equipping regional HazMat response teams (WMD coordinators) in their largest cities so that they are capable of operating in Level B protective equipment.

It is expected that local HazMat teams and investigators will be on scene prior to the arrival of the FBI. HazMat will conduct operations in support of the Incident Commander in order to rapidly identify the agent. During such operations they may choose to support the law enforcement investigation by obtaining additional agent samples and turning them over to investigators. Local investigators may play a role in establishing a chain of custody over such samples until they are relinquished to the FBI for processing at an approved laboratory.

The LEFG acknowledged that in order for the investigation to be successful, it would require extensive coordination, cooperation, and communication among law enforcement agencies from all levels of government. Local law enforcement can expect to support any part of the investigation, however, the Group did not see a need for local investigators to possess a capability to provide levels of protection essential to performing rapid collection of evidence from the scene. The primary focus that the LEFG took regarding PPE was to provide departments with guidelines for protecting the initial responding officers, patrol officers responsible for security on the scene and officers (patrol or tactical) who must perform duties inside of the Warm Zone. These duties and missions were considered part of the overall control of the incident scene and protection of lives. Departments choosing to establish investigative capabilities for contaminated areas have to train and equip their investigators with Level A response capability and should coordinate with the FBI crime lab to obtain specific collection procedures and materials necessary for chemical agents.

5.0 SPECIAL PLANNING CONSIDERATIONS

5.1 General

The IRP performed evaluations on several types of protective suits with applicability to law enforcement agencies choosing to undertake operations such as those previously described. The general procedure used to perform these evaluations is outlined in Appendix A (Man-In-Simulant Tests [MIST]). Separate evaluations were conducted for patrol officers and tactical officers. This was based on the differences in the protective clothing that was suitable to each mission. Performance results of these evaluations are outlined in Appendix B (Ensemble Stay-Times). Specific information regarding each of these evaluations is provided below.

5.2 Patrol Officers Operations

5.2.1 General

While identifying PPE for law enforcement operations, the LEFG considered the level of expected contamination that may be encountered and ensembles that were consistent with this level. Ensembles were also chosen based on their compatibility with the mission that must be performed. As discussed in section 4, patrol officers are expected to be on the scene almost immediately, if not already on scene when an incident occurs. Duties performed by patrol officers in support of overall on-scene operations include, but are not limited to:

- External perimeter security (traffic control, major access ways etc.).
- Inner perimeter security (boundaries of the Warm Zone).
- Security of the decontamination corridor (crowd control, law enforcement sensitive equipment, personal property, evidence).

An important factor in determining contamination threat and operational considerations is whether there are live victims in the contamination zone.

It was determined that officers operating on the perimeters of a chemical agent incident are expected to be far enough away from the agent source that they will come into contact with little, if any agent. The basis for protective equipment guidelines focuses on identifying if victims are alive inside of the initial exclusion zone (Hot Zone). This is an indicator of a limited agent concentration and should be used in making risk-based operational decisions by responders on the scene.

Officers operating on the inner perimeter and decontamination corridor should have adequate protection if they are equipped with a high-quality respirator, butyl rubber gloves, chemical protective footwear, and a commercial chemical overgarment. Departments may choose not to provide complete Level C ensembles to every officer; however, any officer responding to a chemical terrorist incident scene should have available at least a high quality respirator and chemical protective gloves.

Officers operating on the external perimeter should not be exposed to agent at all, but it is recommended that PPE be immediately available in case of secondary agent releases located in/around the initial incident site. This is a modification of Level D protection in that a complete Level C ensemble is recommended to be immediately available (such as in the officers' patrol car).

Impermeable suits were recommended for patrol officers based on the following criteria:

- These suits provided levels of protection consistent to that of the respirator being worn.
- Chance of exposure to water in and around the decontamination corridor required impermeable suits.
- A major consideration of any department is the cost of outfitting every patrol officer. Impermeable suits are less costly than other types.

Protective suits with built-in boots, hoods, and elastic wrist closures are the preferred type of suits as these factors increase the overall protective qualities of the suit. Most manufacturers have suits made of identical materials with and without these additional factors. The cost of upgrading to the "deluxe" style is minimal considering the added protection afforded.

5.2.2 Man-in-Simulant-Testing (MIST)

For the patrol officer ensemble testing, various impermeable, chemical-resistant, hooded, protective ensembles representing Level C protection were tested. The MCU2P mask with, seven-mil butyl rubber gloves, and butyl rubber boots were worn with all suits. The MCU2P is a military mask that was later adapted for civilian use in the form of the Millennium by Mine Safety Appliances (MSA). The Maryland State Police (MSP) provided Special Tactical Assault Team Element (STATE) team members as the test participants.

Details of the patrol officer ensemble testing, results and recommendations are outlined in the report *Chemical Protective Clothing for Law Enforcement Patrol Officers and Emergency Medical Services when Responding to Terrorism with Chemical Weapons*. Key information from this study and report are referenced herein.

Four chemical-resistant protective suits were evaluated, using the procedures outlined in Appendix A, with the standard MSP duty uniform worn underneath. In order to establish a baseline for the protection offered by the MSP duty uniform, it was tested as an ensemble with only the addition of the respiratory and glove protection outlined above. In addition to the above, a suit worn by MSP mechanics for asbestos abatement (Tyvek® Protective Wear™ suit) was tested. Prices for the commercial chemical-resistant suits (suit alone) ranged from $15-$60. Commercial chemical-resistant ensembles that were tested included:

Kappler CPF® 4 suit (model 4T34).

Dupont TyChem® 9400 suit (style 94160).

Dupont TyChem® SL suit (style 72150).

Tyvek® ProTech F suit.

Volunteers rotated test ensembles through six test repetitions that consisted of performing routine patrol officer duties for 30 minutes in the MIST facility. Activities were performed for three-minute intervals at each station, actions that were performed included:

Station	Activity Performed
1	Standing.
2	Slow walk on treadmill, moderate rate (2.5 km/hr).
3	Hand movements (directing traffic, radio operation).
4	Evacuation procedures (knocking on doors, talking).
5	Running on treadmill, fast rate (5 km/hr).
6	Seated rest.
7	Hand movements (directing traffic, radio operation).
8	Handcuffing, use of firearm.
9	Slow walk on treadmill, moderate rate (2.5 km/hr).
10	Seated rest.

Issues that were identified by the officers during the assessment were:

- Suits made a lot of noise during wear.
- Heat build-up was a problem.
- Very large sizes must be ordered to prevent tearing when crouching or bending over.

The results of the evaluations are listed in the form of overall Physiological Protective Dosage Factors (PPDF). The overall PPDF indicates how well the protective ensemble protects the officer's skin from chemical agent vapors as compared to the exposure that would be received with no protection. For example, the PPDF of 42 for the Tyvek® ProTech F suit, with butyl rubber gloves/boots and the MCU2P mask indicates that the protection afforded by the suit is 42 times greater than no protection at all. Results indicate that the Tyvek® ProTech F suit provided the best overall protection and appeared to have a better seal around the chin and neck area. The overall PPDFs for each ensemble tested are represented in Table 3. The PPDF was used to determine ensemble stay-times based on the likely concentration of agent to be encountered. These results are discussed in Appendix B.

Suit Configuration	# Suits Tested	Average Overall PPDF
Standard MSP Uniform	3	2
Tyvek® Protective Wear Suit	4	4
TyChem® 9400 Protective Suit	4	17
Kappler® CPF4 Protective Suit	4	18
TyChem® SL Protective Suit	5	24
Tyvek® ProTech F Protective Suit	5	42

Table 3. Overall PPDFs for Patrol Suit Ensembles

5.2.3 Weapons Proficiency

In addition to identifying the protective factors of certain ensembles, the LEFG was concerned with the potential for degradation of weapons accuracy when wearing PPE. Members of the Maryland State Police performed weapons qualification in the suit ensembles that were used in the MIST testing. The results of these qualifications were compared to the scores from previous qualifications conducted in standard duty uniform. The scores were essentially the same with only a difference of one or two points between firing situations.

Protective ensembles caused no noticeable degradation in weapons firing proficiency.

While qualification scores were basically unaffected by the PPE, officers experienced other negative impacts on functions that were attributable to the ensembles. Loading ammunition into magazines took longer, and the fingertips of the gloves were ripped during the course of reloading the magazine. Additionally, officers noted a decrease in mobility, as well as a noticeable heat build-up. The firing was conducted in the morning under warm, but not hot conditions and moderate humidity. All officers felt that if they had to remain in the ensembles for a period of more than an hour in the summer, the heat build-up would seriously degrade their ability to function.

5.2.4 Conclusions

Based on the PPDFs for suits tested for patrol officers, these ensembles will provide adequate protection to officers operating on the perimeter of a chemical agent incident as defined in section 4. Officers could expect to remain in the suits in this environment in excess of 14 hours without experiencing chemical agent symptoms (disregarding heat buildup). This stay-time is limited by the protective factor assigned by the National Institute of Occupational Safety and Health (NIOSH) to the negative-pressure respirator. Currently NIOSH has established a base respiratory protective factor of 50 for any negative-pressure respirator. Although SBCCOM conducted a quantitative fit test on each test subject and obtained a respiratory protection factor greater than 1000 for each respirator, the NIOSH requirement was applied in computing stay-times for the ensembles. This stay-time represents the point where minimum affects due to eye exposure would occur. The standard duty uniform and mechanics overalls did not provide sufficient protection to be considered for these situations.

These ensembles have been evaluated and stay-times calculated for exposure to vapor concentrations, which is the most likely form of contamination that will be encountered in performance of these missions. Officers performing the operational missions referenced in this report experience their most predominant chance of encountering liquid agent through cross-contamination from victims. Every attempt should be made to avoid any type of liquid contamination.

This assessment demonstrates that law enforcement officers can be equipped with an effective low-cost PPE ensemble for responding to a chemical terrorist incident. An ensemble consisting of a high quality respirator, butyl rubber gloves, a commercially available chemical-resistant overgarment, and either built-in booties or butyl rubber boots provides an adequate level of protection against chemical agent vapors for officers operating on the perimeter of the incident. **It must be emphasized that this clothing ensemble is inadequate protection for use in areas where significant levels of CWA vapor concentration may be present (Hot Zone) or interior spaces where reduced airflow will impede the dissemination of agent.** The Hot Zone should only be entered by personnel in higher levels of protection (Level A/B) who are certified to operate in this level of equipment such as HazMat technicians, regional FBI WMD coordinators.

5.3 Tactical Team Operations

5.3.1 General

Tactical officers, by nature of the missions they perform, receive a higher degree of training in their operational procedures, and are accustomed to operating with specialized equipment and performing specialized tactics. With this background, they are also considered good candidates for conducting operations where a greater threat of chemical agent exposure requires enhanced equipment and training in operational procedures (contamination avoidance, decontamination).

Prior to discussion of tactical operations, it should be reiterated that some departments might choose not to outfit all patrol officers with PPE. In these circumstances, tactical officers or civil disturbance teams may be called on to perform some or all of the missions described in the previous section on patrol officers. In these instances, tactical officers could use the PPE recommended in the patrol officer section; however, this level of protection does not lend itself to true tactical operations. The remainder of this section focuses on conduct of tactical operations in chemically contaminated areas or those with the potential for chemical agent exposure

The tactical clothing assessment conducted by SBCCOM focused on the PPE requirements based on tactical operations and an increase in the potential for chemical agent exposure. Missions that may subject tactical teams to chemical agent exposure include, but are not limited to:

- Apprehension of a suspect at a chemical terrorist incident.
- Take down of a suspect who is in possession of a chemical agent.
- Raid on a suspected chemical terrorist facility/laboratory.
- Hostage rescue operations.
- Dignitary protection missions.

Individual departments need to make operational assessments regarding performing missions inside of a known chemically contaminated area. Officers should then be equipped and trained accordingly.

The topic of tactical officers entering an area where chemical agents have been released was the basis of numerous LEFG discussions. It clearly is the intent of any department conducting a tactical mission to perform the mission in the safest manner for the officers involved while accomplishing the objective. Tactical officers may encounter chemical agents in both liquid and vapor form and are subject to direct attack with agents by means of a perpetrator or booby-trap. The CWIRP did not attempt to outline

if a department will or will not conduct operations in a chemical agent environment. Individual departments based on the current situation, level of training, and protective equipment available, will make these decisions.

PPE worn by tactical officers needed to be more durable, allow for unencumbered movement, be compatible with tactical considerations and equipment (dark colored, quiet), and provide an increased level of chemical agent protection.

Since tactical team operations are military-like in nature, the style of chemical protection already in use by military units was considered for evaluation. This type of protection consists of a permeable chemical protective suit (one or two piece), negative-pressure respirator, and chemical protective gloves and boots.

The impermeable style clothing evaluated for patrol officers were incompatible with tactical operations because they are noisy, brightly colored (although manufacturers can make them in almost any color desired), and tears easily.

5.3.2 MIST Testing

For the tactical clothing assessment, permeable, charcoal-impregnated, military style, chemical protective suits were used. In addition, two chemical protective undergarments (CPU) and one impermeable suit were tested. As with the patrol officer testing, the MSP STATE team provided volunteers for the test. Officers wore the MSA Millennium mask with hood and seven-mil butyl rubber gloves.

Eight protective suits were evaluated during the tests in accordance with procedures outlined in Appendix A. When the suit consisted of an integrated hood, the mask hood was worn under the integrated hood, tucked fully inside of the suit. Manufacturer's chemical protective gloves and socks that are considered a part of the suit were worn, if supplied. The standard MSP STATE team uniform, consisting of camouflaged fatigues and leather boots was worn in conjunction with the protective suits. Costs for suits other than the Tyvek® Pro-Tech F ($42) ranged from $150 - $960 for the suit alone.

Suits that were used in the test include:

- Tyvek® Pro-Tech F suit.
- Hammer Coverall.
- Hammer 2-piece suit.
- Giat Nuclear, Biological and Chemical (NBC) Special Weapons and Tactics (SWAT) suit.

- Tactical Operations Multi-Purpose Suit (TOMPS).
- Saratoga® CPU.
- Lanx CPU.

Tests were conducted in a warehouse that was modified for test purposes to support the vapor test requirements. To provide a tactical scenario for testing, the interior of the warehouse was configured with moveable partitions that were altered for each test to provide members with a variable floor layout consisting of rooms and stairways. Members of the MSP STATE team initiated each test by performing a dynamic entry for 3 minutes to sweep through and clear the warehouse. They then proceeded to conduct stealth operations for 27 minutes in order to complete the 30-minute test cycle. Activities performed during both phases of the test included:

Dynamic Mode

- Forced entry through doorway.
- Clear all areas of building.
- Sighting and discharging weapons.
- Suspect take-down.

Stealth Mode

- Entry and reconnaissance.
- Forced entry through doorway.
- Clear all areas of building.
- Climb ladder/stairs to evaluate overhead conditions.
- Crawling, climbing, crouching, maneuvering through building.
- Movement along walls.
- Hostage rescue.
- Sighting and discharging weapons.

Issues that were identified by officers during the assessment are:

- Tightness around the head and neck area restricted head movement. This, coupled with the reduced peripheral vision caused by the mask, resulted in more hand/shoulder contact along walls that could lead to an increase in liquid agent exposure.

- Inability to wear the ballistic helmet with the suit hood/mask hood combination. This is under investigation by the helmet manufacturers who identified that there is an oversized helmet available. This, however, would result in the necessity of two helmets per officer, one specifically for chemical situations.
- The ability to use whisper mikes was hampered by the masks.
- Heat build-up in the suits.

The overall PPDFs for each ensemble tested are represented in Table 4. The overall PPDF indicates how well the protective ensemble protects the officer's skin from chemical agent vapors as compared to the exposure that would be received with no protection. For example, the PPDF of 173 for the Hammer Coverall, with butyl rubber gloves and the MCU2P mask indicates that the duration (time) where an unprotected individual reaches a hazardous exposure level is increased 173 times for someone wearing the ensemble. The PPDF was used to determine ensemble stay-times based on the likely concentration of agent to be encountered. These results are discussed in Appendix B.

The Tyvek® ProTech F was used in both the patrol officer tests as well as this one. It is pointed out that in the tactical clothing assessment the suit PPDF is more than double that from the patrol test. This is clearly the result of the addition of the butyl-rubber mask hood which provided better protection around the chin and neck area. See the discussion in section 3.3.4 under protective clothing. Although the Tyvek® ProTech F suit achieved a PPDF near those of the permeable suits, participants determined that the fabric of the suit created too much noise for it to be used for SWAT operations. Therefore, testing of the suit was discontinued.

Suit Ensemble	# Suits Tested	Overall PPDF
Tyvek® Pro-Tech F Suit	3	103
Hammer Coverall	9	152
Hammer 2-Piece	10	106
SWAT NBC Suit	8	186
TOMPS Suit	8	141
Saratoga® CPU	8	116
Lanx CPU	8	113

Table 4. Overall PPDFs for SWAT Protective Suit Ensembles

A human factors evaluation was conducted following each test iteration to evaluate the operating aspects of the suits. The overall results of this evaluation are included in Appendix F.

5.3.3 Conclusions

The ensembles recommended for tactical operations clearly provide a greater level of protection over those for patrol officers. However, the limiting factor associated with the ensembles tested continues to be the negative-pressure respirator. Currently NIOSH has established a base respiratory protective factor of 50 for any negative-pressure respirator. Although SBCCOM conducted a quantitative fit test on each test subject and obtained a respiratory protection factor greater than 1000 for each respirator, the NIOSH requirement was applied in computing stay-times for the ensembles. Calculated stay-times are referenced in Appendix C. As such, the ensembles provide protection to an officer operating on the perimeter of a chemical agent incident (roles outlined in the patrol officer section) for over 14 hours of operation. When applied to a highly lethal concentration such as may be the case if attacked with a chemical agent during a take down of a perpetrator, the ensemble only provides protection for a 3-minute duration before officers would experience mild agent symptoms associated with eye exposure. Once the eyes are affected, the ability of an officer to sight and use their firearm is in jeopardy. Again, the limiting factor in these circumstances is the respirator. Increased levels of protection can be obtained by increasing the level of respiratory protection (PAPR, SCBA) but at a reduction in tactical operating ability.

Based on the information gained from the study the following conclusions can be drawn:

- The ensembles tested provide a high level of protection for officers operating on the perimeter of the incident.
- The chemical protective clothing systems are of secondary importance to respiratory and eye protection.
- With a respiratory protection factor of 50, operations in any chemical environment are limited by eye exposure.
- Within minutes of exposure to a highly lethal concentration personnel must exit the area.
- Possibly saturated chemical environments are not safe for personnel using the ensembles examined in this study.

5.4 Ensemble Considerations

This report is intended to provide law enforcement commanders with essential information to make critical decisions regarding response procedures and equipment considerations. Protective ensembles were identified and

evaluated based on the mission, contamination levels, and likelihood of contamination that may be encountered.

The CWIRP focused on affordable, high-quality PPE that was compatible with the law enforcement mission, minimized the contamination threat, and seemed within the department's capability to procure, use, and maintain. These ensembles were then evaluated in accordance with standard analytical procedures.

Regardless of the type, style or level of PPE used there are additional considerations that must be addressed by departments. Every piece of protective clothing and equipment that makes up a protective ensemble is sized. Even with these suits there is no one-size that fits all. While suits, especially impermeable ones, are normally worn two sizes larger than normal clothing, someone needing a medium may have a difficult time performing mission requirements if they are forced to wear a 3XL. To provide protection to first responding patrol officers, PPE (at least respirators) must be readily available, i.e., in the patrol vehicles. Departments choosing to provide PPE to their officers must determine how to ensure that their proper equipment is available to them. While vehicles are already over crowded with equipment, the most logical solution is to package each officer's PPE in a carry-on bag that can be stored and placed in the vehicle during their shifts.

In addition to sizing, storage and maintenance presented concerns. Extreme temperatures and/or high humidity can damage most respirators as may be presented through storage in the trunk of a patrol vehicle. The mask face blank is also susceptible to damage, mainly through deformation that can occur when it is crushed or pushed out of shape for an extended period of time as can occur if stuffed between a lot of equipment that may be in the trunk of a car. This problem is particularly true of the eye lens on singular-vision masks.

Another concern presented was the maintenance of any equipment that required batteries, such as a PAPR mask. As referenced in the LEFG meetings, anything with a battery isn't cop proof. To ensure proper functioning, batteries must be in proper working order with a good charge. Departments must establish a thorough maintenance program to insure that all of their PPE is adequately maintained and capable to providing the protection for which it was designed. Personnel who perform maintenance checks and services on protective equipment must be fully trained on the procedures.

Finally, obtaining and issuing PPE to officers is useless unless they are trained and proficient in its use, care and maintenance, and understand the limits of the protection it affords. Without this final consideration, PPE can produce more harm than good by providing an officer with a false sense of protection beyond the limits of the ensemble. A mask and suit doesn't allow an officer to rush into any and every contaminated area.

5.5 Conclusions

It is the intent of this report to indicate the types of law enforcement operations that may be performed in response to an act of terrorism using chemical agents and the types of personal protection that may support such operations. Each department must consider what roles they will perform in support of the overall response, what actions they feel must be handled by local authorities before state and federal resources arrive, and what their equipment requirements are to perform such missions.

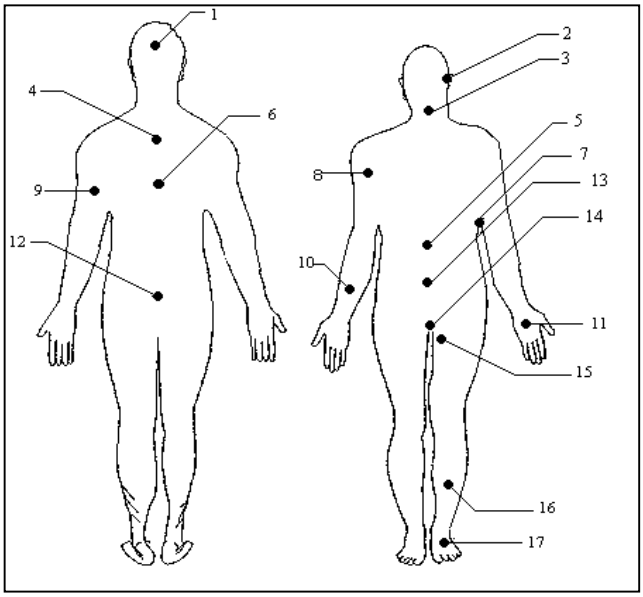
As demonstrated through the testing performed in this study protection is achieved only by providing serviceable and well-maintained equipment to officers who are trained in its proper use. In addition, officers must be knowledgeable of the limits of the protection they are issued; otherwise they may gain a sense of being indestructible and exceed the safe operational capacity of their equipment.

APPENDIX A

Man-In-Simulant Tests (MIST)

The LEFG identified styles and types of protective ensembles that support law enforcement efforts on a chemical terrorist incident based on the outlined missions and threat of vapor and liquid contamination. Variations of these ensembles were tested using internationally accepted protocols. The chemical protection offered by these ensembles was measured using the Man-In-Simulant Test (MIST) procedure, at the Edgewood Area of Aberdeen Proving Ground. MIST fully assesses the protection offered by complete protective ensembles by measuring the absorption of chemical vapors at the surface of the skin. Protection is determined by comparing that absorption to the absorption that occurs without any protection. MIST is used by the US Army, in development of its personal chemical protective ensembles, and by the Domestic Preparedness Program, in assessing operational protective performance of personal protective systems.

Test subjects wear full protective ensembles, in a vapor simulant, while performing activities that they would perform in an actual chemical response. MIST does not place people at risk of exposure to chemical agents because a chemical simulant vapor is used in place of actual agent vapors. The simulants used duplicate actual agents in the manner in which they penetrate protective ensembles.



MIST uses passive samplers, which sample by absorption. They are placed on the skin so that they can accurately measure the absorption of vapor at the skin surface. Samplers are placed at 17 specific body locations to determine the amount of vapor absorbed at various locations on the body.

The Maryland State Police (MSP) Special Tactical Assault Team Element (STATE) supported testing by providing members for both the patrol and tactical testing phases of the program. During testing, these volunteers performed actions like those they would conduct at the incident scene. Tests were performed over a 30-minute period. A description of actions performed during each phase of testing is included in the sections addressing that specific assessment. After the thirty-minute vapor exposure, protective clothing is removed and vapor samplers are collected in a clean room. Analysis

of each sampler yields the dosage received at the skin.

The overall protective performance of the chemical protective system is determined through the Body Region Hazard Analysis (BRHA)[3] and is expressed in the form of a Physiological Protective Dosage Factor (PPDF). The higher the PPDF the greater is the level of protection. The PPDF is then used to compute the increase in time (stay-time) that the wearer can be exposed to a specific agent concentration, above that of an unprotected person, before experiencing mild agent affects.

[3] Fedele, PD, and Nelson, DC, *A Method of Assessing Full Individual* Protective *System Performance Against Cutaneous Effects of Aerosol and Vapor Exposures,* US Army Edgewood Research Development and Engineering Center, APG, MD, October, 1995; Section 1-3 "Body Region Hazard Analysis Process" included in report for the JSLIST Program: Cronin, TD, *Final Report for the Development of the Man-In-Simulant Test (MIST) Method for Evaluation of Chemical/Biological (CB) Protective Garments,* TECOM Project No. 8-EI-825-ABO-004, US Army Dugway Proving Ground, Dugway, Utah, April 1996.

APPENDIX B

Ensemble Stay-Times

General

The MIST analysis studies, as described in Appendix B, were used for determining stay-times for PPE ensembles for law enforcement officers based on the operational procedures and protection considered in this report. The ensemble stay-times represent the duration that someone can remain in the exposure concentration before experiencing mild chemical agent effects.

Chemical Agent Exposure

Chemical agents are absorbed into the body through the respiratory system, eyes, and skin. Agent absorption differs based on the type of agent and the route of exposure. Stay-time is based on how long an unprotected person can remain in a certain vapor concentration before they experience threshold effects of the agent. The threshold effects represent the point where the mildest chemical agent effects occur in the most sensitive part of the body. Additional exposure increases the extent and severity of the agent effects and can result in death depending on the agent and total amount of exposure.

Depending on the agent, threshold effects develop either in a localized region, or through total body absorption of agent. Vapors from vesicants, like mustard (HD), cause reddening of the skin, and eventually blisters, in very localized areas (local effects). These areas are generally in the warm, moist, areas of the body such as the groin and underarms. Alternately, nerve agent vapors, like sarin (GB), soman (GD), and VX produce effects as a result of total body absorption (systemic effects). Direct eye exposure to nerve agent vapors; however, produces a localized effect known as miosis which is a severe constriction of the pupil.

The two areas found to be most vulnerable to localized effects during MIST were the scrotum and the chin and neck region. The scrotum is very sensitive to chemicals. Exposure to over-the-counter liniments, such as Ben Gay® exemplifies this. As such, this area is highly vulnerable to chemical agents. In instances where the chin and neck region presented the most vulnerable area it was mainly attributed to a poor seal between the suit and mask in this area. The use of a hood, specifically designed for the mask being worn, can increase the amount of protection provided in this area.

The amount of agent absorbed depends on the concentration of agent C (mg m^3) and duration of exposure T (minutes). When the combination of concentration and exposure (time) cause threshold agents effects an individual is said to have received a threshold-effective dosage. Threshold effective dosages are labeled TE_{CT}(mg min m^3). All people do not experience the same sensitivity to agents thereby creating a variance in the threshold-effective dosages for each

individual. For each agent, the average threshold-effective dosage for all people represents the dosage whereby 50 percent of the exposed people will experience effects. This is expressed in the form of $TE_{CT(50)}$. The National Research Council[4] has developed $TE_{CT(50)}$ values for chemical agent exposures. Unprotected stay-times, T_s, are calculated using these averages and are expressed as

$$T_S = \frac{TE_{CT(50)}}{C}$$

SBCCOM calculated stay-times for the ensembles tested using five chemical agent vapor concentration levels. Patrol officer stay-times were based on the perimeter boundaries outlined in the 2000 Emergency Response Guidebook[5] (ERG) and the maximum downwind agent concentration expected at these boundaries from a 55-gallon chemical agent spill. The three perimeter boundaries correspond to the Initial Isolation Zone, the Day Protect Zone, and the Night Protect Zone. Chemical agent concentrations for these distances were calculated using spill evaporation and atmospheric transport and dispersion models detailed by Stuempfle[6].

The nature of the missions identified for SWAT teams may require them to operate indoors where chemical agent contamination exists or may be released. Chemical agent concentrations are expected to be greater in enclosed spaces and therefore, different agent concentrations are used in computing the stay-times for SWAT ensembles. The first concentration used represents the level whereby 95 percent of **unprotected** persons would receive a lethal dosage after 15 minutes of exposure. This concentration is referred to as a "Highly Lethal Concentration". The second concentration calculates the worst-case vapor concentration, referred to as "Saturation Concentration" and reflects a saturation of agent at a temperature of 18 degrees Celsius (65 degrees Fahrenheit). It is emphasized that the concentrations referred to as "Highly Lethal" is in reference to unprotected persons.

Physiological Protective Dosage Factor

Chemical protective ensembles reduce the body's exposure to chemical agent vapors thereby allowing personnel to remain in a contaminated environment for longer durations than they could without protection before experiencing chemical agent effects. The MIST measures the amount of agent absorbed by the body while a protective ensemble is being worn. The increase in protection that the ensemble provides, above that of an unprotected person, is expressed in the form of a Physiological Protective Dosage Factor (PPDF). For example, if an unprotected person exposed to a certain concentration of chemical agent vapor experiences threshold effects in 1 minute, then someone wearing a protective ensemble with a PPDF of 10 could be exposed for 10 times as long, 10 minutes, before experiencing the same effects. The PPDF is applied to

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[4] Review of Acute Human-Toxicity Estimates for Selected Chemical-Warfare Agents, Subcommittee on Toxicity Values for Selected Nerve and Vesicant Agents, Committee on Toxicology, Board on Environmental Studies and Toxicology, Commission on life Sciences, National Research Council, National Academy Press, Washington, DC, 1997, available at http://books.nap.edu/books/0309057493/html/index.html.

[5] US Department of Transportation, 2000 Emergency Response Guidebook, January 2001, available at: http//hazmat.dot.gov/erg2000/erg2000.pdf.

[6] KL Stuempfle and AD Stuempfle, "Visual Comparision of Perimeter Challenge Levels from Model Predictions of Chemical Incidents", Poster Paper, 2001 Chemical and Biological Defense Conference, March 2001.

the unprotected stay-time to derive a protected stay-time (T_{SP}) for the protective ensemble. This is computed using the formula $T_{SP} = T_s \times PPDF$.

Calculating the PPDF takes into account the type of agent and the earliest indication of threshold effects through either systemic or localized exposure. Therefore, a single protective ensemble may have separate PPDFs for different agents.

SBCCOM computed PPDFs for law enforcement PPE ensembles using localized skin effects of HD and systemic effects of GB, GD, and VX. The overall protective performance of each suit is summarized by a systemic PPDF ($PPDF_S$) and a local PPDF ($PPDF_L$). Tables 5 and 6 below give the local and systemic PPDFs for each of the suits tested in the SWAT and patrol tests, respectively. The third column of each table indicates the region of the body where the threshold effects of HD are first expected.

Protective Suit Ensemble Tested	**$PPDF_S$ (for systemic effects of nerve agents)**	**$PPDF_L$ (for skin effects of HD)**	**Body Region of skin irritation for HD**
LANX® Chemical Protective Undergarment	113	95	Scrotum
Saratoga® Chemical Protective Undergarment	116	125	Scrotum
Hammer® Two-Piece Chemical Protective Overgarment	106	148	Scrotum
Giat® SWAT One-piece Chemical Protective Overgarment	186	179	Scrotum
TOMPS® Two-Piece Chemical Protective Overgarment	141	183	Scrotum
Hammer® One-piece Chemical Protective Overgarment	152	191	Scrotum

Table 5. Physiological Protective Dosage Factors For SWAT Chemical Protective Suits Tested

Protective Suit Ensemble Tested	$PPDF_S$ (for systemic effects of nerve agents)	$PPDF_L$ (for skin effects of HD)	Body Region of skin irritation for HD
MSP Standard Duty Uniform	2	3	Scrotum
Tyvec ® Protective Wear ™ Coverall	4	4	Scrotum
Kappler CPF®4 Suit	18	5	Chin and Neck
Dupont Tychem® 9400 Suit	17	7	Chin and Neck
Dupont Tychem® SL Suit	24	8	Chin and Neck
Tyvek® Protech F Suit	42	44	Chin and Neck

Table 6. Physiological Protective Dosage Factors For Patrol Chemical Protective Suits Tested

Respiratory Protection Factor

To fully evaluate a complete protective ensemble, stay-times must be determined for all principle chemical agent threshold effects. The respiratory protection factor (PF) must be used to determine stay-times for eye effects; the suit PPDFs must be used to determine stay-times for systemic nerve agent effects and the local mustard effects. The minimum stay-times of all of these is then used to indicate how long it would take to receive a hazardous exposure with using the protective ensemble. The respiratory PF indicates the limits where threshold effects based on eye exposure occur for the type of respirator being worn. SBCCOM did not measure respiratory PF as part of their ensemble studies. Stay-times for law enforcement PPE ensembles were calculated using two respiratory PFs. The first was the NIOSH applied PF for negative-pressure respirators[7] which is 50. The second, a value of 6,666, represents the respiratory PF typically achieved by modern tight-fitting, full-face, negative-pressure respirators[8].

Ensemble Stay-Times

Using the agent concentrations, ensemble PPDFs, and respiratory protection factors described above, SBCCOM computed stay-times for each protective ensemble tested. The calculation of stay-time takes into account the systemic effects, localized skin exposure, and localized eye exposure threshold effects levels. The lowest of these three threshold effect levels is used in calculating the stay-time for that particular ensemble and agent.

The ensemble stay-time represents the point where the average person can expect to experience chemical agent effects no more severe than the threshold effect. Threshold effect refers to the initial, first noticeable, symptoms indicating that a person has been exposed to a chemical agent (such as miosis for nerve agent eye exposure). Since people have different sensitivities to

[7] National Institute for Occupational Safety and Health, Research Development Letter (RDL) # 78-108; Applied Protection Factor Table, May 2000.
[8] SBCCOM, Program Manager for NBC Defense, private communications, February 2001.

chemical agent exposures, the stay-time represents the point where 50 percent of the exposed people can expect to experience threshold effects. Some individuals will experience threshold effects earlier, while others will experience no effects at the calculated stay-time. It is emphasized that regardless of time spent in a contaminated area, if an individual feels they are experiencing chemical agent effects they should immediately exit the area, undergo decontamination, and seek medical aid.

Tables 7 and 8 below show the stay-times for all protective suits tested using a respiratory protection factor of 50. Using the respiratory PF of 50, localized eye effects becomes the limiting factor for exposure. Therefore, regardless of the protective suit worn, stay-times for all ensembles are the same.

Protective Suit Ensemble Tested	Highly Lethal Concentration	Saturation Concentration (at 65°F)
All Suits Tested*	3	0.007 (0.4 sec)

Table 7. Minimum Stay-Times in Minutes for SWAT Teams Inside Buildings Using a Respiratory Mask PF of 50

Protective Suit Ensemble Tested	Perimeter (Isolation Protect Zone) Concentration	Perimeter (Day Protect Zone) Concentration	Perimeter (Night Protect Zone) Concentration
All Suits Tested*	22	850 (14 hours)	3220 (53 hours)

Table 8. Minimum Stay-Times in Minutes for Patrol Officers at ERG Protect Zones Using a Respiratory Mask PF of 50

* Minimum stay-times are due to threshold effects associated with eye exposure, so stay-times do not vary by protective suit.

Modern, well-fitted, respiratory protective masks can typically deliver protective factors of 6,666. Tables 9 and 10 below indicate stay-times using a respiratory PF of 6,666 when applied to the PPDFs of the ensembles tested.

Stay-times for SWAT ensembles vary based on the agent. The HD limits represent the point where localized reddening and irritation of the scrotum first appears. Stay-times for nerve agents indicate where threshold effects from local eye exposure (miosis) occur. Since the respiratory PF is still the limiting factor for nerve agent exposure, the stay-times for different suits does not change. Stay-times listed for "Highly Lethal Concentrations for Nerve Agents" should only be considered if nerve agents are known to be present, mustard (HD) is NOT present, and there are surviving unprotected people in the area. In the absence of surviving unprotected people, stay-times for a "Saturation Concentration" should be applied. Stay-times under saturated conditions are too short for most operational missions.

Protective Suit Ensemble Tested	Stay-Time (Minutes) at Highly Lethal Concentration (HD)	Stay-Time (Minutes) at Highly Lethal Concentrations for Nerve Agents Only*	Stay-Time (Minutes) at Saturation Concentration (at 65°F)*
LANX® Chemical Protective Undergarment	19	395	1
Saratoga® Chemical Protective Undergarment	25	395	1
Hammer® Two-Piece Chemical Protective Overgarment	30	395	1
Giat® SWAT One-piece Chemical Protective Overgarment	36	395	1
TOMPS® Two-Piece Chemical Protective Overgarment	37	395	1
Hammer® One-piece Chemical Protective Overgarment	38	395	1

Table 9. Minimum Stay-Times in Minutes for SWAT Protective Suits Tested Using Respiratory Mask PF of 6666 Inside Buildings

* For Columns 2 and 3, Minimum stay-times are due to threshold effects associated with eye exposure, so stay-times do not vary by protective suit.

Patrol officer ensembles tested provide adequate protection for prolonged operations on the perimeter of the Day Protect Zone and beyond. In fact, the limiting factor at these distances and stay-times will more likely come from fatigue and heat related injury rather than agent threshold effects. For operations inside of the Day Protect Zone functions are more limited due to agent exposure. Stay-times for all of the patrol officer ensembles represents the limits for localized threshold effects of mustard (HD) on either the scrotum or the chin and neck areas.

Protective Suit Ensemble Tested	Perimeter (Isolation Protect Zone) Concentration	Perimeter (Day Protect Zone) Concentration	Perimeter (Night Protect Zone) Concentration
MSP Standard Duty Uniform	61	1520 (25 hours)	5750 (95 hours)
Tyvec ® Protective Wear ™ Coverall	93	2310 (38 hours)	8740 (145 hours)
Kappler CPF®4 Suit	109	2710 (45 hours)	10200 (170 hrs)
Dupont Tychem® 9400 Suit	152	3770 (62 hours)	14300 (238 hrs)
Dupont Tychem® SL Suit	171	4250 (70 hours)	16100 (268 hrs)
Tyvek® Protech F Suit	944 (15 hours)	23500 (391 hrs)	88800 (1480 hrs)

Table 10. Minimum Stay-Times in Minutes for Protective Suits Tested Using Respiratory Mask PF of 6666 at ERG Protect Zones for Patrol Officers

APPENDIX C

Safety Requirements

General

The LEFG examined the Occupational Safety and Health Administration (OSHA) and National Institute of Occupational Safety and Health (NIOSH) safety and certification requirements for protective clothing and respiratory equipment. NIOSH has historically focused on the environment encountered by workers in the chemical industry while OSHA has outlined standards for hazardous waste operations and emergency response. NIOSH has established new standards for certification of respiratory protective equipment against CBRN materials. The NIOSH standards are available at http://www.cdc.gov/niosh/npptl/scbasite.html for CBRN SCBA, and http://www.cdc.gov/niosh/npptl/cbrnstdpg.html for CBRN APR. The National Fire Protection Association (NFPA) has established a standard for certification of protective clothing against CBRN materials. The NFPA 1994 standard is available at http://www.nfpa.org/Codes/index.asp. The National Institute of Standards and Technology (NIST) is currently developing a CBRN protective clothing standard to complement the NIOSH standards for CBRN respiratory protection. NIST and the Office of Law Enforcement Standards are currently addressing law enforcement CBRN protection concerns. OSHA PPE requirements for chemical environments other than CWA are outlined in Appendix F.

There is no direct correlation between military protective equipment and civilian standards.

It must be noted that equipment in use by the U.S. Armed Forces is tested and complies with Department of Defense (DoD) standards and that OSHA and NIOSH do not govern DoD requirements for operations in a combat environment. Therefore, a direct correlation between military protective equipment and civilian application cannot be assumed. This holds true for protective equipment as well as certification standards for determining completeness of decontamination ("how clean is clean").

The Department of Justice, DoD, and NIOSH have entered into agreement to develop standards for protective equipment for CWAs. In the interim, many emergency response agencies faced with responding to an act of chemical terrorism today have indicated that they will use the military guidelines and standards until further research is conducted and further civilian standards published. It is understood that failure to comply with NIOSH, OSHA and other guidelines carries increased risk.

Currently NIOSH maintains a list of CBRN protective equipment that has been certified under appropriate NIOSH standards on its web site. A National Domestic Preparedness Office list of questions to ask when considering purchasing equipment for chemical and biological operations

is included as Appendix I. This list offers a very thorough outline of the important facts that should be obtained from manufacturers when considering what equipment to purchase.

Respiratory Protection Requirements

OSHA Regulations (Standards – 29 CFR), Respiratory Protection 1910.134 outline requirements for agencies and individuals using respiratory protection. For the most part law enforcement agencies using masks for riot control purposes have not followed these requirements. As departments establish operating procedures and procure equipment for responding to acts of chemical/biological terrorism they can probably expect a more stringent application of the requirements of 1910.134. In the future, we expect that OSHA regulations may require that PPE be in compliance with established NIOSH and NIST standards.

OSHA's respiratory protection standards require employers to develop and implement a written respiratory protection program. Further requirements of 1910.134 that must be outlined in the respiratory protection program include:

- Procedures for selecting respirators.
- Medical evaluations.
    - Establishes requirements to determine an employee's ability to use a respirator.
    - Must be administered by a physician or other licensed health care professional.
    - Begins with a medical questionnaire.
    - Can develop into a complete medical examination based on answers to the medical questionnaire.
    - Must be provided at no cost to the employee.

- Fit testing procedures.
    - Required prior to initial use, whenever a different size, style, model or make of respirator is to be used and at least annually.
    - Required whenever there is a change in the employee's physical condition that could affect respirator fit. Such conditions include, but are not limited to, facial scarring, dental changes, cosmetic surgery, or an obvious change in body weight.
    - Requires masks to pass an approved OSHA quantitative fit testing (QNFT) protocol. This QNFT requires testing of the fit of the respirator using calibrated test equipment.
    - For a more detailed discussion of testing and evaluations conducted on the fit of masks currently issued to law enforcement officers refer to Appendix D.

    - It is noted that use of a PAPR or SCBA or other form of respirator that provides an air source does not eliminate the requirement for passing a QNFT. These masks, which form a tight fitting seal on the wearer's face, must still be tested to standards in the negative-pressure mode.

- Procedures for proper use of respirators in routine and reasonably foreseeable emergency situations.
- Procedures for maintaining respirators.
    - Cleaning and disinfecting.
    - Storage.
    - Inspection.
    - Repair.
- Training requirements.
    - Proper use of respirators, including putting on and removing them, any limitations on their use, and their maintenance.
    - Required annually.

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APPENDIX D

Fit Testing

The respirator fit test represents a quantitative evaluation of the effectiveness of the mask. Officers can compare this type of evaluation to that of calibrating a radar gun. Both identify the ability of the piece of equipment to accurately perform its designated function.

Performing and maintaining respirator fit test requirements is one of the more difficult aspects of the respiratory protection program for departments because it is very time consuming and requires costly equipment. Even in departments that try to meet the requirements of respiratory protection the fit test is often neglected. However, it is the most essential in determining if the wearer has the proper style, type and size respirator for him/her. A well-trained officer with a highly maintained respirator isn't protected if the respirator isn't fitted properly. On the other hand, a properly fitted respirator isn't much good if the wearer isn't properly trained in its use, or the respirator isn't maintained to serviceability standards.

A well-trained officer with a highly maintained (serviceable) respirator isn't protected if the respirator isn't properly fitted.

A quantitative fit test (QNFT) requires a respirator fit test machine, someone (preferably more than one individual) trained in its use, and a computer for recording test data. Respirator fit test machines generally cost between $7000-$10,000 to purchase. Once the equipment is procured and operator(s) trained, fit testing of individuals takes approximately 15-20 minutes per person. It is required that individuals be tested using the same style, model, make, and size of respirator as that which they are issued for wear. Ideally, the individuals should be tested using their issued respirator.

Results of testing of respirators currently in use by law enforcement officers indicated that almost 50% were not properly sized and/or could not establish a seal in accordance with OSHA fit test requirements.

The CWIRP conducted a sampling of respirators in use by one of the law enforcement agencies supporting the IRP efforts. The intent of this sampling was to evaluate the departments' procedures for issuing (sizing and fitting) respirators, how well officers were trained on donning and sealing the respirators, and to perform a QNFT on each officer with their mask as they would be wearing it in response to a chemical agent incident.

Officers were not assigned individual masks; rather, they were issued masks from stocks as needed (primarily when faced with a riot control situation). Masks were issued to officers according to current procedures. A total of 44 officers were tested on the standard QNFT equipment used by SBCCOM for their employees within the respiratory protection program.

Results of testing showed that almost half of the officers tested could not obtain a fit that satisfied OSHA requirement. Of the 44 officers tested, 20 were not able to attain a validated fit. Seven of the 20 who originally failed were able to pass after receiving assistance from a member

of the SBCCOM fit test team in refitting the mask. The results indicated that 13 of the 44 officers were issued the wrong size mask and others lacked the familiarity and training with the equipment to don it properly.

APPENDIX E
OSHA Protection Requirements

LEVEL OF PROTECTION	EQUIPMENT	PROTECTION PROVIDED	SHOULD BE USED WHEN:	LIMITING CRITERIA
A	RECOMMENDED: • Pressure-demand, full-facepiece SCBA or pressure-demand supplied-air respirator with escape SCBA. • Fully-encapsulating, chemical-resistant suit. • Inner chemical-resistant gloves. • Chemical-resistant safety boots/shoes. • Two-way radio communications. OPTIONAL: • Cooling unit. • Coveralls. • Long cotton underwear. • Hard hat. • Disposable gloves and boot covers.	The highest available level of respiratory, skin, and eye protection.	• The chemical substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system based on either: – Measured (or potential for) high concentration of atmospheric vapors, gases, or particulates or – Site operations and work functions involving a high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates of materials that are harmful to skin or capable of being absorbed through the intact skin. ▪ Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible. ▪ Operations must be conducted in confined, poorly ventilated areas until the absence of conditions requiring Level A protection is determined.	▪ Fully-encapsulating suit material must be compatible with the substances involved.

LEVEL OF PROTECTION	EQUIPMENT	PROTECTION PROVIDED	SHOULD BE USED WHEN:	LIMITING CRITERIA
B	RECOMMENDED: ▪ Pressure-demand, full-facepiece SCBA or pressure-demand supplied-air respirator with escape SCBA. ▪ Chemical-resistant clothing (overalls and long-sleeved jacket; hooded, one or two-piece chemical splash suit; disposable chemical-resistant one-piece suit). ▪ Inner and outer chemical-resistant gloves. ▪ Chemical-resistant safety boots/shoes. ▪ Hard hat. ▪ Two-way radio communications. OPTIONAL: ▪ Coveralls. ▪ Disposable boot covers. ▪ Face shield. ▪ Long cotton underwear.	The same level of respiratory protection but less skin protection than Level A. It is the minimum level recommended for initial site entries until the hazards have been further identified.	• The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection, but less skin protection. This involves atmospheres: – With IDLH concentrations of specific substances that do not represent a severe skin hazard; or – That do not meet the criteria for use of air-purifying respirators. ▪ Atmosphere contains less than 19.5 percent oxygen. ▪ Presence of incompletely identified vapors or gases is indicated by direct-reading organic vapor detection instrument, but vapors and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the intact skin.	▪ Use only when the vapor or gases present are not suspected of containing high concentrations of chemicals that are harmful to skin or capable of being absorbed through the intact skin. ▪ Use only when it is highly unlikely that the work being done will generate either high concentrations of vapors, gases, or particulates or splashes of material that will affect exposed skin.

LEVEL OF PROTECTION	EQUIPMENT	PROTECTION PROVIDED	SHOULD BE USED WHEN:	LIMITING CRITERIA
C	RECOMMENDED: ▪ Full-facepiece, air-purifying, canister-equipped respirator. ▪ Chemical-resistant clothing (overalls and long-sleeved jacket; hooded, one- or two-piece chemical splash suit; disposable chemical- resistant one-piece suite). ▪ Inner and outer chemical-resistant gloves. ▪ Chemical-resistant safety boots/shoes. ▪ Hard hat. ▪ Two-way radio communications. OPTIONAL: ▪ Coveralls. ▪ Disposable boot covers. ▪ Face shield. ▪ Escape mask. ▪ Long cotton underwear.	The same level of skin protection as Level B, but a lower level of respiratory protection.	• The atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect any exposed skin. • The types of air contaminants have been identified, concentrations measured, and a canister is available that can remove the contaminant. • All criteria for the use of air-purifying respirators are met.	▪ Atmospheric concentration of chemicals must not exceed IDLH levels. ▪ The atmosphere must contain at least 19.5 percent oxygen.
D	RECOMMENDED: ▪ Coveralls. ▪ Safety boots/shoes. ▪ Safety glasses or chemical splash goggles. ▪ Hard hat. OPTIONAL: ▪ Gloves. ▪ Escape mask. ▪ Face shield.	No respiratory protection. Minimal skin protection.	• The atmosphere contains no known hazard. • Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.	▪ This level should not be worn in the Exclusion Zone. ▪ The atmosphere must contain at least 19.5 percent oxygen.

APPENDIX F

Human Factors Evaluation

Human Factors Evaluation and Operational Characteristics for SWAT Suits

Evaluations of the operating aspects of the suits were performed during SWAT Team MIST testing by having the test participants fill out a Human Factors Questionnaire immediately after the mission ended. They rated different operational procedures of the suits, how long they could expect to operate in the suits during different seasons, and how much initial and yearly training was required. The test participants' rating of the suits is summarized in (Table 1). The biggest problems noted for all of the suit ensembles were:

- The inability to use the whisper mikes (for communication to the other officers).
- The inability to wear the ballistic helmets.
- The restrictions on head movement caused by the mask hood/suit hood combination.
- Heat loading during the warmer test periods.

Most of the problems had to do with the Millennium mask system. The manufacturer of the mask (Mine Safety Appliances - MSA) was contacted regarding the microphone problem and stated that a system is available for the Millennium Mask that will allow communications between the SWAT Team members. This system is called the ESP® RI (Electronic Speech Projection with Radio Interface) Communications System; it consists of an in-mask microphone and a corded control module with output-adapters to a wide variety of walkie-talkie radios. The system costs around $400 and is easily adapted for use with the Millennium mask. The external wiring that connects from the mask system to the officer's radio is designed to be routed over the back and must be concealed (may be routed under the suit jacket).

The problem with tightness around the neck and restriction of movement were caused because the hood of the mask was tucked under the hood of the suits, and some of the suit hoods sealed very tightly. This provides increased protection against vapors (as noted previously); however, it also limits the free movement of the head and may restrict SWAT Team officers from quickly rotating the head to clearly see hidden suspects. Some subjects noted that the tightness of the hood temporarily broke the mask seal when they turned their heads, or looked over their shoulders. The problem with free movement of the head was more evident with the French-manufactured GIAT suits (NBC SWAT and TOMPS), but was also reported for the Hammer Coverall and 2-Piece suits. Test participants stated that the NBC SWAT was better than the TOMPS for this problem.

It should be noted that most of the SWAT Team members who participated in this testing are very large (Football-Player Physiques), and several required sizes for the suits that were bigger than 'Large' and 'Extra-Large'. This may have contributed to the head movement problem and could be eliminated if suit manufacturers could provide suit-sizes that are bigger than 'Extra-Large' (or suits that have more room in the neck area). It should also be noted that the GIAT suits were designed for a different type of mask, and much of the problems with hood restriction

are eliminated when the French-manufactured mask is used with this suit. The manufacturer has stated that a different hood configuration can be made available for different masks.

	Compatibility of suit with:				
	Gloves?	Boots?	Mask?	Mask Hood?	Other SWAT Equipment?
Average Score all suits:	**4.63**	**4.68**	**4.45**	**4.45**	**4.44**
Average Hammer Coverall:	4.38	4.75	3.75	3.63	3.88
Average Hammer 2-piece suit:	4.50	4.20	4.70	4.80	4.00
Average SWAT NBC suit:	5.25	4.88	3.88	3.88	4.75
Average TOMPS 2-piece suit:	5.00	4.67	4.50	4.50	4.67
Average Score Saratoga® CPU gear:	4.57	5.00	4.71	5.00	5.33
Average Score Lanx CPU gear:	3.71	4.29	4.71	4.43	4.43
Average Tyvek® F suit:	5.25	5.25	5.25	5.67	4.75

	While operating in the suit:			Ease of putting the suit on?	Ease of taking the suit off?
	level of Noise	level of Comfort	Heat Burden?		
Average Score all Suits:	**4.45**	**4.27**	**3.62**	**4.08**	**4.23**
Average Hammer Coverall suit:	4.00	3.88	3.88	3.75	3.75
Average Hammer 2-piece suit:	4.90	4.30	3.40	4.40	4.40
Average SWAT NBC suit:	4.63	4.50	3.75	3.25	3.38
Average TOMPS 2-piece suit:	4.50	4.17	3.67	4.17	4.50
Average Score Saratoga® CPU gear:	5.00	4.29	4.00	4.86	4.86
Average Score Lanx CPU gear:	4.57	3.71	3.00	3.57	4.14
Average Tyvek® F suit:	2.50	5.00	4.00	4.50	4.75

	Ease of Operating Weapons?	Ease of SWAT Team Operations?	Ease of Communications With others?	Overall adequacy of suit?
Average Score all Suits:	**4.58**	**4.50**	**2.97**	**4.43**
Average Hammer Coverall suit:	4.25	4.00	2.75	3.88
Average Hammer 2-piece suit:	4.70	4.40	2.90	4.50
Average SWAT NBC suit:	4.63	4.50	2.75	4.50
Average TOMPS 2-piece suit:	4.50	4.33	3.00	4.67
Average Score Saratoga® CPU gear:	4.86	4.86	2.71	4.86
Average Score Lanx CPU gear:	4.14	4.29	3.29	4.14
Average Tyvek® F suit:	5.25	5.25	3.25	4.50

Table Score Rating: 6 = Extremely good, 5 = Above average, 4 = Adequate, 3 = Not very good, 2 = Poor, 1 = Extremely poor

Table 11. Test Subjects Questionnaire Responses (Suit Operational Characteristics)

	How would you rate the:		Restriction of movement by suit?	Adequacy of suit/mask interface?
	suit's fit?	suit's weight?		
Average Score all Suits:	**4.58**	**4.87**	**4.53**	**4.15**
Average Hammer Coverall suit:	4.00	4.25	4.00	3.50
Average Hammer 2-piece suit:	4.80	4.80	4.70	4.50
Average SWAT NBC suit:	4.63	4.75	4.50	3.88
Average TOMPS 2-piece suit:	5.00	5.33	4.67	4.17
Average Score Saratoga® CPU gear:	4.57	5.14	4.57	4.50
Average Score Lanx CPU gear:	4.43	4.86	4.43	4.14
Average Tyvek® F suit:	4.50	5.75	4.75	5.00
Table Score Rating: 6 = Extremely good, 5 = Above average, 4 = Adequate, 3 = Not very good, 2 = Poor, 1 = Extremely poor				

Table 11. Test Subjects Questionnaire Responses (Suit Operational Characteristics) (con't)

All test participants were concerned about the inability to wear ballistic helmets over the charcoal suit hood and mask/hood combination. This issue is being investigated with helmet manufacturers, and preliminary inquiries show that commercially available over-sized ballistic helmets are available. However, during later testing one of the test subjects found a way to wear the ballistic helmet with the mask/suit hood (during test 5), but the chinstraps had to be extended to the last hook. Extending the chinstrap appeared to solve the helmet issue for overgarments, but not for CPUs. Later on in the testing the same problem reappeared with the CPUs. The CPUs do not use a suit hood, and the problem with the helmet was trying to fit it over the mask/hood combination and secure the strap under the chin without bunching the hood up.

The evaluation of how hard the suits were to put on or to take off showed that most of the suit ensembles were ranked easy to get into, or to get out of. Coverall suits were ranked harder to get out of than the two-piece suit ensembles. The average ranking[9] for all suits was 4.08 for putting the suits on and 4.23 for taking them off. The one suit that was ranked hardest to put on and get out of was the SWAT NBC suit. This suit had a double zipper that extended from the chin to the ankles and ran down both legs. Many SWAT Team members verbally expressed the difficulties of putting it on and taking it off. Other suits that had lower ratings than the average were the Hammer Coverall and the Lanx CPU. These results were not verbalized but showed up on the questionnaire summary. Even though the SWAT NBC suit was hard to get into and out of, overall the test participants liked this suit ensemble the best and rated it as "The most comfortable to wear" (ranking of 4.5) and as more compatible with the SWAT Team equipment.

Weapons firing was ranked lowest for the Lanx CPU ensemble (score of 4.14). Ease of SWAT Team Operations was rated lowest for the Hammer Coverall (score of 4.00). Subjects who wore the Lanx CPU had problems with the length of the fingers in the gloves. The gloves used for this suit were manufactured specifically for all of the test subjects based upon anthropometric data provided to the manufacturer; however, most fingers of the gloves were longer than necessary. Heat burden was ranked worst for the Lanx CPU and the Hammer 2-piece ensembles. It should be noted that most of the Lanx CPUs were tested in the summertime. The level of noise was worse for the Tyvek F suit (score of 2.5). It was suggested that if the plastic fabric of the Tyvek F

[9] All rankings from the questionnaire ranged from 1 to 6, with one being the worst and six being the best.

suit could be 'softened' this might help. None of the suits were rated as being "Restrictive in Movement" and all of the suit's fit and weight were considered good.

A summary of the questionnaire responses on how long the subjects could stay in the suits is presented in Table 2. The average time the subjects stated they could stay in the suits during winter-time operations was around 12 hours (all suits) with the shortest times being 6 ¾ hours for the SWAT NBC suit, and around 8 ¼ hours for the Hammer Coverall and the Lanx CPU. The average stay-times dropped to around 8 hours for spring/fall conditions (all suits) with the shortest times being 3 ¾ hours for the Hammer Coverall. The stay-times for summer-time conditions dropped to just under 2 hours for all suits. The best suits for summertime wear were the Hammer 2-piece suit and the Saratoga and Lanx CPUs. These values conflicted somewhat with the ratings stated earlier for "Heat Burden" of the Hammer 2-piece suit and the Lanx CPU (where they were rated poorly). Generally a two-piece suit ensemble will be better for heat stress management.

Most test subjects felt that they could remain operational in the protective suit ensembles for only a very short time in the heat of summer. This became apparent during the late spring tests (May) when the temperature was between 75 and 80ºF. The SWAT Team leader stated in the questionnaire after one of these tests "The stay-times in spring/fall and summer are dependant upon getting water". Subjects felt that if they could get water to rehydrate their bodies, they could operate longer; otherwise, the time they could wear the suits in the heat was very limited. Since the Millennium mask contains the standard military drink tube system, canteens with the M1 cap were used during the summer tests that were capable of connecting the valve of the canteen cap to the drink tube of the mask. This worked very well to solve the problem and improved the comfort level greatly during the summer test periods. One subject stated "I was able to operate the drink tube/canteen without problems"; other subjects stated that it improved the operational capability of the suit systems and allowed them to withstand the heat better. The canteen used is available commercially; ordering information for the standard military canteen and M1 cap with the valve that connects to the drinking tube is as follows:

Canteen, plastic, OD green, 1-quart capacity, cost around $2.00
Canteen, plastic, black, 1-quart capacity, cost around $2.00
M1 canteen cap with valve for mask drink-tube system, plastic, OD green, cost around $2.50

	How long could you stay in this suit (hours) during the:		
	Winter?	Spring/Fall?	Summer?
Average Score all Suits:	**11.77**	**7.73**	**1.89**
Average Hammer Coverall suit:	8.19	3.29	1.09
Average Hammer 2-piece suit:	10.94	9.70	3.80
Average SWAT NBC suit:	6.75	5.56	1.63
Average TOMPS 2-piece suit:	14.50	9.67	1.16
Average Score Saratoga® CPU gear:	13.36	9.36	2.21
Average Score Lanx CPU gear:	8.14	6.71	2.14
Average Tyvek® F suit:	24.00	12.67	1.88

Table 12. Test Subjects Questionnaire Responses (Seasonal Wear Times)

The response on how much initial training was required (see Table 13) for officers to become familiar with the use of the suit and the mask was around two to three days training for each. Yearly training requirements indicated a need for approximately a one-day quarterly refresher training for the mask and for the suit ensemble.

	Initial training (days) required to become familiar with:		Yearly training (days) required	
	the suit?	the mask?	for suit?	for mask?
Average Score all Suits:	**2.71**	**2.59**	**3.17**	**3.41**
Average Hammer Coverall suit:	2.63	2.44	2.63	3.31
Average Hammer 2-piece suit:	3.44	3.30	3.21	4.40
Average SWAT NBC suit:	4.19	2.63	4.00	2.50
Average TOMPS 2-piece suit:	2.90	3.50	2.83	3.67
Average Score Saratoga® CPU gear:	2.21	2.36	1.93	2.50
Average Score Lanx CPU gear:	2.14	1.93	1.29	2.43
Average Tyvek® F suit:	1.03	3.53	3.06	4.00

Table 13. Test Subjects Questionnaire Responses (Training Requirements)

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APPENDIX G

Overview of Chemical Warfare Agents

A chemical agent is any chemical substance that is intended for use in military operations to kill, seriously injure, or incapacitate humans because of its physiological effects. A chemical agent symbol usually consists of two letters that are used as a designation to identify the chemical agent (e.g., GA = Tabun) and has nothing to do with the chemical formula of the agent. The onset of medical symptoms from chemical agent exposure is measured in minutes to hours, whereas the onset from biological agent exposure is measured in days. Additionally, easily observed signatures, such as colored residue, dead foliage, and dead insect and animal life, may be present.

Persistency: An expression of the duration of effectiveness of a chemical agent. The level of persistency is used to describe the tactical use of chemical agents and should not be used as terms to technically classify the agent.

- **Non-persistent agents** remain in the target area for a relatively short period of time. The hazard, predominantly vapor, will exist for minutes.
- **Semi-persistent agents** remain in the target area for a period of hours.
- **Persistent agents** remain in the target area for long periods of time. Hazards from both vapor and liquid may exist for days or, in exceptional cases, weeks after dissemination of the agent.
- There are many factors that will affect the persistency of chemical agents including the following:
  - ***Type of Agent***—Different agents have various consistencies/viscosities ranging from rubbing alcohol to motor oil. Agents with similar consistencies/viscosities will evaporate/dissipate at approximately the same rate.
  - ***Amount of Agent***—Different amounts and dispersal of agents will impact the persistency of an agent.
  - ***Terrain***—The area of dissemination (e.g., open area, vegetative, urban, soil composition) will affect the persistency of an agent. For example, terrorist use of a chemical agent would be most effective in enclosed spaces such as building entrances or underground subway platforms where evaporation is limited and the vapor can be recycled through the facility by the air handling systems.
  - **Weather**—Wind, temperature, humidity, and precipitation all impact the persistency of an agent.

Following is a general overview of chemical agents.

Nerve Agents

Chemical agents that affect the transmission of nerve impulses by reacting with the enzyme cholinesterase, permitting an accumulation of acetylcholine and continuous muscle stimulation. The muscles tire due to overstimulation and begin to contract. Nerve agents are colorless to light brown liquids, some of which are volatile. Toxic liquids are tasteless. Nerve agents may be absorbed through the skin, respiratory tract, gastrointestinal tract, and the eyes. Significant absorption through the skin takes minutes and prompt medical treatment and decontamination is imperative.

A. Types of Nerve Agents

(1) G series—GA (tabun), GB (sarin), GD (soman)

(a) Persistency—G agents are normally considered to be non-persistent. They evaporate at about the same rate as water. These agents will remain in the target area for a relatively short period of time. The hazard, predominantly vapor, will exist for minutes or, in exceptional cases, hours after dissemination of the agent.

(b) Physical states (at 20 °C/68 °F)

GA – Colorless to brown liquid
GB – Colorless liquid
GD – Colorless liquid

(c) Odors

GA – Faintly fruity; none when pure
GB – Faintly fruity; none when pure
GD – Fruity; camphor when impure

NOTE: Agent odors should only be used as a reference if victims relate noticing a strange smell at the time of agent release. Responders should not attempt to determine an odor themselves. If you can smell the odor, you are exposing yourself to the agent.

(d) Primary hazard—Respiratory tract.

(e) Rate of action—Immediate for all G series agents.

(2) VX series

(a) Persistency—Normally considered to be persistent (days to months) and will remain in the target area for longer periods. The consistency is similar to motor oil.

(b) Physical state (at 20 °C/68 °F)—colorless to amber liquid.

(c) Odor—None.

(d) Primary hazards—Skin (direct contact), respiratory (vapors).

(e) Rate of action – Immediate.

B. Symptoms of Nerve Agents

(1) Initial

(a) Dimness of vision. Constricted pupils (miosis), marked, usually maximal (pinpointing of pupils). On exposure to vapor or aerosol the pupils become pinpointed immediately. If the nerve agent is absorbed through the skin only or by ingestion of contaminated food or water, the pinpointing will be delayed or even absent.

(b) Runny nose (rhinorrhea).

(c) Localized sweating.

(2) Advanced

(a) Tightness in chest
(b) Difficulty in breathing
(c) Nausea and vomiting
(d) Involuntary twitching and jerking
(e) Frontal headaches
(f) Convulsions and coma

(3) Nerve agent symptoms can easily be identified through use of the acronym SLUDGE.

S – Salivation
L – Lacrimation (tearing)
U – Urination
D – Defecation
G – Gastrointestinal effects
E – Emesis (vomiting)

C. Treatment for Nerve Agents

If conditions permit, the treatment center should be established upwind from the contaminated area. The casualties should be undressed and washed thoroughly, downwind of the treatment area, before being brought into the treatment area.

- Immediately remove any liquid contamination.

- If drop or a splash of liquid nerve agent gets in the eyes, immediately irrigate the eyes with copious amounts of water or saline solution/mydrin eye drops. Treat ocular symptoms (minimal pain relief with atropine sulfate ophthalmic ointment – 1%). Notify ophthalmologist immediately.

- If available, administer 2 mg. of atropine as soon as any local or systemic nerve agent symptoms are noted. **DO NOT GIVE ATROPINE FOR PREVENTIVE PURPOSES BEFORE EXPOSURE TO NERVE AGENT!!!** If the patient has mild symptoms due to nerve agents, the IM injection of 2 mg. atropine should be repeated at 20-minute intervals, and 10-minute intervals if moderate to severe symptoms are present, or until signs of atropinization (dry mouth, blurry near vision) are achieved. A mild degree of atropinization should be maintained for at least 24 hours by INI or oral administration of 1-2 mg. of atropine every ½ to 4 hours.

    1. Atropine can be given IM, Intravenously (IV), or orally. Atropine given IM requires approximately 8 minutes before effects are noticed.

    2. Atropine given by IV will show effects within 1 minute and will reach maximum effect within 6 minutes.

    3. Atropine tablets require 20 minutes before effects are felt and 50 minutes before maximum effect takes place.

Atropine effects include dryness of the mouth and throat, with slight difficulty in swallowing. Patient may have a feeling of warmth, slight flushing, rapid pulse, some hesitancy of urination, and an occasional desire to belch. The patients' pupils may be dilated slightly but react to light and near vision is blurred. Some individuals may experience mild drowsiness, slowness of memory, and the feeling that body movements are slow. Further doses of 2 mg. of atropine intensify the symptoms and prolong the effects. Effects of one to two 2 mg. injections last 3 to 5 hours, and the effects of four injections given at close intervals last 6 to 12 hours.

- Patients with moderately severe nerve agent symptoms have increased tolerance to atropine, so fairly large doses may be administered before signs of atropinization appear.

- Severe nerve agent exposure may rapidly cause unconsciousness, muscular paralysis, and cessation of breathing. If this occurs, artificial respiration is required along with the atropine injections. If the patient is in severe respiratory distress or is convulsing, 4 to 6 mg. of atropine should be injected by IV. If relief does not occur and bronchial secretions and salivation does not decrease, give 2 mg. of atropine every 3 to 8 minutes

until relief occurs and secretions diminish. In severe nerve agent poisoning, the effect of each injection of atropine may be transient, lasting only 3 to 10 minutes. This requires the patient to be monitored closely and atropine repeated as needed. A mild atropinization should be maintained for at least 48 hours.

- Pralidoximine chloride (2-Pam Cl or Protopam Cl) can be used to increase the effectiveness of therapy in nerve agent poisoning. 2-Pam Cl reduces the time during which artificial respiration is required. Dosage for 2-Pam Cl is 1 gm. in 100 ml. of sterile water, normal saline, or 50/10 dextrose and water; administer by IV slowly over 15 to 30 minutes.

Choking Agents

Chemical agents that irritate the alveoli in the lungs. This irritation causes the alveoli to constantly secrete fluid into the lungs. The lungs slowly fill with this fluid (a process known as pulmonary edema), and the victim dies from lack of oxygen (also known as dry land drowning).

A. Types of Choking Agents

(1) CG (Phosgene), CL (Chlorine)

(a) Persistency—Considered non-persistent, (vapors may persist for a longer period of time in low-lying areas or enclosed areas) is broken down rapidly by water (i.e., fog, rain, heavy vegetation).

(b) Physical State (at 20 °C/68 °F)
CG – Colorless gas
CL – Greenish-yellow liquefied gas

(c) Odor

CG – New mown hay, freshly cut grass, or green corn
CL – Bleach

NOTE: Agent odors should only be used as a reference if victims relate noticing a strange smell at the time of agent release. Responders should not attempt to determine an odor themselves. If you can smell the odor, you are exposing yourself to the agent.

(d) Primary hazard—Respiratory

(e) Rate of action—(Initially) rapid; (latent) delayed 2 to 24 hours

B. Symptoms of Choking Agents

(1) Initial

(a) Dry throat (CG)

(b) Feeling of suffocation (CL)
(c) Tightness of chest
(d) Coughing
(e) Nausea and vomiting
(f) Choking (CL)
(g) Headache (CG)
(h) There may be an initial slowing of the pulse followed by an increase

Irritation quickly disappears when exposure is ended, and a symptomless period of 2 to 6 hours elapses before pulmonary edema sets in. The onset of pulmonary edema is indicated by uneasiness, fear, and productive cough, with white or yellow phlegm that is often bloody. Nausea, vomiting, and gastric pain are common. Breathing is rapid, pulse is fast and faint. Shock develops, and the victim may die from heart failure or lack of oxygen.

(2) Advanced

(a) Rapid shallow breathing, painful cough, and cyanosis.

(b) Severe coughing-up of frothy sputum (blood – CL).

(c) Convulsions.

(d) Victim may develop a shock like state, with clammy skin, low blood pressure, and feeble rapid heart action.

(e) Pulmonary edema.

C. Treatment of Choking Agents

- When latent symptoms appear, allow victim to rest in semi-seated position and keep warm.
- Treatment is rest, oxygen therapy, codeine for cough control, and antibiotic therapy to prevent secondary infections. **Do not use** expectorants or atropine. Patients who survive the first 48 hours usually recover.

Blood Agents

Chemical agents that act upon the enzyme cytochrome oxidase. This allows the red blood cells to acquire oxygen but does not allow them to transfer oxygen to other cells. Body tissue decays rapidly due to lack of oxygen and retention of carbon dioxide (first the heart and then the brain are effected).

A. Types of Blood Agents

(1) AC (Hydrogen Cyanide), CK (Cyanogen Chloride)

(a) Persistency—Considered non-persistent, highly volatile, dissipates rapidly (within minutes). Evaporates faster than gasoline.

(b) Physical state (at 20 °C/68 °F):

AC – Colorless gas or highly volatile liquid that is highly soluble and stable in water.

CK – Colorless gas or highly volatile liquid that is slightly soluble in water but dissolves readily in organic solvents.

(c) Odor

AC – Has a faint odor of peach kernels or bitter almonds.
CK – Has a faint odor of peach kernels or bitter almonds.

NOTE: Agent odors should only be used as a reference if victims relate noticing a strange smell at the time of agent release. Responders should not attempt to determine an odor themselves. If you can smell the odor, you are exposing yourself to the agent.

(d) Primary hazard—Respiratory only. **Note:** Blood agents degrade military style nuclear, biological and chemical (NBC) protective filters (like the MCU2P mask) by breaking down the charcoal.

(e) Rate of action
AC and CK – Very Rapid

B. Symptoms of Blood Agents

(1) Initial

(a) Strongly stimulates breathing rates (AC)

(b) Immediate intense irritation of the nose, throat, and eyes, slows breathing rate with coughing, tightness of the chest, and tearing (CK)

(c) Headache.

(d) Nausea.

(2) Advanced

(a) Pinkish color to lips and skin.

(b) Violent convulsions (AC)

(c) Severe exposure causes an increase in the depth of respiration within a few seconds, vomiting is possible, unconsciousness, violent convulsions, cessation of regular breathing, occasional gasps, and dilation of the pupils (AC).

(d) Choking, slowing of breathing rate, strong irritating tearing effect on the eyes (CK).

(f) Death occurs rapidly (within 15 minutes) or recovery takes place after removal from the toxic area.

C. Treatment for Blood Agents

- Give artificial respiration if patient is not breathing.
- Emergency treatment is IV administration of 10 ml. of 3% sodium nitrite over a 1-minute period plus 50 ml. of a 25% solution of sodium thiosulfate given slowly by IV.
- Further treatment is symptomatic. Recovery from AC or CK may disclose residual CNS damage to the CNS. The CNS damage may be manifested by irrationality, altered reflexes, and unsteady gait all of which may last for weeks, months, or be permanent.
- For lung irritant effects of CK, treatment is the same as that for choking agent poisoning:
  - Rest and warmth
  - Sedation (used sparingly)
  - Oxygen
  - Antibiotics (acquired bacterial bronchitis/pneumonia)
  - Steroids

Blister Agents

Chemical agents that affect the eyes, respiratory tract, and skin, first as a cell irritant, and then as a cell poison. Blister agents initially cause irritation of the eyes (and respiratory tract if inhaled), erythema (reddening of the skin), then blistering or ulcerations followed by systemic poisoning. There are three types of blister agents.

A. Types of Blister Agents

(1) Mustards (H, HD [sulfur mustard]):

(a) Persistency—From 1 day to several months depending upon the type used and the weather conditions in the incident area.

(b) Physical state (at 20 °C/68 °F)

HD – Colorless to pale yellow liquid

(c) Odors

HD – Strong garlic or horseradish smell

NOTE: Agent odors should only be used as a reference if victims relate noticing a strange smell at the time of agent release. Responders should not attempt to determine an odor themselves. If you can smell the odor, you are exposing yourself to the agent.

(d) Primary hazard - (Eyes and respiratory tract vapor), skin (direct contact), digestive system (ingestion).

(e) Rate of action - Most symptoms are delayed (from 12 hours to days), HN-3 may cause immediate lacrimation and eye irritation after exposure.

(2) Arsenicals. L (Lewisite),

(a) Persistency - somewhat shorter than HD when in dry climate; all relatively short when in wet or humid conditions.

(b) Physical state (at 20 °C/68 °F)

Colorless to brownish liquid

(c) Odor

Geraniums

NOTE: Agent odors should only be used as a reference if victims relate noticing a strange smell at the time of agent release. Responders should not attempt to determine an odor themselves. If you can smell the odor, you are exposing yourself to the agent.

(d) Primary hazard—Eyes and respiratory tract (vapor), skin (direct contact), digestive system (ingestion).

(e) Eye effects and stinging sensation are immediate, prompt burning redness within 30 minutes, blister on 1st or 2nd day. Pain more severe.

(3) Urtricants. Phosgene oxime (CX) is a powerful irritant that is especially effective as a liquid:

(a) Persistency—Days to weeks in soil, otherwise relatively nonpersistent. Heavily splashed liquid persists for 1 to 2 days in concentrations and persists for a week to months in cold weather.

(b) Physical state—(at 20 °C/68 °F)—colorless solid or liquid.

(c) Odor—A disagreeable penetrating odor.

NOTE: Agent odors should only be used as a reference if victims relate noticing a strange smell at the time of agent release. Responders should not attempt to determine an odor themselves. If you can smell the odor, you are exposing yourself to the agent.

(d) Primary hazard—Eyes and nose and respiratory tract (vapor), skin (direct contact) and digestive tract (ingestion).

(e) Rate of action—Immediate.

B. Symptoms of Blister Agents

(1) Mustard Agents—Most symptoms are delayed (4 to 6 hours for H, HD):

(a) Eye effects—In a single exposure the eye is the most vulnerable. In mild exposure there is a latent period of 4 to 12 hours, followed by tearing and a gritty feeling in the eyes. Heavy exposure has a latent period of 1 to 3 hours, followed by severe irritation and lesions.

(b) Effects on skin—The latent period depends on weather conditions. In hot, humid weather, latency may be as short as 1 hour, in cool weather after mild vapor exposure, latency may be days. Normal latency is 6 to 12 hours. The initial symptom is erythema resembling sunburn, followed by multiple pinpoint lesions that enlarge and form the typical blisters. The blisters are usually large, thin walled, superficial, translucent, yellowish domes surrounded by erythema. The blister fluid is clear, thin, and straw colored at first; later is yellowish and tends to coagulate. Liquid contamination of the skin usually results in a ring of vesicles around a gray-white area that does not blister.

(c) Respiratory effects—Develop slowly, taking several days to reach maximal severity. Symptoms begin with hoarseness which may progress to loss of voice. A cough, which is worse at night, appears early, and later becomes productive. There is pronounced dyspnea. Consequently, the lower airways become easily infected, causing broncho-pneumonia.

(d) Systemic and gastrointestinal effects—Ingestion of contaminated food or water produces nausea, vomiting, abdominal pain, diarrhea, and prostration. Skin exposure may cause malaise, vomiting, and fever that appear about the same time as erythema.

(2) Arsenicals—Vapors are unlikely to cause significant injuries. Liquid will cause severe burns of the skin and eyes and can gradually penetrate rubber and most impermeable fabrics:

(a) Eye effects—There is immediate pain on contact. Edema follows rapidly, causing the eye to close within an hour. Severe exposure can cause permanent injury or blindness.

(b) Effects on Skin—Effects are more severe than those from liquid mustard. Stinging pain is usually felt 10 to 20 seconds after contact. The pain increases in severity with penetration and in a few minutes becomes deep and aching. About 5 minutes after contact, a gray area of dead skin appears that resembles what is seen in corrosive burns. Erythema resembles that caused by mustard agents but is accompanied by more pain. Itching and irritation persist for about 24 hours, whether or not a blister develops. Blisters are often well developed in 12 hours and are painful at first (mustard blisters are relatively painless). The pain lessens in 48 to 72 hours.

(c) Respiratory effects—Effects are similar to those produced by mustard agents. Systemic absorption of arsenicals causes a change in the capillary permeability. This can permit sufficient fluid loss from the blood stream to cause hemoconcentration, shock, and death.

(d) Systemic effects—Acute systemic poisoning from large skin burns causes pulmonary edema, diarrhea, restlessness, weakness, subnormal temperature, and low blood pressure.

(3) Urtricants

(a) Eye and nose effects—There is a strong and violent irritation of mucous membranes from vapors. Even low concentrations can cause tearing.

(b) Effects on skin—Any exposure to liquid or vapor that produces pain (strong stinging sensation similar to bee stings) will also produce skin necrosis at the site of contact. The area becomes blanched and is surrounded by an erythematous ring within 30 seconds. Within 24 hours the original blanched area acquires a brown pigmentation. Itching may be present throughout the entire course of healing, which may take 2 months or more.

C. Treatment of Blister Agents

(1) Mustard Agent

(a) Immediately remove any liquid contamination. Speed in decontamination of the eye is absolutely essential. Rinse the eye with copious amounts of water.

(b) After rinsing the eyes, apply a steroid antibiotic eye ointment. The eyes **must not** be bandaged or the lids allowed to stick together.

(c) All blisters should be opened and the fluid drained with care, as the fluid itself may be irritating and cause secondary erythema and blisters. Cleanse the area with tap water or apply saline and burn cream (10% Sulfamylon burn cream).

(2) Arsenicals. Treatment can be handled one of two ways

(a) Local neutralization can be achieved by liberal application of dimercaprol (BAL) ointment that must remain on the affected area. Remove any other protective ointment before applying BAL ointment.

(b) Perform INI injection of dimercaprol (13AL) 10% solution in oil.

- For mild to moderate poisoning give 2.5 mg./kg. (1.5 ml./60 kg.) every 4 hours for 2 days, then one injection every 12 hours on the third day. From the fourth to tenth day give one injection once or twice a day.

- For severe poisoning give 3 mg./kg. (1.8 ml./60 kg.) every 4 hour for 2 days, third day give one injection every 6 hours. The fourth through fourteenth day, give one injection twice a day. Up to 5 mg./kg. can be given in severe cases.

Symptoms caused by BAL include dryness of the mouth and throat, mild tearing, slight reddening of the eyes, feeling of constriction in the throat, burning sensation of the lips, generalized muscular aching, abdominal pain, mild restlessness, sweating of the hands, apprehension, mild nausea and vomiting on eating, and a transient rise in blood pressure. Symptoms start 15 to 30 minutes after injection and last about 30 minutes. Unless they are severe or prolonged, they are not a contraindication for continuing therapy.

(3) Urtricants

Decontamination is not effective after pain starts, but the contaminated area should be flushed with copious amounts of water to remove any agent that has not yet reacted with the tissue. Treat as any other ulcerated necrotic skin lesion, plus supportive care, as needed.

Chemical Agents Not Usually Life Threatening

The following chemical agents are usually not life-threatening in nature. While all require treatment, the urgency associated with agents previously discussed is not as apparent.

Incapacitating Agents

Agents that cause physiological or mental effects which lead to temporary disability lasting from hours to days after exposure to the agent has ceased.

A. Types of Incapacitating Agents

(1) There are two types of incapacitating agents. Central nervous system (CNS) depressants and CNS stimulants. CNS depressants block the transmission of

information across the synapse (the point at which a nervous impulse passes from one neuron to another). CNS stimulators tend to boost the transmission of information across the synapse.

(a) CNS depressants (BZ, marijuana) have a delayed action rate of 2 to 4 hours if inhaled, and up to 36 hours from skin absorption.

- Persistency—BZ is very persistent in soil, water, and on surfaces.
- Odor—BZ has no odor. Marijuana has a distinct smell.
- Primary hazard—Respiratory, skin absorption possible.

(b) CNS stimulants (LSD, psilocybin, and mescaline) have an action rate of minutes if inhaled and 30 to 60 minutes if ingested.

- Persistency—Unknown
- Odor—None
- Primary hazard—Respiratory

B. Symptoms of Incapacitating Agents

(1) Depressants (BZ)

(a) From 1 to 4 hours symptoms are the following:
- Dizziness
- Vomiting
- Dry Mouth
- Confusion
- Sedation, progressing to stupor
- Ataxia (an inability to coordinate voluntary muscular movements)
- Rapid heart beat

(b) From 4 to 12 hours there may be an inability to respond effectively to the environment.

(c) From 12 to 96 hours symptoms are the following:

- Increasing activity
- Random, unpredictable behavior
- Gradual return to normal in 48 to 96 hours

(2) Stimulants (LSD) produce the following symptoms:

- Rapid heart beat
- Sweating palms
- Pupillary enlargement
- Cold extremities
- Mental excitation

- Possible paranoia

C. Treatment of Incapacitating Agents

General treatment consists of close observation, restraint and confinement as required, supportive care with fluids, and appropriate clothing. Underlying medical problems should be treated as needed. If the specific agent can be identified, treat appropriately.

(1) CNS Depressants

- Prevent heat stroke
- Keep temperature down
- Segregate and provide reassurance
- Constant supervision until withdrawal is complete

(2) CNS Stimulants

- Provide reassurance
- If possible, sedate the patient

Irritant or Tear Agents

Compounds that cause a large flow of tears and intense (although temporary) eye pain and irritation of the skin. The effects are immediate but transient.

A. Types of Irritant or Tear Agents

(1) CA, CN, CNB, CNC, CNS, CS, CR and PS:

(a) Persistency—Short for the CN series; varies with CA, CS, and CR.

(b) Physical state

CA	–	Yellow solid or liquid
CN	–	Solid Powder
CNB, CNC and CNS	–	Liquid
CS	–	Colorless solid, powder or liquid
CR	–	Yellow powder in solution
PS	–	Colorless, oily liquid

(c) Odor

CA	–	Soured fruit
CN	–	Apple blossoms
CNB	–	Benzene (gasoline)

CNC – Chloroform
CNS – Flypaper
CS – Pepper like
CR – Burning sensation
PS – Stinging, pungent

NOTE: Agent odors should only be used as a reference if victims relate noticing a strange smell at the time of agent release. Responders should not attempt to determine an odor themselves. If you can smell the odor, you are exposing yourself to the agent.

(d) Primary hazard—Respiratory only.

(e) Rate of action—Immediate.

B. Symptoms of Irritant or Tear Agents. Effects last 5 to 10 minutes after removal from contaminated area.

(1) Immediate burning sensation of the eyes.
(2) Coughing. Following heavy exposure there may be nausea and vomiting.
(3) Difficulty in breathing.
(4) Involuntary closing of the eyes.
(5) Stinging sensation on moist skin, especially on the face, neck, ears, and body fluids.

C. Treatment of Irritating or Tear Agents

- Do Not Rub Eyes
- Flush the eyes with copious amounts of water.
- To prevent skin reaction, rinse the body with water or 5 or 10% sodium bicarbonate in water.
- Delayed erythema (irritant dermatitis) may be treated with a bland shake lotion.
- Most persons affected by irritant agents require no medical treatment. Severe reactions of the eyes or skin may take days or weeks to heal depending on their severity.
- Decontamination – Aeration; cool shower may help.

Vomiting Agents

Compounds that cause irritation of the upper respiratory tract and involuntary vomiting.

A. Types of Vomiting Agents

(1) DA, DC, DM—Produce a strong pepper-like irritation in the upper respiratory tract. They are usually dispersed by heat as fine particulate smoke.

(a) Persistency—Short (disseminated as an aerosol).

(b) Physical state—All are colorless when diluted with air.

DA – White to brown solid
DC – White to pink solid
DM – Yellow to green solid

(c) Odor:

DA – None
DC – Bitter almond-garlic mixture
DM – None

NOTE: Agent odors should only be used as a reference if victims relate noticing a strange smell at the time of agent release. Responders should not attempt to determine an odor themselves. If you can smell the odor, you are exposing yourself to the agent.

(d) Primary hazard—Respiratory only.

(e) Rate of action—Very rapid, with a rate of action from 30 seconds to 2 minutes.

B. Symptoms of Vomiting Agents—Effects last 30 minutes to several hours after leaving from contaminated area. Mild exposure symptoms resemble those of a severe cold. Symptoms include the following:

(1) Irritation of eyes (tearing) and mucous membranes. A feeling of pain and fullness in the nose and sinuses.

(2) Viscous discharge.

(3) Intense burning in the throat.

(4) Uncontrollable coughing, violent and persistent sneezing, runny nose. And ropy saliva flow from mouth.

(5) Severe headache.

(6) Acute pain and tightness in chest.

(7) Nausea.

(8) Vomiting.

C. Treatment for Vomiting Agents

- Most individuals recover promptly after removal from the contaminated area.

- Symptomatic relief is provided by inhaling chloroform vapors either directly from a bottle or by pouring a few drops into the cupped palms and breathing.

- Chloroform is inhaled until the symptoms or irritation subsides and is repeated when the symptoms become severe again. **Do not use** to the point of anesthesia.

- Aspirin may be given to relieve the headache and general discomfort.

Indicators of Possible Use of Chemical Agents

Some clues may be present that could be indicators that a weapon of mass destruction (WMD) incident involving chemical agents has taken place:

- Unusual numbers of dying animals are present. Some indicators are: birds that are usually present at outside trash bins are dead; no insect sounds; numerous dead animals on the road.

- There is a lack of insect life. If normal insect activity (ground, air, and/or water) is missing, check the ground, water, and the shoreline for dead insects.

- Numerous individuals are experiencing unexplained water-like blisters, wheals (like bee stings), and/or rashes.

- Numerous individuals are exhibiting serious health problems ranging from nausea, disorientation, and difficulty breathing to convulsions and death. It is apparent that a mass casualty incident exists.

- There is a definite pattern of casualties (i.e. the casualties are aligned with the wind direction outdoors). Casualties are distributed in a pattern that may be associated with possible agent dissemination methods (i.e. there is a lower number of ill people working indoors versus outdoors, or outdoors versus indoors).

- Unusual liquid droplets are present. Numerous surfaces exhibit oily droplets or film. Numerous water surfaces have an oily film; no recent rain.

- Unscheduled and unusual spray being disseminated.
- Abandoned spray devices, such as chemical sprayers used by landscaping crews, are found.

- The area looks different in appearance. Not just a patch of dead weeds, but trees, shrubs, bushes, and/or lawns are dead, discolored, or withered and there is no current drought.

- Unexplained odors completely out of character with the surroundings are present.

- Unexplained low-lying clouds or fog-like conditions exist.

- Unusual metal debris is present, such as unexplained bomb/munition material, especially if it contains a liquid and there has been no recent rain.

APPENDIX H

Decontamination Operations

General

Decontamination after exposure to a chemical agent environment is necessary to protect individuals from becoming contaminated through contact with agent that may be on the protective clothing that they wore. The fire service is generally well versed in decontamination procedures; however, decontamination, as well as operating in a contaminated environment, is relatively new to law enforcement.

HazMat technicians perform decontamination on a routine basis as part of any HazMat response. Many firefighters also possess a good knowledge of decontamination operations and may have supported HazMat decontamination operations. As a result of enhanced training on chemical terrorism and the mass casualties that it may cause, firefighters are also becoming more aware of decontamination techniques for mass numbers of casualties.

Law enforcement agencies may not choose to develop their own decontamination capabilities. Experienced manpower and resources should already be on scene in the form of the fire department and HazMat teams. Law enforcement **must coordinate for decontamination** with the fire department Incident Commander, it cannot be assumed. Numerous exercises conducted as part of the DPP training program have resulted in fire departments tearing down their decontamination stations once all victims had been processed even though law enforcement was still operating inside of the hazard zone. The predominant disconnect being the fact that decontamination support was never coordinated at the command post.

Specific areas where law enforcement can be expected to require decontamination support include:

- Crowd control and perimeter security along the perimeter of the Warm Zone.
- Processing evidence out of the Warm Zone.
- Investigators processing the crime scene.
- Bomb technicians conducting operations in a contaminated area or on a suspected chemical device.
- Tactical operations taking place in a known or suspected chemical agent environment.
- Take down of a suspect or perpetrator who may possess chemical agents or of a chemical production facility.

Decontamination of Permeable Clothing

The recommendations for PPE for law enforcement include both permeable and impermeable clothing ensembles. Just as these are recommended for different operations based on the types of environment that may be encountered, different decontamination procedures must be used depending on the suit. Impermeable suits are generally used for HazMat operations and can be decontaminated simply by washing the exterior of the suit with a spray from a fire hose. This is the type of decontamination that fire departments are used to performing. Wet decontamination, however, is inappropriate for permeable suits.

The protection provided by permeable suits is degraded if the suit becomes wet. Therefore standard water decontamination should not be performed on such suits.

Permeable suits protect the wearer through a process whereby chemical agent vapors are absorbed into layer of charcoal material (usually beads) within the lining of the suit. Performing a wet decontamination of these suits can serve to transfer both agent on the outer layer of the suit, as well as agent trapped in the charcoal, through the suit along with the water and into contact with the wearers skin. Therefore a slightly more elaborate process for decontamination is required for permeable clothing.

The basic steps to decontamination for permeable clothing consist of:

- Overgarment removal.
- Glove removal.
- Inner clothing removal.
- Respirator removal.
- Shower.

Throughout the process, the operator should continue to move through the decontamination corridor, starting in complete ensemble and finishing at the shower point. Steps are performed as stations along the corridor so that as more clothing is removed, the individual is further through the corridor.

The first step to decontamination for permeable clothing is to have someone assist with removal of the protective overgarment; we refer to this individual as the assistant. Ideally the assistant is someone performing decontamination, as they are less likely to be contaminated themselves, but it can be another team member who was operating on the mission. It must be noted however that a decontamination operator must assist the last person through the process. This individual should be dressed in the same level of PPE as those individuals going through the decontamination process.

The person going through decontamination opens all overgarment closures (zippers, buttons, strings, etc.). The assistant can help, if necessary, but this serves as an avenue to increase their direct exposure to agent. The assistant then removes the overgarment by grasping the outside of the suit and pulling it off of the operator. At no time should the outside of the suit touch the

inner clothing or skin of the operator. If chemical protective over-boots are worn, they must be removed before the overgarment.

Throughout the process of overgarment removal the wearer must keep his/her gloves and respirator on. Respirators with a powered air supply (PAPR) or external air supply (SCBA) require the operator to carry the blower/bottled air supply and harness through the decontamination process.

Gloves are removed by pulling on them until they are loose enough to be shaken off. At no time should one glove be removed and the bare hand used to remove the other. Proper removal of gloves is fairly simple with prior practice.

At this time, the operator removes any inner clothing (duty uniform, chemical protective undergarments) and proceeds to the final stage of decontamination.

The respirator is the last item removed in the decontamination process prior to stepping into the shower.

The final stage in the process consists of mask removal and showering. Operators should hold their breath, remove their mask by placing their hands inside of the hood, if worn, and stepping into the shower or water stream. At this time, they can resume breathing and exit the shower when directed by the station operator.

It cannot be over emphasized that while more labor intensive and time consuming, this is the best decontamination process for permeable clothing. It must also be stressed that fire departments do not normally perform such decontamination operations and training through joint training and exercises is necessary in order to ensure that proper techniques are performed.

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APPENDIX I

NDPO Bulletin

IB-2 **National Domestic Preparedness Office** **March 9, 2000**

INFORMATION BULLETIN

OFFICIAL USE ONLY NOT FOR DISSEMINATION OUTSIDE OF PUBLIC SAFETY AGENCIES

Chemical/Biological Equipment Questions for Procurement Officials in Public Agencies

Buying detection, protection and decontamination equipment to respond to the threatened terrorist use of chemical or biological warfare agents may be new for Public Safety Agencies. To help procurement officials obtain the best value for their domestic preparedness dollar, a group of experienced federal chemical and biological project managers have compiled a series of questions to ask equipment vendors. These questions should assist officials in selecting products from the large number in the present day marketplace. Requesting vendors to provide written responses to your specific questions may also be helpful in the decision process.

Recommended Questions on Personal Protection Equipment

1. What chemical warfare agents, toxic industrial chemicals and biological agents has the equipment been tested against?

2. What were the testing procedures and standards NFPA, ASTM, NIOSH, U.S. Military Standards, NATO, European Standards, MILSPEC?

3. Who conducted the tests and when? Have the test results been verified by an independent laboratory or only by the manufacturer?

4. What types of tests were conducted - spray, vapor, man-in-simulant (MIST)?

5. Were respirators, suits, gloves and boots tested against the agents individually or as part of an integrated ensemble?

6. Is the test data available? Where? How can I get a copy? Curves showing concentration as a function of time are better than just a single breakthrough time.

7. Was the equipment ever used in live agent testing? Who did the testing and is the data available?

8. What is the fabric used to make the suits? How are the seams put together? Simple sewn seams are weakest, covered or bound seams are better.

9. What are the breaking strength and tear strengths of the fabrics? How was the equipment wear and tear tested?

10. If the manufacturer recommends sealing seams with tape, ask why and whether that was the configuration the suit was tested in?

11. How flammable is the fabric and how quickly will a hot ember melt through the fabric compromising protection? Is there an aluminized version or overcover for use where there is a fire threat in addition to the toxic agent?

12. How long does it take to don the equipment and can one person do it or is a buddy system required? Does the equipment allow sufficient operational flexibility to do the job to include use of firearms?

13. What sizes are sold for boots and gloves? Does suit sizing consider people with special builds? For suits, ask for nominal heights and weights - one size does not fit all!

14. What training is required to fit face masks? Does the company provide those services and how frequently? How do the masks accommodate prescription glasses, long hair or facial hair?

15. How long can responder safely work in the suit at 50oF, at 70oF and at 90oF? Are cooling suits available to help manage heat stress? How much do they cost and what are the maintenance requirements? Do the cooling suits require any penetrations of the suit?

16. Can the protective equipment be decontaminated after use or must it be disposed of? What are the decon and sampling procedures? What tests are required to verify that protection capability has not been compromised in the process? What are the procedures and costs for disposing of used equipment, for example spent mask filters?

17. How long has the company/manufacturer been involved with the Chem-Bio-Nuc and first responder industries? You may also ask for references.

18. Ask for names and phone numbers of departments currently using the company's equipment. Ask to follow-up on the phone any written testimonials.

19. What additional items are required to operate/maintain the equipment? At what cost?

20. What training materials are provided - manuals, videotapes, CD ROMs? Are less expensive training suits available? Is there a chart available identifying PPE requirements as a function of agents and concentrations?

21. What type of warranty/maintenance support is offered? Cost?

22. What is the return rate on the equipment under warranty? What are the top five reasons for failure?

23. What similar companies' products has this product been tested against? What were the results of the tests?

24. What is the shelf life for the equipment? (open exposed, closed exposed, open unexposed, closed unexposed). What is the recommended storage procedure after opening (hanging, folded)? What factors, if any, decrease shelf life (UV, critical temperature)?

25. What are the environmental limitations - high temp, low temp, humidity, sand/dust, broken glass?

Recommended Questions on Detectors

1. What agents has the equipment been tested against?

2. Who conducted the tests? Have the test results been verified by an independent laboratory or only by the manufacturer? What were the results of those tests?

3. What common substances cause a "false positive" reading or interference?

4. Is the test data available? Where?

5. What types of tests were conducted? Have any engineering changes or manufacturing process changes been implemented since the testing? If so, what were the changes?

6. Can the equipment detect both large and small agent concentrations?

7. Are there audible and visual alarms? What are their set points and how hard is it to change them? Are the alarm set points easily set to regulatory or physiologically significant values?

8. How quickly does the detector respond to a spike in the agent concentration? How quickly does the detector clear when taken to a clean area? What is the response time of the detector to a spike in the agent? How much time does the detector take to clear when taken to a clean area?

9. How long does it take to put the equipment in to operation? Can it be efficiently operated by someone in a Level A suit?

10. How long do the batteries last? How long does it take to replace batteries or recharge? What is the cost of new batteries? Are the expended batteries HAZMAT and what is the cost of disposal of batteries?

11. How long has the company/manufacturer been involved with the Chem-Bio-Nuc and first responder industries? You may also ask for references.

12. Is the company currently supplying its product(s) to similar agencies? If so, who? Ask for names and phone numbers of departments currently using the company's equipment. Ask to follow-up on the phone any written testimonials.

13. What additional items are required to operate/maintain the equipment? At what cost? What training materials are provided - manuals, videotapes, CD ROMs? What is the cost of training materials?

14. What type of warranty/maintenance support is offered? Cost?

15. What is the return rate on the equipment under warranty? What are the top five reasons for failure?

16. What is the required on-hand logistical support and costs? How often does the equipment need to be sent back to the manufacturer for maintenance?

17. How often does the equipment require calibration? Does calibration require returning the equipment to the manufacturer? Does the calibration involve hazardous materials?

18. What special licenses/permits/registrations are required to own/operate the equipment?

19. What similar companies' products has this product been tested against? What were the results of the tests? Compare it in cost and performance to M-8/M-9 paper.

20. What is the shelf life of the equipment? (open exposed, open unexposed, closed exposed, closed unexposed)

21. What is required to decontaminate the equipment if taken into the Hot Zone?

22. What capability does this equipment give me that I do not currently possess? What equipment can I do away with if I purchase this? Is it only used for military chemicals?

23. Does this equipment require any hazardous materials for cleaning? If yes, what are they?

24. Taking weight and size into consideration, what procedures/process is needed to employ down range? How hard is it to decontaminate to get it out of the Hot Zone? What procedures/process is employed to decontaminate to remove from Hot Zone?

25. What is the theory of operation? Surface Acoustic Wave (SAW) Photo ionization, Flame ionization, etc.

26. What are the environmental limitations - high temperature, low temperature, humidity, sand/dust?

27. What are the storage requirements? (i.e., refrigerators, cool room or no special requirements)

28. What training is required to use the equipment and interpret the results? Does the company provide this training, and what is the cost? How often is refresher training required?

Questions on Decontamination Equipment

1. What decontamination operations does the system support - personnel, vehicles, buildings?

2. What chemical warfare agents and biological agents has the decon equipment been designed against?

3. What chemical warfare and biological simulants has the decon equipment been tested against? Has the equipment been tested against live agents? Which ones?

4. Who conducted the tests and when? Have the test results been verified by an independent laboratory or only by the manufacturer?

5. Is the test data available? Where? How can I get a copy?

6. What decontamination agents does the system use? What precautions are required in storing, transporting and mixing the concentrated decontamination reagent?

7. How much does the decon agent cost (per person treated or per vehicle treated) and what is the recommended quantity that a department should keep on hand? What are the shelf life and storage requirements? Is expedited logistics support for decon reagent available in an emergency? What are the costs, response times and time delays?

8. What water sources does the system support - hydrant, open water source (pond, river)? How much water is consumed per hour?

9. Does the system heat the water? If so what is the energy source? Does the heater capacity become the limiting factor on throughput during cold weather operations?

10. Does the system include equipment for managing run-off? What are the hazards and precautions?

11. What is the design throughput of the system - people per hour, vehicles per hour, square meters per hour?

12. Has the system been tested in extended operations? Is the system capable of continuous operations or must the processing be stopped periodically to replenish consumables? How long between required maintenance? Equipment?

13. What is the minimum suite of equipment for decon operations? How long does it take to set up the equipment? How many personnel are required for set up, continuous operations and breakdown?

14. How large is the equipment - weight and cube? What is the recommended method of transport? Are there any transportation limitations?

15. For personnel decon, does the design provide for gender separation, if disrobing is required?

16. What training is required to set up, operate and maintain the system? Does the company provide those services? Are training materials (videos, books, CD-ROMs available for use by new personnel? What are the costs of training materials?

17. Has the system been tested in extreme weather conditions - cold, rain, heat and wind? At what wind speed does the tent become a kite?

18. How is the equipment decontaminated after use? What are the sampling procedures to verify safe?

19. What are the procedures and costs for disposing of expended decontamination solution?

20. How long has the company/manufacturer been involved with the Chem-Bio-Nuc and first responder industries?

21. Ask for names and phone numbers of departments currently using the company's equipment. Ask to follow-up on the phone any written testimonials.

22. What additional items are required to operate/maintain the equipment? At what cost?

23. What type of warranty/maintenance support is offered? Cost?

24. What is the return rate on the equipment under warranty? What are the top five reasons for failure?

25. What similar companies' products has this product been tested against? What were the results of those tests?

26. What is the expected life span of the equipment?

Questions or comments can be sent to the NDPO at **ndpo@leo.gov**, or call **(202) 324-9025**.

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This information is provided by the National Domestic Preparedness Office (NDPO), in coordination with the National Institutes of Justice, the Technical Support Working Group, and the students and staff of the Center for Domestic Preparedness, military Chem/Bio units, and members of the Inter Agency Board. This document was reviewed by all of the agencies represented at the NDPO. The NDPO was established to coordinate the Federal Government's efforts to prepare the nation's response community for threats involving Weapons of Mass Destruction (WMD). Contact your local FBI office if confronted by a WMD Threat.

APPENDIX J

Summary of Stay-Times for Personnel Using Personal Protective Equipment in Chemical Warfare Agent Vapors

The following summarizes the Chemical Weapons Improved Response Program stay-time guidance for various configurations of personal protective equipment (PPE) ensembles. This guidance applies to chemical warfare agent vapors. It does not address liquid-contact hazards, or any toxic industrial compounds. This guidance is intended to support actions appropriate only in immediately life-threatening situations. It does not replace Level A/B/C protective system applications other emergency situations.

Stay-times depend on agent type, agent concentration, clothing protection, respiratory protection and the type of toxic effect that limits exposure. However, when full PPE ensemble performance has been assessed, chemical agent toxicities can be applied to determine the chemical agent effect that limits PPE ensemble exposure. The stay-time is the time spent in a vapor concentration, at which the first observable chemical agent effect becomes likely. Stay-times are not zero-risk exposure times; they are exposure times at which chemical effects are anticipated, even though those effects are expected to be of minimal medical consequence and not life-threatening. Specific health risks associated with the presented stay-times are described in reports of the Chemical Weapons Improved Response Program[10].

Stay-times depend on vapor concentration. Three levels of vapor concentration have been used to help illustrate how various PPE ensembles can be used in different hazard situations. The smallest vapor concentration is called the perimeter concentration. This is the maximum concentration expected at the down-wind, Day-Protect Perimeter of a small chemical spill. The Day-Protect Perimeter is defined and specified in the North American Emergency Response Guidebook, prepared by the U.S. Department of Transportation, Research and Special Programs Administration. This perimeter is located down-wind of a hazardous chemical spill, at a distance within which personal chemical protective equipment should be used. This distance is established at each incident by HAZMAT procedures.

The next largest vapor concentration is called the highly lethal concentration. It corresponds to the amount of vapor in which an unprotected victim has a small possibility of surviving (5%), after 15 minutes of unprotected exposure. This is the maximum concentration in which we anticipate the possibility of rescuing surviving victims of chemical exposure. At concentrations greater than the highly lethal concentration, we do not anticipate victim survival.

Note. The vapor concentration percentage and exposure time standard is under consideration and will be adjusted when approved and standardized.

The highest concentration considered is saturation. This is the highest vapor concentration that can be produced by evaporation from a liquid. It is not practical to reach a

[10] Risk Assessment of Using Firefighter Protective Ensemble with Self-Contained Breathing Apparatus for Rescue Operations During a Terrorist Chemical Agent Incident, US Army Soldier and Biological Chemical Command, Homeland Defense Business Unit, Improved Response Program, July 2003..

saturated vapor concentration in real-world scenarios. However, the saturated concentration represents the theoretical worst-case vapor hazard.

Stay-times have been determined for these concentrations of chemical warfare agent vapors, when individuals are using various combinations of personal chemical protective equipment. These stay-times illustrate how long it takes before people can expect to experience initial threshold chemical effects, when they wear certain, broadly defined types of personal chemical protective equipment, in the indicated concentrations of chemical agent vapors.

For this stay-time summary, we consider broadly defined categories of PPE. For respiratory protection, we consider the self-contained breathing apparatus (SCBA), the negative pressure respiratory protective mask, which is well maintained and offers a measurement-verified respiratory protection factor (PF) of 6666, and a negative pressure respiratory protective mask, which offers the National Institute of Occupational Safety and Health (NIOSH) applied PF of 50[11]. These disparate values are used because respiratory protection factors are highly dependent on maintenance and good fit of the negative pressure mask. Military testing shows that well-fitted, high quality ,negative pressure respirators typically offer PFs of 6666 and greater. However, the performance of such masks can significantly degrade without proper fit, mask maintenance, and user-training. Verification testing is the only way to ensure high levels of protection from negative pressure masks. Thus, NIOSH assigned an applied PF of 50 to negative pressure respirators.

We consider personal protective clothing in three broad categories. We consider modern structural fire fighting protective clothing. This clothing is considered with SCBA, because this typically constitutes what firefighters wear. Such equipment is called firefighter turnout gear.

We also consider permeable chemical protective clothing ensembles. These clothing ensembles are similar to many military-style chemical protective clothing systems. They are not designed to protect against toxic industrial compounds and toxic industrial materials, but they are effective against the battlefield use of chemical warfare agents that have been developed for military use. We refer to these clothing ensembles as Tactical (SWAT) PPE Ensembles. The following Tactical (SWAT) Ensembles were considered:

Hammer® Two-Piece Chemical Protective Overgarment
Saratoga® Chemical Protective Undergarment
Hammer® One-piece Chemical Protective Overgarment
Giat® SWAT One-piece Chemical Protective Overgarment
TOMPS® Two-Piece Chemical Protective Overgarment
LANX® Chemical Protective Undergarment

For these Tactical (SWAT) PPE Ensembles, the minimum Man-In-Simulant-Test (MIST) Physiological Protective Dosage Factor (PPDF) was 95. For stay-time analysis, these clothing ensembles were paired with negative pressure respiratory protective masks, with PFs of 50 and 6666.

[11] National Institute for Occupational Safety and Health, Research Development Letter (RDL) # 78-108; Applied Protection Factor Table, May 2000.

We also consider impermeable, Level C, PPE clothing ensembles. The following Level C PPE ensembles were considered:

Maryland State Police Standard Duty Uniform
Tyvec®Protective Wear TM coverall
Dupont Tychem®9400 suit
Kappler CPF®4 suit
Dupont Tychem®SL suit
Tyvek®Protech F suit

These clothing ensembles also were paired with negative pressure respiratory protective masks, with PFs of 50 and 6666.

PPE ensembles offering significant protection with respect to highly lethal concentrations offer more than adequate protection at perimeter concentrations. Thus, stay-times for perimeter concentrations are not given for PPE ensembles that offer significant levels of protection against highly lethal vapor concentrations. Details of chemical hazards associated with using firefighter's turn out gear as PPE are addressed in the report, *Risk Assessment of Using Firefighter Protective Ensemble with Self-Contained Breathing Apparatus for Rescue Operations During a Terrorist Chemical Agent Incident.*

Stay-times Tactical (SWAT) clothing ensembles with negative pressure respiratory protective masks in a CWA hazard environment are given below, in Table 14.

	Nerve Agent Concentration	
	Highly Lethal	Saturation
PPE Ensemble Characteristics	Stay-Time (minutes)	
Tactical (SWAT) PPE Ensembles and Negative Pressure Respirators with a PF of 50	3	0.007
Tactical (SWAT) PPE Ensembles and Negative Pressure Respirators with a PF of 6666	20	1

Table 14. Stay-Time Guidance for Various Personal Protective Ensembles in a Highly Lethal and a Saturated Concentration of Chemical Warfare Nerve Agent Vapors

Stay-times for Level C PPE clothing ensembles, with negative pressure respiratory protective masks, are given below, in Table 15.

	Nerve Agent Concentration
	Perimeter - Day Protect Zone
PPE Ensemble Characteristics	Stay-Time (minutes)
Level C PPE Ensemble and Negative Pressure Respirator with a PF of 50	850
Level C PPE Ensemble and Negative Pressure Respirator with a PF of 6666	1500

Table 15. Stay-Time Guidance for Various Personal Protective Ensembles in a Perimeter Concentration of Chemical Warfare Nerve Agent Vapors

STAY-TIME EXPLANATIONS

The protection offered by an overall PPE ensemble can be limited by either the respiratory protective mask, or the chemical protective clothing. In general, the respiratory system is more vulnerable to chemical exposure than the skin surface of the body. Thus, with a minimal respiratory protection factor of 50 and ordinary clothing, such as the Maryland State Police Standard Duty Uniform, an individual has a low risk of chemical effects in concentrations expected at the perimeter of a chemical release. Even if they remain for long periods in the maximum vapor concentrations expected at the down-wind Day-Protect Perimeter of a chemical release, chemical effects are not anticipated.

In higher agent concentrations, with minimal respiratory protection, stay-times are severely limited, regardless of protective clothing for the skin. With a respiratory PF of 6666, stay-times are limited by clothing protection. The increased skin protection offered by Tactical (SWAT) PPE ensembles leads to longer stay-times. However, as the stay-times indicate, negative pressure respirators offering a respiratory protection factor of 6666 should still be considered primarily for escape purposes, or short-duration, dynamic operations. Such personal chemical protective ensembles do not equip law enforcement officers for operations that may involve long periods of exposure to highly lethal vapor concentrations. Limitations of such Tactical (SWAT) PPE ensembles must be weighed when considering stealth operations in potentially contaminated environments.

In general, when self-contained breathing apparatus is used, protection against chemical warfare nerve agent vapors is limited by clothing protection. Firefighter turnout gear does not offer as much chemical protection as the Tactical (SWAT) PPE ensembles tested. However, with the use of SCBA, firefighter turnout gear offers sufficient chemical vapor protection to

successfully manage chemical effect risks in quick rescue operations, even in highly lethal concentrations of chemical warfare agents vapors.[12]

Further details regarding the tests performed on these ensembles and the stay-times, please consult the referenced reports of the US Army Soldier and Biological Chemical Command, Domestic Preparedness Chemical Team, available at the web site: http://hld.sbccom.army.mil/ip/ .

[12] Risk Assessment of Using Firefighter Protective Ensemble with Self-Contained Breathing Apparatus for Rescue Operations During a Terrorist Chemical Agent Incident, US Army Soldier and Biological Chemical Command, Homeland Defense Business Unit, Improved Response Program, July 2003.

APPENDIX K

List of Acronyms

BALTEX	Baltimore Exercise
BRHA	Body Region Hazard Analysis
C/B	Chemical and Biological
CBRN	Chemical, Biological, Radiological and Nuclear
CPU	Chemical Protective Undergarment
CWA	Chemical Warfare Agent
CW IRP	Chemical Weapons Improved Response Program
DoD	Department of Defense
DPP	Domestic Preparedness Program
EMS	Emergency Medical Services
FBI	Federal Bureau of Investigation
FY	Fiscal Year
HazMat	Hazardous Materials
IC	Incident Commander
IRP	Improved Response Program
LEFG	Law Enforcement Functional Group
MIST	Man-In-Simulant Tests
MSA	Mine Safety Appliances
MSP	Maryland State Police
NBC	Nuclear, Biological and Chemical
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
NIST	National Institute of Standards and Technology
OLES	Office of Law Enforcement Standards
OSHA	Occupational Safety and Health Administration
PAPR	Powered Air Purifying Respirator
PF	Protection Factor
PPE	Personal Protective Equipment
QNFT	Quantitative Fit Test

SBCCOM	Soldier and Biological Chemical Command
SCBA	Self-Contained Breathing Apparatus
STATE	Special Tactical Assault Team Element
SWAT	Special Weapons and Tactics
TOMPS	Tactical Operations Multi-Purpose Suit
TOP	Test Operation Procedure
WMD	Weapons of Mass Destruction