Risk Assessment of Using Firefighter Protective Ensemble with Self-Contained Breathing Apparatus for Rescue Operations During a Terrorist Chemical Agent Incident

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EXECUTIVE SUMMARY

Introduction

This report provides the Incident Commander with an understanding of the protection afforded by standard firefighter protective ensembles (FFPE) and the associated risks involved if the ensemble is worn while performing rescue operations at the scene of a terrorist incident involving the use of military chemical warfare agents. FFPE, as discussed in this report, consists of standard turnout gear and self-contained breathing apparatus (SCBA).

This report supersedes the U.S. Army Soldier and Biological Chemical Command (SBCCOM) Domestic Preparedness Report titled *Guidelines for Incident Commander's Use of Firefighter Protective Ensemble (FFPE) with Self-Contained Breathing Apparatus (SCBA) for Rescue Operations During a Terrorist Chemical Agent Incident* dated August 1999.

This report updates the previously conducted analysis, based on the newly published chemical, biological, radiological and nuclear (CBRN) standards and input from the fire service. Although this report provides hazard awareness for performing quick rescue in chemical agent contamination using FFPE with SCBA, this protective equipment provides less chemical protection than is required for certification under existing CBRN standards, including the NIOSH CBRN *Standard for Self-Contained Breathing Respirators (SCBA) for Emergency Workers in Terrorist Attacks*, and NFPA 1994 *Standard on Protective Ensembles for Chemical/Biological Terrorism Incidents*.

When firefighters use FFPE with SCBA to perform quick rescue under the operational restrictions in this report, they are subject to **greater risk of chemical effects** than they are if they use protective equipment fully certified under existing CBRN standards. SBCCOM recommends that fire departments obtain CBRN-certified chemical protective equipment for use in hazardous chemical operations. When available, CBRN–certified chemical protective equipment should be worn instead of turnout gear, in operations involving hazardous chemicals. This report addresses situations when firefighters are not aware that a chemical agent hazard exists, or when certified chemical protective equipment is not available at the emergency scene. For these situations, this report gives operational restrictions, which limit potential exposure times for firefighters, who are wearing FFPE with SCBA, while they perform initial reconnaissance of the scene and quick rescue of living victims. This report also describes the chemical effects that firefighters possibly will experience as a result of chemical exposures occurring during these restricted operations.

Background

Under the Nunn-Lugar-Domenici Domestic Preparedness Legislation (Fiscal Year 1997 Defense Authorization Bill, Public Law 104-201, Sep 1996) the U.S. Army Soldier and Biological Chemical Command (SBCCOM) conducted an assessment of the protection afforded by standard FFPE, when used in responding to a terrorist act using military chemical warfare agents.

The SBCCOM Improved Response Program (IRP) conducted the initial assessment of FFPE in order to answer questions from the fire community regarding the risks associated with

performing rescue of victims from a chemical agent terrorist incident in turnout gear and SCBA if higher levels of protective clothing were not immediately available.

Testing was conducted using civilian firefighters representing several of the fire departments supporting the SBCCOM IRP. Multiple configurations of FFPE and several potential field expedient enhancements (quick-fixes) were tested. Testing was performed using firefighters dressed in commonly used turnout gear, utilizing both Nomex® and PBI®/Kevlar® outer shells and Crosstech® moisture barriers. Tests were performed with both new and used gear. Results of SBCCOM's testing were independently validated by testing conducted by the Royal Military College of Canada, Kingston, Ontario, Canada. The results of the study were published in the above referenced report.

When the referenced report was published, standards for civilian CBRN personal protective equipment did not exist. Subsequent to the SBCCOM IRP testing, the National Institute of Occupational Safety and Health (NIOSH) established CBRN standards for respiratory protection, which specify chemical agent challenge concentrations. In this update of the original assessment, SBCCOM has reassessed the risks associated with quick rescue in FFPE by applying the new agent challenge concentrations to the protective factors measured in the original FFPE tests. In addition, in consideration of newly existing CBRN protective equipment standards, SBCCOM has reviewed the applicability of the "quick-fix" options that were outlined in the original assessment and has eliminated response options based on field-expedient "quick-fixes."

Findings and Conclusions

The initial assessment of the protection afforded by FFPE and the risks associated with performing rescue operations in a terrorist incident involving military chemical warfare agents were substantiated. Application of the new chemical agent vapor challenge concentrations specified in the NIOSH CBRN Standard did not change the overall associated risks to firefighters. Based on this reassessment, FFPE, with SCBA, continues to afford limited protection, which is sufficient to allow firefighters to perform quick rescue operations in a chemical agent environment.

FFPE (turnout gear) is not a substitute for certified chemical protective clothing, however, in certain emergency response situations the Incident Commander may find himself on the scene, faced with a casualty rescue mission, without certified chemical protective clothing. If a rescue operation with the protective equipment that is readily available (FFPE and SCBA) is performed, SBCCOM's study indicates that the operation should be minimized and should not exceed the constraints outlined in the Incident Commander's Operational Considerations (see below). Incident Commanders must be aware that there is a higher degree of risk to firefighters using FFPE and SCBA than there is to firefighters using certified CBRN protective clothing. In addition to certified protective clothing, SCBA used for chemical agent response should be certified to meet the NIOSH CBRN SCBA Standard.

Based on a reassessment of the operational procedures involving the use of field-expedient quick-fix options, and in consideration of recently established standards for CBRN protective equipment, it was determined to eliminate these quick-fix options from SBCCOM's recommended Incident Commander operational considerations.

Incident Commander Operational Considerations

In many instances firefighters may arrive on the scene of an incident where numerous victims exhibit varying degrees of injury and illness. It may not be immediately recognizable that a chemical agent is the cause of the victim's distress. As such, firefighters possibly will enter a potentially hazardous environment in order to perform rescue of living victims wearing only their basic firefighter protective ensemble (structural turnout gear and SCBA).

Based on the testing performed by the SBCCOM IRP, Incident Commanders have some basic knowledge of the operational limitations of performing quick rescue operations in a chemical weapon environment with FFPE and SCBA. The following basic operational considerations summarize the contents of this report.

- The presence of **LIVING** victims inside the potential hazard area provides the basic indicator for firefighters to assess the level of nerve agent contamination.
- Rescue entry occurs after vapor concentration has peaked (assumed approximately ten minutes after the release of agent).
- Firefighters using standard turnout gear and SCBA to perform rescue of **KNOWN LIVE VICTIMS** can operate in a nerve agent vapor hazard for up to 30 minutes with minimal risks associated with nerve agent exposure.
- The risks associated with these 30-minute operations are that 50% of firefighters **MAY** experience increased sweating and muscle weakness 1-18 hours after exposure.
- Firefighters entering a nerve agent environment **WITHOUT KNOWN LIVE VICTIMS** using standard turnout gear and SCBA should limit their potential exposure to three minutes.
- Firefighters searching an enclosed area for victims should immediately exit the area and undergo decontamination if they encounter evidence of chemical contamination and cannot identify any living victims.
- If firefighters encounter oily liquid contamination (puddles/drops) and victims report signs of mustard agent (i.e. garlic odor), firefighters and victims should immediately exit the area and undergo decontamination.

Additional Considerations

The information in this report is based on testing of FFPE against chemical agent VAPOR only. SBCCOM is currently conducting liquid hazard testing and analysis for FFPE. Once completed an updated report will provide the overall risks of using FFPE based on both vapor and liquid contamination hazards. But even if FFPE protects well against liquid contact, firefighters performing quick rescue operations should continue to avoid liquid contamination and should always seek to minimize liquid contact.

The information regarding rescue operations is based on the presence of **live, viable victims** being in the hazardous area once first responders arrive on the incident scene (estimated to be 10 minutes after the release of the agent). The information is also presented with the understanding

that responders and victims exiting the rescue scene will immediately undergo a water-based (high-volume, low-pressure) decontamination.

The concepts outlined in this report are neither mandated nor required procedures for first responders arriving on the scene of a chemical terrorism incident. Rather, they are presented to provide an assessment of the protection afforded by firefighter structural turnout gear and SCBA and the possible risks associated with firefighters entering an area where a terrorist has released chemical agents.

The information provided in this report is based on the results of testing with chemicals that simulate known characteristics of specific chemical agents. This report suggests restrictions for operating in vapor hazards resulting from a terrorist attack involving the release of chemical warfare agents. In an actual incident, first responders possibly will operate in a hazardous environment as long as the incident requires, their SCBA air supply lasts, and they remain capable, within the constraints of local command policy. These operational restrictions do not replace such command policy or lawful orders, however, they can be used to develop command policy or assist the Incident Commander in identifying the risks of initial reconnaissance in unknown contamination and quick rescue of victims who have survived a chemical agent release.

Testing was performed on a limited number of the many turnout gear configurations and styles that are available to firefighters. Fire departments participating in the tests considered the configurations and styles tested to be a good representation of turnout gear used throughout the country. Other configurations and styles of turnout gear may offer different amounts of protection.

Using turnout gear and SCBA, while rescuing known live, viable victims in a chemical agent environment, does not justify performing hazardous material operations, such as agent detection, identification, or mitigation procedures, in other than the appropriate level of Occupational Safety and Health Administration (OSHA) Personal Protective Equipment (PPE) for the estimated hazard.

It is up to each jurisdiction, and/or the Incident Commander on the scene, to determine what actions can be taken when first responders discover surviving, but incapacitated, victims of a possible chemical hazard. T**o make a valid risk assessment for performing casualty rescue, jurisdictions and Incident Commanders should know the risk of physiological effects that firefighters might experience, as a result of exposures received while using turnout gear and SCBA to rescue victims in a chemical agent environment. Under the operational restriction outlined in this report, the risk is that half of firefighters possibly will experience threshold effects for chemical agent exposure.**

In 2002, NIOSH established a standard for SCBA systems for use in a Chemical, Biological, Radiological, and Nuclear (CBRN) environment. Agent vapor challenge concentrations from this standard are applied in this report. However, FFPE and SCBA protection levels used herein are from the original testing; equipment testing has not been repeated. The hazard awareness offered herein and test data used to determine the protection afforded by FFPE and SCBA do not indicate or imply that the equipment complies with the recently developed NIOSH CBRN SCBA standard.

Future Research Activities

SBCCOM laboratory research and investigations continue to address further emergency responder hazards, including hazards associated with liquid contact on firefighter protective clothing. This additional effort will better define overall risks of using FFPE based on both vapor and liquid contamination hazards.

In 2002, the International Association of Fire Fighters (IAFF) initiated "Project HEROES" (Homeland Emergency Response Operational and Equipment Systems) to capitalize on the technological advances of the last 20 years as well as emerging technologies. The project goal is to develop new firefighter personal protective clothing and equipment that will save lives, reduce injuries, and safely increase the work capacity of firefighters engaged in high-risk operations in extreme environments. The Project HEROES ensemble will optimize the firefighter's protective equipment for all homeland emergency responses, which could include structural firefighting, search and rescue, and industrial hazardous materials, biological materials and other weapons of mass destruction response. Project HEROES will conduct research as well as develop, integrate, evaluate and accelerate the use of advanced, emerging, and future protective technologies (clothing, equipment, electronics, and integrated systems) through the establishment of a multi-disciplinary team of fire service, academic, private sector, and governmental entities. The National Institute for Occupational Safety and Health's National Personal Protective Technology Laboratory, the U.S. Army SBCCOM Edgewood Chemical/Biological Center, the SBCCOM Natick Soldier Center – National Protection Center (NPC), the National Fire Protection Association (NFPA), the International Association of Fire Chiefs (IAFC), the Department of Homeland Security (DHS), and the Technical Support Working Group (TSWG), are among those participating in this effort.

An electronic copy of this report can be obtained from the following Web site:

http://www.ecbc.army.mil/hld/ip/reports.htm

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TABLE OF CONTENTS

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RISK ASSESSMENT OF USING FIREFIGHTER PROTECTIVE ENSEMBLE AND SELF-CONTAINED BREATHING APPARATUS FOR RESCUE OPERATIONS DURING A TERRORIST CHEMICAL AGENT INCIDENT

1.0 INTRODUCTION AND BACKGROUND

Congressional legislation signed in 1996 provided a method for the Department of Defense (DoD) and other federal partners to assist the first responder community at the state and local level in preparing for a potential chemical or biological terrorist attack. Under the Nunn-Lugar-Domenici Domestic Preparedness Program, SBCCOM formed teams of operational and technical experts to focus on high-priority responder needs through an effort called the Improved Response Program (IRP). Through a series of tabletop exercises called BALTEX, the IRP identified a gap in the first responder's ability to perform rapid rescue of surviving victims and their need to operate quickly and safely in potentially unidentified and unmonitored chemical contamination. This gap arises because first responders frequently do not have fully-encapsulating Level A protective equipment initially available at many emergency scenes. Delays in performing rescue operations to wait for a Level A response team increases the exposure of the surviving victims and can further endanger their safety. Although such equipment provides better protection during a chemical terrorist incident, it is routinely not necessary, or even useful, in most emergencies. To continue emergency response, under the threat of chemical terrorism, potential Incident Commanders (IC) needed to know how well their Firefighter Protective Ensemble (FFPE) with SCBA, commonly called turnout gear, would protect first responders in highly toxic chemical warfare agent contamination.

Firefighters by nature incur a certain degree of risk in the performance of their duties in an effort to save the lives of victims at an emergency response scene. It can be expected that firefighters arriving on the scene of a potential chemical agent incident will not know immediately the true nature of the hazard they are facing. As such, firefighters possibly will enter areas contaminated with chemical agent while performing search and rescue operations.

With operational input and active participation from a broad community of first responders, the SBCCOM IRP conducted a series of technical tests (outlined in Appendix A). Firefighters from Montgomery County (MD) and Baltimore County (MD) participated as test subjects. These tests identified and validated how well standard turnout gear protects a first responder from injury, incapacitation, or death while operating in an environment containing chemical agent vapor. The test results are used to determine operational limits that maintain a minimal level of risk to firefighters performing quick rescue operations wearing this ensemble.

To put these test results into terms usable by firefighters throughout the nation, an Incident Command Research Team was formed under the IRP (see Appendix B). The IC Research Team included firefighters representing:

- Montgomery County (MD)
- Baltimore County (MD)
- Baltimore City (MD)

- Howard County (MD)
- Washington, DC
- Columbus (OH)
- Los Angeles (CA)
- Aberdeen Proving Ground (MD)

Representatives from this research team consulted with a cross-section of additional firefighters at all ranks through face-to-face interviews, a questionnaire survey, and in meetings.

2.0 CONDITIONS FOR RESCUE OPERATIONS

The use of FFPE and SCBA to perform rescue operations at a potential chemical agent incident is based on the following conditions:

- The type and extent of the chemical hazard is determined based on an immediate assessment of the scene that includes victim signs and symptoms.
- Entry using turnout gear and SCBA is only a consideration, if the initial responders do not have chemical agent detectors or certified chemical protective clothing immediately available.
- Firefighters will only enter potentially contaminated areas to perform rescue of **KNOWN LIVE VICTIMS** or to perform an immediate reconnaissance to determine if live victims exist.
- Firefighters will immediately exit any area where they encounter evidence of chemical contamination and cannot identify any living victims.
- Firefighters will avoid contact with any unidentified liquids.
- Firefighters and rescued victims will undergo an emergency decontamination immediately upon exit from the potentially hazardous area.
- Immediate medical assistance such as that provided by EMS providers is immediately available on scene.

3.0 ASPECTS OF CHEMICAL AGENT HAZARDS

3.1 Agent Types, States, and Exposure Routes

Several chemical agents can be manufactured in quantities sufficient to produce a viable terrorist threat. Physical evidence, chemical odors, and victim symptoms - shown in Table 1 - can possibly help assess which chemical agent may be present after a terrorist attack. For example, several chemical agents can be smelled at or below concentrations where they become immediately lethal hazards, so odor reports from victims may be an important indicator. However, as indicated, agents GB and VX in pure forms are odorless, so lack of smell is not evidence of safe exposure levels. Further details of chemical agent effects are summarized in Appendix C.

Agent Name and Symbol	Agent Class	Odor	Potential Vapor Exposure Symptoms (Immediacy[1], Exposure Route, Exposure Severity)
Sarin (GB)	Nerve	No Significant Odor	**(immediate, eye contact effects)** Pinpointing of pupils, blurred or dimmed vision, eye pain, headache; **(delayed, skin contact effects)** Increased local sweating, tremors (mild exposure) Vomiting, nausea, headache (moderate exposure) Convulsions, diarrhea, loss of consciousness, death (severe exposure); **(delayed, inhalation effects)** Vomiting, nausea, headache, convulsions, diarrhea, loss of consciousness, death
Soman (GD)		Fruity, Camphor	
VX		No Significant Odor	
Lewisite (L)	Blister	Geraniums	**(immediate, skin contact effects)** Pain, irritation, burn **(slightly delayed, skin contact effect)** Blisters
Mustard (HD)		Garlic-like	No immediate[2]

[1] Dependent on exposure rate and total dosage
[2] Skin reddening and blisters generally are delayed by 4 to 18 hours after exposure

Table 1. Chemical Agent Vapor Odors and Exposure Symptoms

At normal indoor temperatures, chemical agents may be disseminated as a liquid, aerosol, and/or vapor. These dissemination forms effectively create a continuum of mass sizes. Small aerosols can remain suspended in air for long times and are removed from enclosures by ventilation, as are vapors. Aerosol droplets, both liquid and solid, can deposit on surfaces and become skin contact hazards as well as sources for evaporation and re-aerosolization. Vapors can adsorb onto surfaces and subsequently offgas as vapor.

This report provides estimations of the vapor hazard potentially faced by first responders**. It does not address aerosol or liquid hazards.** However, aerosol testing by SBCCOM has shown that new PBI turnout gear offers significantly better protection against chemical agent aerosols than chemical agent vapors. Therefore, vapor is a greater hazard to first responders. However, when entering an area contaminated with liquid chemical agent, contact with liquid must be avoided.

WARNING

Even small amounts (several droplets) of liquid nerve agent contacting the unprotected skin can be severely incapacitating or lethal if the victim or responder is not decontaminated rapidly (minutes) and treated medically.

After a terrorist event, chemical agent vapor could affect firefighters through three potential exposure routes – skin contact (percutaneous), inhalation, or eye (ocular) exposure. SCBA protects both the firefighter's eyes and respiratory system from agent exposure and effects. This protection is much greater than the protection provided to skin by FFPE. However, if the SCBA system fails (i.e. is improperly fitted) inhalation and ocular effects may occur.

Direct exposure of the eyes, even to extremely low vapor concentrations of nerve agents, may cause an ocular effect known as miosis. When miosis occurs, the pupil of the eye becomes smaller (contracts), making it more difficult to see in low levels of light. Miosis occurs more rapidly than chemical agents effects due to exposure of the skin to the same vapor concentration. Miosis may occur after several seconds of exposure and could take five to 10 minutes to fully develop. Miosis is reversible, but any occurrence is an indication that the SCBA is not working effectively and the responder should immediately exit the contamination. Any occurrence of miosis should be medically evaluated.

This report addresses vapor hazards through all three exposure routes. The analysis of turnout gear and SCBA considered vapor hazards through all three routes. The analysis shows that the significant hazards are created only by skin exposure. Combining hazard contributions from the other routes does not change the overall assessment; therefore, this report presents hazard assessments associated with skin exposure.

3.2 Vapor Dosage Calculation

In general, exposure to a chemical agent vapor concentration (C) over time (T) produces an exposure dosage (CT). As vapor concentration and/or exposure time increases, exposure dosage will become higher. Furthermore, exposure dosage is cumulative; recovery after nerve agent exposure may take weeks to months. However, medical intervention after nerve agent exposure is very effective for all but the most severe exposures.

While nerve agent exposure can be recognized by observing the reactions of exposed victims, mustard agent exposure cannot. Symptoms of exposure to mustard (HD) are latent and may not appear for four to 18 hours after exposure. Mustard-exposed victims may leave the incident scene and may seem relatively unaffected, even several hours after exposure to significant HD agent concentrations.

4.0 DETERMINING SPECIFIC HAZARDS TO FIREFIGHTERS

A basic factor in determining the hazards faced by firefighters is the vapor concentration that a firefighter might encounter while performing rescue or reconnaissance. If a chemical agent detector capable of accurate near-real-time vapor quantification is not available and/or entry into an unknown environment for detection is not performed, the IC must base hazard assessments on other indicators, including the signs, symptoms, and reports from escaping victims, and knowledge of the room size and air handling characteristics.

4.1 Man-In-Simulant Test (MIST) Results

Chemical protective ensembles reduce the exposure of the body 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 vapor absorbed by the body (through the skin) 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 (initial) effects in one minute, then someone wearing a protective ensemble with a PPDF of 10 could be exposed for 10 times as long, or 10 minutes, before experiencing the same effects.

For vesicants, threshold effects represent the point where the mildest chemical agent effects occur in the most sensitive part of the body. 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 localized body regions (local effects). These regions are generally warm, moist regions of the body, such as the groin and underarms. Alternately, nerve agent vapors, like sarin (GB), soman (GD), and VX produce systemic effects as a result of total body absorption.

Calculating the PPDF takes into account the type of agent and the earliest indication of threshold effects: both systemic and local effects. A single protective ensemble may have different PPDFs for systemic and for local threshold effects.

MIST results for turnout gear provide PPDFs for localized skin effects of HD and systemic effects of nerve agents. A systemic PPDF ($PPDF_S$) and a local PPDF ($PPDF_L$) summarize the overall protective performance of each type of tested turnout gear. Table 2, below, gives the systemic and local PPDFs for each type of turnout gear tested. All

clothing tested used PTFE moisture barriers. The third column of Table 2 indicates the region of the body where the threshold effects of HD are first expected.

Structural Turnout Gear Tested	$PPDF_S$ (for systemic effects of nerve agents)	$PPDF_L$ (for local skin effects of HD)	Body Region of skin irritation for HD
New PBI Gear	11.1	14.8	Neck/Groin
Used PBI Gear	16.6	21.5	Neck/Ears
New Nomex Gear	11.1	14.3	Chin & Neck
Used Nomex Gear	16.1	18.9	Chin & Neck

Table 2. Physiological Protective Dosage Factors For Turnout Gear Tested

4.2 Nerve Agent Exposure Hazards

It will take first responders some time to arrive on scene. If responders arrive on scene ten minutes after a high concentration of a chemical vapor has been dispersed, virtually no living victims will be present. If living victims are present in the vapor contamination area ten minutes after the vapor was dispersed, then concentrations in the area of these victims cannot be extremely high.

The risks associated with wearing FFPE and SCBA in a chemical nerve agent environment were assessed at two specific applied concentrations for each nerve agent. The lower applied concentration represents the maximum concentration in which victims might survive a ten-minute exposure. This exposure is assumed to occur before first responders arrive at the scene. This concentration is referred to as the Maximum Survivable Concentration (MSC). In the MSC, two percent (1 in 50) of the exposed victims are expected to survive after ten minutes in the nerve agent vapor. For each nerve agent, this unique concentration is determined by a two-geometric-standard-deviation extrapolation from median inhalation lethality specified by Grotte and Yang[1], applied over ten minutes. The second applied concentration represents a realistic maximum concentration expected for a terrorist chemical agent incident. For this higher concentration, we adopt the values specified in the NIOSH CBRN SCBA Standard[2]. For GB, the MSC is 5 mg/m^3, while the reasonably maximum concentration expected for GB is 2000 mg/m^3.

Using the above concentrations for GB, and similarly established concentrations for GA, GD, GF, and VX, we determined the exposure times for which the expected firefighters risks are that 50% of firefighters may experience increased sweating and muscle weakness 1-18 hours after exposure. The smallest exposure time for all the nerve agents at their respective MSC concentrations is 30 minutes, while the smallest exposure time

[1] Jeffery H. Grotte and Lynn I. Yang 2001. *Report of the Workshop on Chemical Agent Toxicity for Acute Effects*, Institute for Defense Analyses.
[2] National Institute of Occupational Health and Safety. *Standard for Self-Contained Breathing Respirators (SCBA) for Emergency Workers in Terrorist Attacks*, www.cdc.gov/niosh/respinfo.html.

for all nerve agents at the reasonable maximum expected concentration is three minutes. The maximum exposure guideline limits contained in this report are based on these times.

Based on the agent concentrations and the protective factors measured for the FFPE and SCBA ensembles, firefighter cutaneous exposure dosages and the associated risks were calculated for the shortest exposure time among those for all high nerve agent concentrations and the shortest exposure time among those for all MSC values for the nerve agents.

To better illustrate the hazards faced by firefighters, we graphically summarize the hazards faced from the nerve agent GB, at the shortest exposure times for all nerve agents. The two operational situations are:

- Operating for up to 30 minutes inside of a potentially contaminated area to perform rescue of **known live victims** in the MSC for agent GB, or 5 mg/m^3.
- Performing a 3-minute reconnaissance inside of a potentially contaminated area to **identify if live victims exist** in a GB agent concentration of 2000 mg/m^3.

Figure 1 illustrates the dosage that a firefighter performing rescue operations for up to 30 minutes could receive. This situation occurs in an environment where two percent (1 in 50) of the unprotected victims are expected to still be alive after a 10-minute exposure. Figure 1 shows this dosage in relation to the dosages representing threshold, severe and lethal chemical nerve agent effects[3][4]. Firefighters in standard turnout gear and SCBA will receive a percutaneous dose of 15 mg-min/m^3. As shown on the chart, this dose is far below the threshold effects dose of 1200 mg-min/m^3.

Threshold effects are described in the National Research Council Report (National Research Council 1997, Review of Acute Human-Toxicity Estimates for Selected Chemical Warfare Agents, Committee on Toxicology). At the threshold effects dosage, 50 percent of the exposed individuals are expected to experience increased sweating and muscle weakness occurring 1-18 hours after exposure. Severe effects are defined as 50 percent of the exposed individuals may experience nausea and vomiting.

[3] Jeffery H. Grotte and Lynn I. Yang 2001. *Report of the Workshop on Chemical Agent Toxicity for Acute Effect*, Institute for Defense Analyses.
[4] National Research Council 1997. *Review of Acute Human-Toxicity Estimates for Selected Chemical Warfare Agents*, Committee on Toxicology.

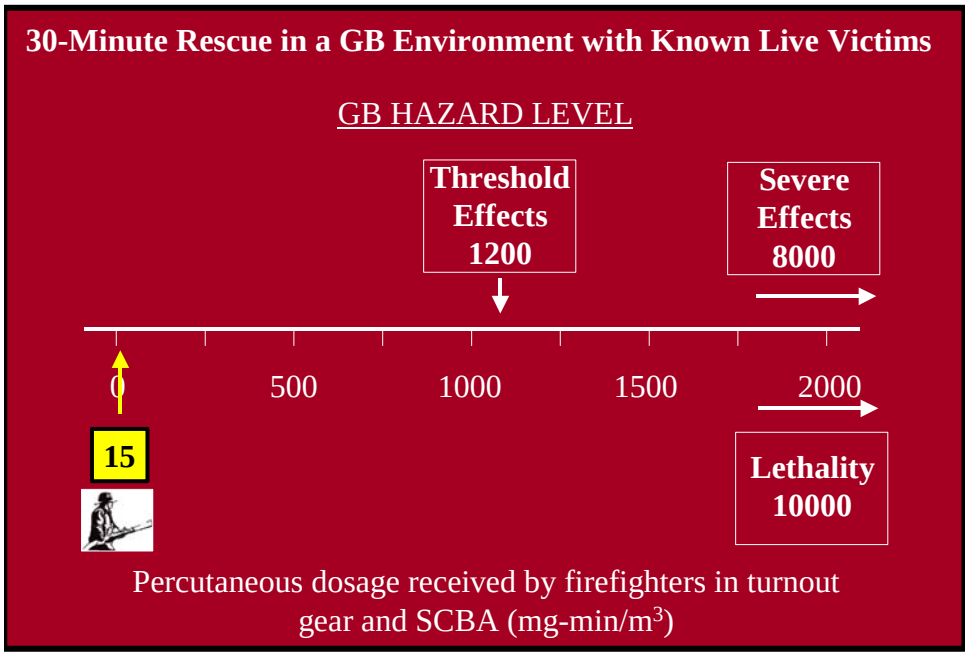


Figure 1. 30-Minute Rescue Dosage for a GB Environment

Figure 2 illustrates the dosage that a firefighter may receive when entering an area of high concentration of GB nerve agent vapor. Firefighters may be exposed to high concentrations of agent, if they enter an area without knowing that a chemical agent is present, or if they enter an area to search for living victims, but find only victims showing no signs of life.

In this situation, we apply the nerve agent concentration specified in the NIOSH CBRN SCBA standard, which is 2000 mg/m^3. This concentration of GB nerve agent represents a realistic maximum value, for the GB concentration expected to be produced in a terrorism scenario.

At this concentration (2000 mg/m^3) the firefighter in standard turnout gear and SCBA will receive a percutaneous dose of 571 mg-min/m^3 after 3 minutes. Although some chemical agent effects may occur, as shown on the chart the dose remains below the threshold effects dose of 1200 mg-min/m^3.

With nerve agent vapors, the absence of living victims shows when exposure times should be limited as much as possible and should, in any case, not exceed three minutes. This continues to apply even if responders arrive on scene earlier than ten minutes after vapor dissemination. If responders, using FFPE and SCBA, and unprotected victims are both present when agent is initially disseminated, it will take at least six times longer for responders to reach a threshold effect exposure than it will take for victims to reach a lethal exposure. If at any point during the rescue operation, all victims should die, responders using FFPE and SCBA should limit their own exposures, rapidly exit the area, and be decontaminated.

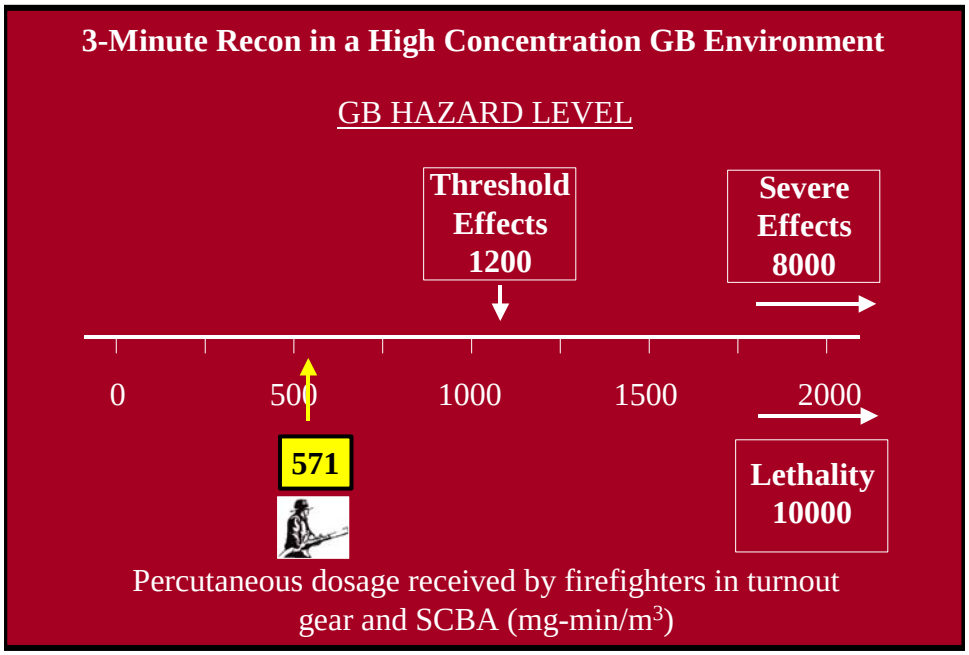


Figure 2. 3-Minute Recon Dosage for a GB Environment

4.3 Vesicant Agent Exposure Hazards

Although certain vesicants such as Lewisite (L) and Phosgene Oxime (CX) present immediate effects such as irritation of the eyes, throat, and exposed skin, mustard agents (H Series) in general present immediate reaction only from exposures to high concentrations. As such, responding to an incident involving mustard agent is entirely different for first responders. Mustard agent provides no reliably immediate reactions in the exposed victims. The effects of mustard exposure are often not apparent until hours after the exposure. The absence of immediately recognizable signs and symptoms in the victims means that the first responders must use other means to identify the presence of mustard contamination. Other means include:

- Victim reports of a garlic-like odor
- Observed or reported presence of an oily liquid or spray
- Presence of a spray device at the scene

Unlike incapacitated victims of nerve agent exposure, victims of mustard exposure are not expected to require quick rescue as a result of agent effects. However, it is conceivable that firefighters may possibly enter a mustard agent environment, if they are attending victims suffering from other injuries associated with the incident. This situation could arise if an explosive device were used to disseminate mustard agent and the device also produced trauma victims requiring extraction.

With nerve agents, the presence or absence of living victims provides a clear indicator of the level of vapor contamination in the area. This is not true for mustard because most mustard symptoms are delayed. As such, it is not possible to establish a maximum survivable concentration for mustard vapor, based on immediate agent casualties that first responders can observe when arriving on the scene. Therefore, the only mustard agent concentration that the tested protective ensembles were assessed against is the realistic maximum concentration specified in the NIOSH CBRN SCBA Standard, which is 300 mg/m^3.

With the protective system test results, and a mustard concentration of 300 mg/m^3, the maximum exposure time for turnout gear with SCBA is one minute. Using firefighter turnout gear, in a one minute exposure to a mustard concentration of 300 mg/m^3, 50% of exposed firefighters can expect to experience irritation and reddening in sensitive body regions, which include the ears, neck, armpits, and groin (about 4% of the total body surface). The time of one minute is the escape time a firefighter has before they can expect to experience threshold (initial) symptoms of skin exposure to mustard, if they inadvertently enter an area at the NIOSH CBRN SCBA Standard vapor concentration for HD wearing firefighter turnout gear and SCBA.

Figure 3 illustrates that after a 1-minute exposure to HD at a concentration of 300 mg/m^3, the firefighter in standard turnout gear and SCBA will receive a percutaneous dosage of 25 $mg\text{-}min/m^3$. This dosage is equal to the dosage required to cause 50% of firefighters to experience threshold (initial) symptoms. At this dosage (25 $mg\text{-}min/m^3$), up to 50% of firefighters may experience localized (about 4% of the total body surface) skin irritation and reddening, occurring 4-48 hours after exposure. These effects are comparable to a firefighter receiving first-degree burns over about 4% of the total body surface, but in regions of high sensitivity such as those mentioned.

In the event that firefighters fail to recognize the presence of mustard agent, they might unexpectedly operate in the contaminated area for a longer period of time. A nine minute exposure at a concentration of 300 mg/m^3 would result in the firefighter receiving an average dosage of 200 $mg\text{-}min/m^3$. At this dose firefighters could expect to receive blisters and burns, of 2^{nd} degree severity, in sensitive body regions, including the ears, neck, armpits, and groin (about 4% of the total body surface area - BSA) and skin reddening extending to other body regions.

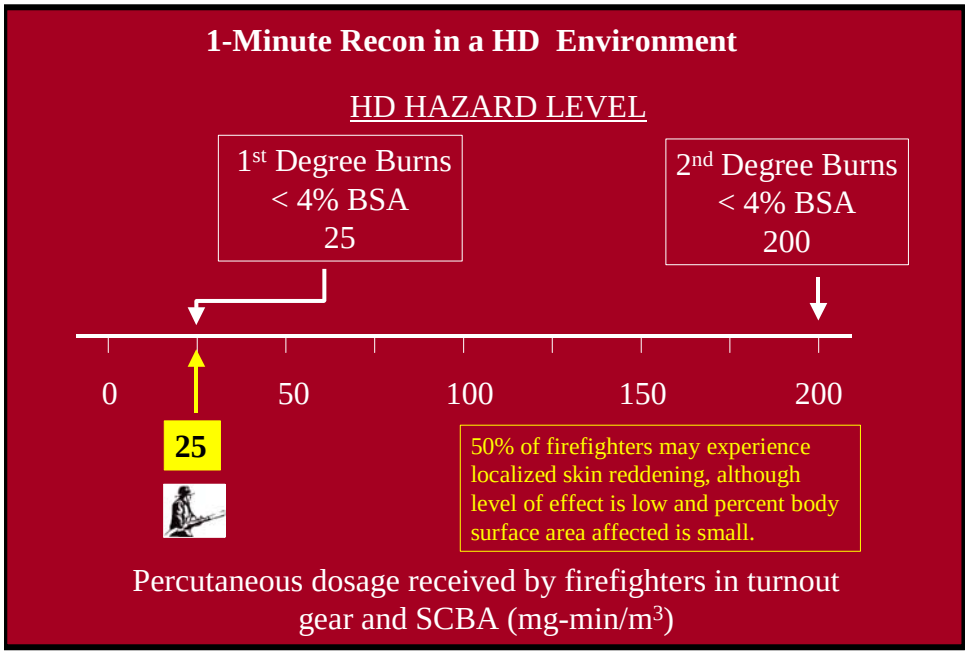


Figure 3. 1-Minute Recon Dosage for a HD Environment

Mustard agent acts locally at the site of absorption into the body, therefore agent effects occur at those areas that are more sensitive to the agent or less protected (ears, neck, armpits and groin). Even though local mustard agent effects can be expected in these sensitive areas based on short-term exposures, much longer-term exposures are not expected to result in lethal skin dosages unless firefighters continue to be exposed to high-vapor concentrations for several hours. Thus while local mustard effects may be produced from exposure during rapid rescue operations, the chance of receiving lethal dosages remains very small.

5.0 INCIDENT COMMANDER OPERATIONAL CONSIDERATIONS

An incident commander may need to decide the safety and feasibility of firefighters entering a potentially contaminated room or building to assist with rescue and evacuation of known live victims. The longer victims remain in a chemical agent environment the more susceptible they are to the effects of the agent. Similarly, the IC may need to decide on risking a reconnaissance to determine if viable live victims remain.

Based on the information provided in this report the following basic operational considerations can be made:

- The presence of living victims inside the potential hazard area provides the basic indicator for firefighters to assess the level of contamination for nerve agents.
- Rescue entry occurs after vapor concentration has peaked (assumed approximately ten minutes after the release of agent).

- Firefighters using complete standard turnout gear and SCBA to perform rescue of **KNOWN LIVE VICTIMS** can operate in a nerve agent vapor hazard for up to 30 minutes with minimal risks associated with nerve agent exposure.
- The risk associated with using turnout gear and SCBA in a nerve agent environment where agent concentrations are low enough to allow for living unprotected victims is that 50% of firefighters **POSSIBLY WILL** experience increased sweating and muscle weakness 1-18 hours after exposure.
- Firefighters entering an unknown environment **WITHOUT KNOWN LIVE VICTIMS** using standard turnout gear and SCBA should limit their potential exposure to three minutes.
- Firefighters searching an enclosed area for victims should immediately exit the area and undergo decontamination if they encounter evidence of chemical contamination and cannot identify any living victims.
- If firefighters encounter oily liquid contamination (puddles/drops) and victims report signs of mustard agent (i.e. garlic odor), firefighters and victims should immediately exit the area and undergo decontamination.

5.1 Rescue of Known Living Victims

The maximum exposure time for rescue of known living victims was determined by using the victim as a detector. If at least 2 percent (1 in 50) of the victims remain alive 10 minutes after the incident, a rescuer can assist that victim with little or no risk (threshold symptoms at worst) while wearing standard turnout gear with SCBA. Indeed, use of the human as a detector indicates the nerve agent vapor concentration is relatively low compared to the range of concentrations achievable.

5.2 Reconnaissance in an Unknown Environment

Firefighters entering an unknown nerve agent vapor environment (no known living victims) to search for living victims should assume worst-case conditions for both the agent and concentration. For this type of situation, standard turnout gear and SCBA was assessed using a vapor challenge concentration of 2000 mg/m^3 for GB, as specified in the NIOSH CBRN *Standard for Self Contained Breathing Respirators (SCBA) for Emergency Workers in Terrorist Attacks*.

5.3 On-Scene Vapor Detection

During an actual event, the uncertainty in making command decisions may be reduced by the use of an accurate and real-time chemical agent vapor detector. Unfortunately, few jurisdictions will have such capability on the first arriving apparatus to the scene. HAZMAT

teams performing initial vapor detection and agent identification should wear Level A PPE.

Any on-scene knowledge of the class, type, and/or concentration of the residual hazard will help the IC to better evaluate the operational hazards for firefighters on the scene.

5.4 Active Hazard Mitigation

Hazards can be mitigated by three general methods: reducing exposure time, reducing agent concentration, or improving equipment.

Reduce Exposure Time – Reduce exposure time by making an organized entry operation. The responder should enter rapidly with a purpose, necessary equipment, and sufficient back-up to accomplish the operation (i.e. reconnaissance to identify live victims) without delay. Recognize that, even after exiting the Hot Zone, turnout gear still holds contaminated vapor inside. The responder must undergo decontamination as soon as possible after exiting the Hot Zone into a contamination-free upwind area (cross-wind from victims), especially if the responder experiences onset of exposure symptoms.

Reduce Agent Concentration – Chemical agent vapor concentration can be reduced by several methods. Ventilation is one of the most dependable methods. For every room volume of air that is displaced, theoretically the agent vapor concentration is reduced by 63 percent if the air is well mixed. However, experience shows that air normally does not mix well due to barriers, room size, and other factors, so chemical agent vapor concentration may be reduced by a much lower factor, perhaps only 10 percent.

If the outside air is free of contamination, opening the fresh air inlet fully on the air handler can speed vapor concentration reduction rate. Many air handlers operate at 15 to 25 percent open; increasing the fresh air makeup to 100 percent can increase the rate of agent removal by up to a factor of 6.

Positive Pressure Ventilation (PPV) fans have been used in testing by SBCCOM to determine their utility in reducing residual vapor hazards. Data indicates that PPV is highly effective, and may reduce chemical agent vapor concentrations by between 40 and 75 percent within 10 minutes of emplacement and operation.

WARNING

PPV fans do not destroy chemical agent vapor. Rather, these fans move chemical agent vapor outside and downwind of the building or possibly to other interior rooms. Although these displaced vapors have lower concentration, they still may potentially cause additional victims. Before initiating ventilation, evacuate all areas that may be contaminated by displaced chemical vapors.

When using PPV or increasing makeup fresh air, use caution to minimize spreading contaminated air into uncontaminated areas of the facility. Given a choice of entrance paths, SBCCOM testing shows that responders should enter through a doorway where a PPV fan is blowing fresh air into the building.

For liquid chemical agent on a floor, spreading vermiculite and/or covering over the spill or droplets with firefighter foam can substantially reduce vapor hazard, based on results of vapor suppression tests conducted by SBCCOM. Vermiculite may also help to contain the spill. However, spills or droplets are not considered generators of high levels of agent in air.

WARNING

Minimizing rescuer exposure duration will minimize their potential hazard. However, a rescuer in standard turnout gear with SCBA is protected adequately for up to 30 minutes in a nerve agent environment with known live victims. Time delays before rescuing known live victims may increase the cumulative dosage a victim receives. Quick entry, quick rescue, and quick exit, while diligently avoiding any contact with residual liquid contamination, followed by immediate decontamination, will minimize the hazards to both victims and rescuers.

5.5 Operational Planning and Responder Training

Incorporating the information presented in this report into firefighter procedures and training will reduce the hazard to individual firefighters and may reduce suffering and death of affected victims. This report should instill confidence that quick and effective rescue of chemical terrorist victims may be accomplished without significant hazard to properly trained and equipped firefighters.

The decision to use standard turnout gear and SCBA to perform rescue operations in a chemical agent environment does not eliminate requirements for necessary training and the use of appropriate certified protective clothing and equipment to perform other operations where chemical agent exposure is possible. Specifically, this report cannot be used to justify the use of turnout gear and SCBA for any purpose other than lifesaving rescue operations. This report does not support the use of firefighter turnout gear and SCBA equipment for detection, monitoring, and mitigation operations in chemically hazardous situations.

See Appendix D for a generic approach to “sizing up” and performing rescue and reconnaissance operations after a chemical agent incident. This appendix is intended to provide a generic approach that any jurisdiction easily can tailor or modify to meet local policy, procedure, and training requirements within the constraints of available staff and any equipment limitations.

APPENDIX A

Summary of Man-In-Simulant Test (MIST) Trials

The maximum exposure times recommended in this report are based on an extensive series of tests conducted at the Edgewood Chemical Biological Center (ECBC), Aberdeen Proving Ground, MD. These tests provided raw data for modeling the Physiological Protective Dosage Factors (PPDF) used in this report. The PPDF is defined as the ratio of the dosage that affects a protected person divided by the dosage that similarly affects an unprotected person. Firefighters in turnout gear with properly fitted SCBA performed mock rescue operations for 30 minutes inside a chamber filled with a non-toxic chemical vapor that simulates the vapor properties of an actual chemical agent.

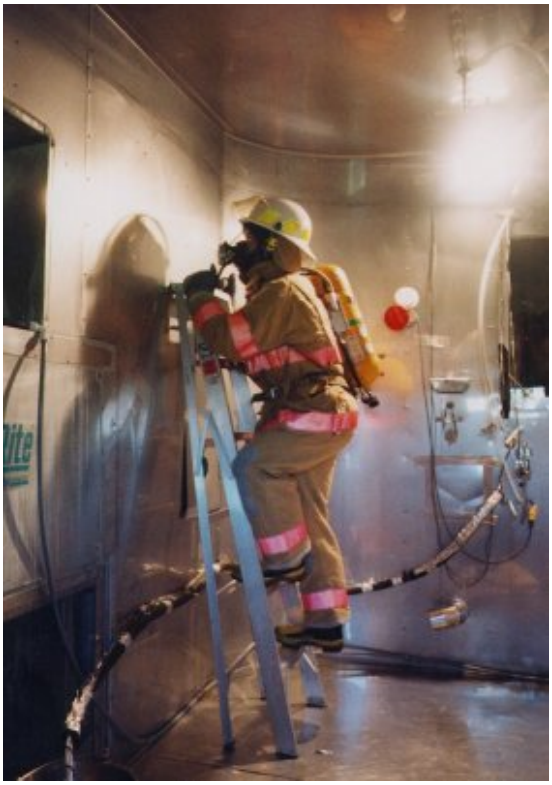
The full explanation of the FFPE MIST tests and test results are being incorporated into a technical report by ECBC. This report, when completed, will be available on the SBCCOM Homeland Defense Web site at http://www.ecbc.army.mil/hld/ip/reports.htm.

The tests, known as Man-In-Simulant Test (MIST) trials, measured how well FFPE protected 17 individual areas of the body compared to having no protection. The U.S. Army SBCCOM Domestic Preparedness Chemical Team, also sponsored MIST testing at the Royal Military College (Kingston, Ontario, Canada) that confirmed and independently validated the ECBC test results.

The MIST trials were conducted with volunteer career firefighters. For each test, special vapor samplers are placed on the skin of a test subject volunteer at 17 different locations. These samplers absorb chemical simulant vapor at the same rate that human skin absorbs chemical agent vapor. Then the test subjects don standard turnout gear with SCBA and enter a vapor chamber containing a measured concentration of simulant vapor and perform a specific series of activities that represent actions expected while rapidly rescuing an individual from a chemically contaminated environment. After 30 minutes, the test subjects leave the chamber and doff their protective clothing. The samplers are removed and analyzed to determine the amount of simulant vapor collected by each sampler. This indicates the amount of vapor exposure in the body region where each sampler was placed and provides evidence of the protection offered to each skin area by each tested configuration.

The MIST trial results then were used in modeling to determine, based on known physiological thresholds and effective dosages, the local and/or systemic potential effects of each of the chemical agents GB, GD, HD, and VX.

The photographs on the following page show one of the vapor samplers affixed to a firefighter prior to donning his protective ensemble and they show firefighters performing two of the activities inside the chamber.



APPENDIX B

Initial Incident Command (IC) Research Team

Charter, Membership, and Process

The U.S. Army Solider and Biological Chemical Command (SBCCOM), Aberdeen Proving Ground, Maryland conducts an Improved Response Program (IRP) to identify problems and develop solutions to the tasks faced by first responders in responding to nuclear, biological, and chemical terrorism incidents.

The IRP includes a broad cross-section of operations and technical experts from local, state, and federal agencies. Most experts in responder operations are volunteers from the Baltimore-Washington DC area, but other experts from across the nation also ensure that solutions are broad-based and adaptable by any jurisdiction. Team members generally are drawn from fire departments, emergency management offices, law enforcement agencies, and military test and evaluation agencies, but also include legal experts, medical doctors, computer modelers, operations researchers, and environmental scientists.

The IRP formed specific "research teams" to address issues that evolved from a series of tabletop exercises and workshops.

Incident Command (IC) Research Team

Once results from FFPE vapor testing were available, a team was formed with representation from technical and operational perspectives. The IC research team charter was to apply and present the ECBC MIST test results to be most useful to first responders. The team completed a survey, conducted interviews, and met as a group to ensure the format and content of any modeled results can be used easily at all levels of operation when responding to a chemical incident.

Area	Specialty	Organization
First Responder	Fire Department	Montgomery County (MD) Department of Fire and Rescue Services
		Baltimore County (MD) Fire Department
		Washington DC Fire Department
		Howard County (MD) Fire and Rescue Service
		Columbus (OH) Department of Fire and Rescue Services
		Baltimore City (MD) Fire Department
		Los Angeles (CA) Fire Department
		Aberdeen Proving Ground (MD) Fire Department
	Emergency Management	Baltimore County (MD)
Technical Reporting	Operations Research	U.S. Army SBCCOM
		Battelle Memorial Institute
	Modeling and Analysis	U.S. Army SBCCOM
		Optimetrics Incorporated
	Testing	U.S. Army SBCCOM

Table B1. Incident Command Research Team

APPENDIX C

Signs and Symptoms of Chemical Agent Exposure

Chemical Agents					
AGENT		SIGNS AND SYMPTOMS	DECONTAMINATION	PERSISTENCE	PHYSICAL STATE
Nerve Agents					
Tabun	GA	Salivation Lacrimation Urination Defecation Gastric disturbances Emesis	Remove contaminated clothing Flush with a soap and water solution for patients Flush with large amounts of a 5% bleach and water solution for objects	1-2 days if heavy concentration	Liquid
Sarin	GB			1-2 days will evaporate with water	Liquid
Soman	GD			Moderate, 1-2 days	Liquid
V Agents	VX			High, 1 week if heavy concentration. As volatile as motor oil	Liquid
Vesicants (Blister Agents)					
Sulfur Mustard	H	Acts first as a cell irritant, then as a cell poison. Conjunctivitis, reddened skin, blisters, nasal irritation, inflammation of throat and lungs.	Remove contaminated clothing Flush with soap and water solution for patients. Flush with large amounts of a 5% bleach and water solution for objects	Very high, days to weeks	Liquid
Distilled Mustard	HD				
Nitrogen Mustard	HN 1,3				
Mustargen	HN2			Moderate	Liquid
Lewisite	L	Immediate pain with blisters later.		Days, rapid hydrolysis with humidity	Liquid
Phosgene Oxime	CX	Immediate pain with blisters later – necrosis equivalent to second- and third-degree burns		Low, 2 hours in soil	Solid
Chemical Asphyxiants (Blood agents)					
Hydrogen Cyanide	AC	Cherry red skin or ~ 30% cyanosis. Patients may appear to be gasping for air. Seizures prior to death. Effect is similar to asphyxiation, but is more sudden.	Remove contaminated clothing. Flush with a soap and water solution for patients. Flush with large amounts of 5% bleach and water solution for objects.	Extremely volatile	Gas
Cyanogen Chloride	CK			Rapidly evaporates and disperses	Gas

Table C1. Chemical Agent Information

After exposure to chemical agents, victims may present one or more of the symptoms described by the mnemonic "SLUDGE." The table on the following page associates specific signs and symptoms with specific chemical agents.

Determining from signs and symptoms alone that a victim has been exposed to a chemical agent can be difficult for a first responder. In general, at least two signs or symptoms should be present to limit the risk of mistaking exposure to less toxic substances with exposure to chemical agents.

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APPENDIX D

Managing the Consequences of a Chemical Attack

A Systematic Approach to Rescue Operations

Modified with Permission from a Document of the Same Title[5]

The information below is intended to help first responders to a chemical agent attack develop an action plan to safely and effectively rescue live victims.

Chemical protective suits compliant with NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies* (with chemical-biological terrorism protection option) or the Class 1 requirements of NFPA 1994, *Standard on Protective Ensembles for Chemical/Biological Terrorism Incidents*, (Level A suits) represent the highest level of protection to emergency responders against both respiratory and skin hazards of exposure to chemical (and biological) warfare agents. However, if the number of live victims, which are exposed to and impaired by chemical agent(s) at an emergency scene, exceeds the availability of personnel in these suits to rescue in a timely manner, the Incident Commander must consider the use of other personal protective ensembles.

Turnout gear with Self-Contained Breathing Apparatus (SCBA) provides less protection than certified protective ensembles, but with operational restrictions discussed in this report, it will limit firefighter exposures to, or below, the levels that are expected to cause mild threshold chemical exposure symptoms.

Saving **live victims** is the rescue mission, while minimizing risk of harm to the rescuers.

Note: First responders must gather information about the incident based on:

- Signs and symptoms of casualties
- Comments from casualties and onlookers
- Previous responder reconnaissance or detector readings
- Information available through intelligence provided by law enforcement officers
- Site specific information
- Current and forecast weather conditions

Note: First responders should not assume an incident involves a highly toxic chemical agent. The released material could be a less toxic industrial chemical or a riot control agent such as pepper spray.

[5] Montgomery County Fire and Rescue Service (MCFRS), Montgomery County, Maryland, December 1998 © MCFRS, Prepared by Deputy Chief Ted Jarboe, District Chief Robert Stephan, and Captain Jack Crowley with technical review by Roger McIntosh, M.D.

Key Factors and Steps to Help Decide Whether Rescue is a "Go" or a "No Go" Situation:

Weather Conditions: Consider the impact of wind direction and speed, temperature and humidity, and precipitation on the behavior and spread of the chemical agent(s) and on emergency operations. Use on-scene weather monitoring equipment if available.

Scene Hazard Assessment: Avoid "tunnel vision." Don't just assume chemical-related hazards. Also consider the possible presence of biological agents, radiological materials, and/or explosive devices.

Reconnaissance (Recon): Conduct Recon using the following steps to determine if live victims are still in the area of the chemical agent release:

1) **Preliminary Assessment** – If available, view the contaminated area through a closed window or an entrance doorway (or other upwind location) to gather victim information. Before entering the building, the Recon team must don at least turnout gear with SCBA. If:

- you observe living victims with nerve agent exposure symptoms
- victims have been exposed for 10 minutes or more
- mustard (HD) is not suspected, and
- the room the victims occupy is directly accessible without having to transit antechambers, stairwells, or other adjacent rooms

then the Recon mission is over, and the Incident Commander can consider immediately starting the rescue mission (no longer than 30 minutes exposure for each responder) for live victims.

2) **Search -** If no living victims are visible from outside the building, the Incident Commander should assume a high concentration of chemical agent likely is present. However, the Incident Commander may consider a rapid reconnaissance by entering the building for no more than 3 minutes to look for living victims, realizing that the resulting potential exposures to chemical agents possibly will result in threshold physiological symptoms of chemical agent exposure among responders.

3) **Rescue in Conjunction with Recon -** During a quick reconnaissance inside the contaminated building, if:

- you observe living victims with nerve agent exposure symptoms
- victims have been exposed for 10 minutes or more, and
- mustard (HD) is not suspected

then the Incident Commander can assume nerve agent concentration is low and perform rescue for up to 30 minutes (see Rescue Team Exposure Time below).

Warning: Avoid transit of antechambers, stairwells, or adjacent rooms when evacuating victims discovered during Recon. These areas may have vapor, aerosol, or liquid chemical agent contamination that could further injure the victim or contribute to the rescuer's dosage.

Warning: Take special care to avoid contaminating footwear and clothing with liquid chemical agent. Skin contact with liquid chemical agent dosage may be lethal. Liquid contamination is very easy to spread. Spread liquid contamination will "offgas" highly toxic vapors and continues as a skin contact hazard.

4) **Without Rescue in Conjunction with Recon** - If no living victims are seen, then leave the building immediately, seal and secure the building, and wait for the arrival of HAZMAT responders, who are appropriately equipped with CBRN-certified protective ensembles (Level A suits).

Victim Information:

Location: Are casualties visible near an entrance? Are they in the line-of-sight? Can they be heard? Estimate how long it would take to reach and remove them.

Number: If there are enough HAZMAT responders equipped with CBRN-certified protective ensembles (Level A suits) available to rescue live victims in a timely manner, use them. Otherwise, consider using personnel who are wearing alternative ensembles (i.e. turnout gear with SCBA), as approved by the Incident Commander.

Condition: Are casualties ambulatory or non-ambulatory? Signs and symptoms? Traumatic injuries? Entanglement? Mental state?

Rescue and Standby Teams: Select at least two personnel per team with appropriate personal protection. Ensure they are hydrated.

Chemical Agent Hazard Reduction: Consider use of positive pressure ventilation (PPV) fans or other fans to reduce or redirect vapor or aerosol concentration. Be sure that use of these fans will not spread chemical agent to endanger other people. If fans are acceptable, they should be placed in service while rescuers are donning their protective ensemble.

Review Information about Chemical Warfare Agents (CWA): The higher the vapor pressure of a CWA, the higher its rate of evaporation (volatility). Temperature and humidity can affect CWA properties and exposure risk.

SCBA (positive pressure): SCBA must be used for all rescue missions. SCBA should be certified under the NIOSH CBRN SCBA standard for use in a chemical agent environment.

Personal Protective Ensemble (PPE): Rescue personnel must wear **as a minimum** standard complete turnout gear with SCBA. This ensemble must consist of a protective garments, helmets, hoods, gloves, and footwear that has been certified to NFPA 1971, Standard on Protective Ensemble for Structural Fire Fighting, that has been properly maintained and is free from damage and self-contained breathing apparatus (SCBA) that is certified to NFPA 1981, Standard on Open-Circuit, Self-Contained Breathing Apparatus.

Rescue Team Exposure Time: Limit the initial exposure time to no more than 30 minutes. In all cases, on-scene exposure times must be minimized, wherever possible. No entry team will re-enter the contaminated area unless authorized and extreme circumstances clearly warrant doing

so. Based on chemical warfare agent(s) released, the quantity, its properties, the circumstances surrounding its release, vapor suppression measures used, and any symptoms displayed by rescuers, the Incident Commander may allow rescue personnel to operate in the contaminated area for a longer period.

Warning: Because concentrations of the chemical agent released in a building could result in different concentrations in the rooms and corridors, victims should be removed through doors or windows that lead directly to the outside. If this is not possible, the rescuers should consider the use of escape masks or chemical masks by victims who must leave through other rooms and corridors to reach the outside.

Warning: Face Piece Removal. After exiting the rescue area, rescuers must continue using their SCBA until their decontamination is complete to prevent respiratory harm from "off-gassing" of chemical agent from the protective clothing. If possible, remove the regulator and face piece last (after protective clothing).

Emergency Decontamination: Unless delay would compromise rescue, set up the decontamination area before entry is made, locate setup upwind and as close as practicable, and monitor operations. Rescuers must be decontaminated immediately and before they remove their regulator and face piece (to avoid breathing any vapors possibly trapped in their protective clothing) or any of their protective clothing. If possible, remove regulator and face piece last. Use chemical agent monitors.

Medical Monitoring: Check vital signs and ECG. Check again for chemical agent signs and symptoms.

Rehabilitation (REHAB): Provide rest and re-hydration. Re-check vital signs as necessary.

Remember this document is a guide. Existing conditions, knowledge of the chemical agents, good judgment, combined with available personnel and personal protective equipment, will greatly influence what level of protection is used by rescuers. The safety of both the rescuers and victims is of paramount concern. **When CBRN-certified protective ensembles (Level A suits) are not available, the mission of protected rescuers is to rescue live victims, nothing more.**

APPENDIX E

Acronyms

CBRN	Chemical, Biological, Radiological, and Nuclear
CWA	Chemical Warfare Agents
DoD	Department of Defense
ECBC	Edgewood Chemical Biological Center
EMS	Emergency Medical Service
FFPE	Firefighter Protective Ensemble
HAZMAT	Hazardous Materials
HVAC	Heating, Ventilation, and Air Conditioning
IC	Incident Commander
IRP	Improved Response Program
MSC	Maximum Survivable Concentration
MIST	Man-In-Simulant Test
NIOSH	National Institute for Occupational Safety and Health
NRC	National Research Council
OSHA	Occupational Safety and Health Administration
PBI	Polybenzimidizole
PPDF	Physiological Protective Dosage Factor
PPE	Personal Protective Equipment
PPV	Positive Pressure Ventilation
SBCCOM	Soldier and Biological Chemical Command
SCBA	Self-Contained Breathing Apparatus

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