

HazMat Emergencies

Decontamination & Victim Chain of Survival

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Consider the following hypothetical scenarios of workplace emergency decontamination incidents involving hazardous materials:

IN BRIEF

- **HazMat emergencies represent a significant response challenge, especially when employees are exposed and the response involves a victim.**
- **A growing body of literature and standards guides emergency medical services (EMS) and hospital professionals in HazMat victim response and treatment. But, the SH&E professional must navigate separate standards: HazWOPER for HazMat emergencies and standard first aid for HazMat victim response.**
- **What strengths each standard may have in isolation are lacking when coupled with each other or as explicit preparation for the more advanced response that follows when EMS arrives.**
- **The authors review these standards and integrate several key concepts for effective response to HazMat victim emergencies in the workplace to make the most of the critical time between employee exposure and EMS arrival.**

A pressurized hose recirculating potassium gold cyanide into a clean room electroplating bath breaks loose from the clamps holding it against the bath wall. The hose whips around and sprays the corrosive liquid onto a nearby employee. She hits the emergency "off" button, and as the chaos quiets, she and her coworkers realize she is standing in a puddle of plating solution, with the liquid dripping from her clean-room clothing. Her first impulse is to go change her clothes in the locker room, but her supervisor orders her to an enclosed emergency shower stall with a drain. She walks from the puddle to the shower, trailing a path of wet footprints.

At another company, an employee loses his hold of a heavy product and

drops it into an acid etching tank. The full-front apron, gloves, face shield and goggles protect him from the splashing acid. But, his coworker who has his back turned feels the acid splash on his back, buttocks and legs at the gaps between his apron ties. He pulls the handle of the emergency shower, an open unit against the wall, and removes his clothing as acid and rinse water cascade across the floor.

Workplace HazMat emergency response is well-defined in standards and regulations such as HazWOPER, and workplace medical emergency response is equally well-defined in practices such as first aid. However, combining the two is complicated because the urgency of first-aid response tends to collide with the systematic and planned sequences of HazWOPER. This article addresses issues around HazMat emergencies with employee exposure, and focuses on safe and effective emergency decontamination of HazMat victims in occupational settings such as manufacturing, warehousing and laboratories (see "Maximizing HazMat Victim Care").

The authors have excluded transportation emergencies, nonoccupational exposures, and criminal, combat or terrorism events due to the broad nature of these subjects and their integration with issues such as traffic control, security and tactical operations. Transportation involves potential exposure to the nonoccupational general public, and in the case of highway incidents, the absence of readily available emergency decontamination facilities.

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ties such as emergency showers. Additionally, law enforcement, military or other potential mass casualty emergencies, such as terrorist attacks with chemical weapons, involve even more issues, such as significant public exposure, potentially long periods with unidentified contaminants and ongoing tactical threats (e.g., active shooter and secondary explosives timed for arrival of emergency responders).

Magnitude of Problem

Agency for Toxic Substances and Disease Registry (ATSDR, 2009) surveyed data from 13 states in the first half of 2009, cataloging 3,458 HazMat emergencies. These emergencies involved 1,050 victims, of whom 44 died. Of these emergencies, 68% were in fixed facilities, with manufacturing representing the highest number (27%). Of the victims, 91% were in fixed facilities, with employees representing the highest number of victims (44%).

In the second half of 2009, six states reported 1,352 HazMat emergencies with 319 victims and 8 fatalities. Like the first half of the year, fixed facilities and manufacturing represented the highest (99% and 27%, respectively). These fixed facilities again reported the highest number of victims (83%), with employees representing 10% (ATSDR, 2009).

HazMat Victim Decontamination

Decontamination practices have evolved since the NFPA 472 standard was created and replaced NFPA 471, which spent much of its decontamination section on standardized procedures for controlled entry and exit through an established corridor linking the operational areas of the hot zone (e.g., exclusion or contamination area), warm zone (e.g., transition or contamination reduction area) and cold zone (e.g., support or clean area). Although this separation of operational areas is ideal in principal, NFPA 472 acknowledges the more realistic potential for chaos as emergency responders arrive, with five categories of decontamination.

1) Emergency decontamination. "The physical process of im-

mediately reducing contamination of individuals in potentially life-threatening situations with or without the formal establishment of a decontamination corridor" (NFPA, 2008b). This is what workplace emergency responders perform when they assist an employee in an emergency shower until emergency medical service (EMS) personnel arrive, and it is the primary focus of this article.

2) Gross decontamination. This may be an initial part of emergency decontamination of victims, or the first step in technical decontamination of responders exiting the hot zone through a supervised decontamination corridor. In both cases, as high a percentage as feasible of contamination is rinsed off prior to further decontamination.

3) Mass decontamination. "The physical process of reducing or removing surface contaminants from large numbers of victims in potentially life-threatening situations in the fastest time possible" (NFPA, 2008b). This may be an emergency decontamination or a gross decontamination, and simply describes the fact that more than one person undergoes decontamination. Although typically performed by EMS personnel, the authors are aware of two separate workplace incidents with two exposed employees each, forcing them to each walk to separate emergency showers; in one incident,

Maximizing HazMat Victim Care

Transitioning From Workplace Emergency Responders to Emergency Medical Services

SH&E professionals can do much to establish safe and effective HazMat victim response and strong links in the response chain between workplace responders and emergency medical services (EMS). Prevention remains the best strategy, and design for safety and training for safe operation is paramount, but a solid emergency response program should at a minimum include the following:

•**Hardware.** Functioning and appropriately located emergency eyewash and shower systems, PPE for employees and workplace responders, first-aid supplies and response supplies such as absorbents on reserve and dedicated for emergency-only use. All hardware must be inspected regularly, maintained and tested periodically.

•**Information.** Safety data sheets and a site-specific emergency response plan at a minimum, ideally including HazMat-specific procedures for highly hazardous materials such as hydrofluoric acid that require rapid response.

•**Internal communications.** HazMat victims must be able to summon assistance and workplace responders must be able to gather team members. Depending on operation size and complexity, internal communications can be as simple as verbally shouting across the room, using handheld radios or public address systems, or emergency shower flow alarms con-

nected to central alarm systems with security personnel on staff able to monitor and notify workplace responders.

•**External communications.** Typically 9-1-1 in the U.S. If site telephones require dialing a special number for an outside line, then this must be included in employee training. Caller identification may or may not be present at the 9-1-1 call center, and the physical address must be either known by employees or posted in visible locations in the workplace so that it can be communicated to the dispatcher.

•**Coordinating with EMS upon arrival.** Workplace emergency responders must greet EMS upon arrival, direct them to the specific location of the emergency and rapidly provide accurate information about the emergency. Emergency locations may be far removed from typical entry points such as front gates, front doors or shipping bays. Additionally, fire and ambulance services may arrive separately, and the greet-direct-communicate sequence may need to be repeated.

•**Training.** Workplace emergency responders must know these procedures, the proper use of their resources and effective communication to EMS during an emergency. Workplace emergency responders must also understand the role of EMS and how workplace responders and EMS can best work together on site.

Table 1

HazMat Emergency & Victim Decontamination Responsibilities

Personnel	Role	Expected levels of contamination
Workplace emergency responders	Initial response; notify EMS; emergency decontamination	High, both scene and victim(s)
Emergency medical services (EMS) personnel	Arrive at scene; assume control of response; emergency, mass, gross and/or technical decontamination; emergency medical treatment; transport victim(s)	High, transitioning to as low as possible for victim(s)
Hospital personnel	Receive victim(s); definitive decontamination and treatment	Low, with exception of self-transported "walking wounded"; emergency and technical decontamination capabilities but preference for receipt of decontaminated victim(s)

the spill size in the facility was doubled with drops and wet footprints from the emergency scene to the two showers.

4) Technical decontamination. This may describe either the controlled decontamination of responders leaving through the decontamination corridor (NFPA, 2008a), or thorough decontamination of HazMat victims for emergency medical treatment on site and/or prior to releasing for transportation and further treatment (NFPA, 2008b). Technical decontamination of HazMat victims typically involves significantly more surface rinsing than occurs in a workplace emergency shower, and may involve use of brushes, cleaning agents

such as soaps and detergents, and, depending on the protocols of the responding agency, irrigation and/or suction of nasal and oral cavities as needed. The transition from emergency decontamination of HazMat victims by workplace emergency responders to technical decontamination by EMS personnel is discussed in more detail.

5) Definitive decontamination. This is performed in the hospital as part of treatment, and it is outside the scope of this article, as well as outside the scope of NFPA 472 and NFPA 473.

Table 1 summarizes typical roles, responsibilities and expectations for each level of decontamination from workplace emergency responders to EMS personnel and, finally, to hospital personnel.

HazMat Victim Care

The following sections describe HazMat victim care in reverse chronological order to provide context for the final section on emergency decontamination by workplace emergency responders. The authors believe that workplace emergency responders perform better if they understand the expectations and actions of the higher-level responders with whom they will interact.

Hospital

Definitive treatment varies with the severity of exposure, the hazard of the substance, positive identification of the substance and the treating physician's diagnosis. Whether simple observation and evaluation, or more advanced decontamination and treatment, it will most likely occur in the hospital (Curran, Clements & Bronstien, 2007). EMS operating under written pre-standing orders and medical direction typically include

Table 2

Summary of NFPA 473 Patient Priority Levels^a

Contamination level	Medically critical	Medically unstable	Medically stable
Heavy contamination; highly toxic substance	Combined priorities	Decontaminate first	Decontaminate first
Heavy contamination; low-toxicity substance	Medical care first	Combined priorities	Combined priorities
Low contamination; highly toxic substance	Combined priorities	Decontaminate first	Decontaminate first
Low contamination; low-toxicity substance	Medical care first	Medical care first	Combined priorities

Note. ^aSummary of NFPA 473 patient priority levels for immediate decontamination, immediate medical care or combined priorities. Medically critical is defined as compromised airway, serious shock, cardiac arrest and/or life-threatening trauma or burns. Medically unstable is defined as shortness of breath, unstable vital signs, altered levels of consciousness and/or significant trauma or burns. Medically stable is defined as stable vital signs, no altered level of consciousness and/or no significant trauma or burns. Adapted from Table A.5.4.2, NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents*, by NFPA, 2008, Quincy, MA: NFPA.

Table 3

Transition Issues Between Workplace Emergency Responders & EMS

Barriers	Solutions
Competency of workplace emergency responders	Effective training
Understanding by workplace emergency responders of EMS procedures	Effective training, emergency preplanning meetings with EMS, joint exercises with EMS
EMS familiarity of site and trust in workplace emergency responder competency	Site tours, emergency preplanning with site representatives, joint exercises with workplace emergency responders, workplace emergency responders provide site emergency response procedures and other information (e.g., floor plans, SDS, etc.) to EMS upon arrival
Delayed or incomplete scene size-up by EMS upon arrival	Workplace emergency responders mark safe vs. hazardous areas prior to EMS arrival
Delayed or incomplete first impression by EMS of HAZMAT victim upon arrival	Workplace emergency responders have critical information ready for transfer to EMS prior to EMS arrival (e.g., incident summary, SDS, time HazMat victim in emergency shower, etc.)

physician review of victims as a standard conclusion in their protocols for HazMat exposures. It is rare for a HazMat victim emergency to end with EMS personnel not transporting the victim for further evaluation and care.

One critical issue for the hospital is secondary contamination, which occurs when hospital personnel, other patients and property are exposed to hazard-

ous materials due to improper decontamination of victims transported to the facility. Where EMS personnel are designated as first *responders* with high levels of HazMat response training, hospital personnel are typically designated as first *receivers*, potentially with less training in emergency decontamination, due to the assumption that EMS personnel will perform proper decontamination prior to transportation (OSHA, 2005; 2008b).

Strong communication between EMS and hospital personnel, as well as good technical decontamination practices in the field, can prevent secondary contamination (Horton, Berkowitz & Kaye, 2003). NFPA 473 strongly emphasizes HazMat victim decontamination as soon as possible and certainly prior to transportation: "It is unwise to accept a contaminated patient into a transport unit or to be unsure of the level of decontamination performed. A poor decision in the field can have significant ramifications at the door of the hospital" (Trebisacci, 2008, p. 485).

Emergency Medical Services

Horrible case studies of ambulance contamination following a fatal exposure to hydrofluoric acid and an emergency department shutdown following the arrival of a pesticide-contaminated patient illustrate the reasons why healthcare professionals emphasize early and thorough victim decontamination (Vogt & Sorensen, 2002). Contamination to personnel and hardware is a real threat to everyone in the emergency response chain; this threat is key to EMS personnel balancing responder safety and victim care.

NFPA 472 and 473, as well as other sources, give priority to EMS personnel safety (NAEMT & American College of Surgeons Committee on Trauma, 2007; OSHA, 2009). EMS personnel perform an initial scene size-up on arrival for their own safety and to prevent increasing the magnitude of the emergency by having responders become additional victims. The actions and communications of workplace emergency responders before and during EMS arrival can either facilitate a smooth transition or cause delays as EMS personnel review the scene for their own protection.



Photo 1: Mass decontamination. EMS responders have erected an inflatable mass decontamination tent to process victims through two separate corridors, one for male and one for female victims, who will place their clothing and personal belongings in plastic bags for tracking and further testing.



Photo 2: Technical decontamination of EMS responder. EMS responders render their PPE safe by systematically rinsing, washing and re-rinsing with soap and water in the warm zone of a decontamination corridor.

Table 4

Standards Related to HazMat Emergencies & HazMat Victim Response

Standard	Target audience	Summary
Hazard Communication OSHA 1910.1200	All workplace employees	Basic training requirements on safe use as well as emergency response to hazardous materials in the workplace
Emergency Action Plan OSHA 1910.38	All workplace employees	Basic emergency requirements (e.g., notification, evacuation)
Medical and First Aid OSHA 1910.151	Workplace emergency responders	Requirements for first-aid supplies, first-aid training and emergency eyewash/showers (see also ASTM 2009 and ANSI 2009)
Hazardous Waste Operations and Emergency Response OSHA 1910.120	Workplace emergency responders	Detailed requirements for HazMat emergency response, including long-term cleanup of contaminated sites
Contingency Plan and Emergency Procedures EPA 265 Subpart D	Workplace emergency responders	Detailed requirements specific to hazardous waste, including documentation of plans and advanced communications with local authorities (e.g., fire, EMS)
NFPA 471		Withdrawn (see NFPA 472 and NFPA 473)
NFPA 472	Workplace and public emergency responders	Competencies for HazMat emergency responders
NFPA 473	Emergency medical service (EMS) personnel	Competencies for EMS personnel responding to HazMat incidents, with emphasis on HazMat victim care at emergency site and during transportation to hospital

The authors have witnessed EMS personnel refuse to enter HazMat emergency scenes because they were not confident about the accuracy of information from workplace emergency responders, resulting in delayed medical care to HazMat victims.

Once confident that they can safely respond, EMS personnel will assume control of the scene for entry and response, including victim care. For HazMat victim emergencies, Table 2 (p. 42) summarizes the priorities for immediate decontamination, immediate medical care or combined priorities.

Workplace emergency responders can either facilitate or delay EMS response. The authors believe that early attention to proper emergency

decontamination and accurate information will permit EMS personnel to more quickly begin medical care for victims. Additionally, preplanning, including tours and training drills, between site and EMS representatives can improve EMS knowledge of the site, its hazards and the capabilities of the workplace responders. This builds working relationships, and improves communications and efficiency during the critical transition between workplace responder and EMS control of emergency operations (Table 3, p. 43).

Workplace Emergency Response

The HazWOPER standard is the cornerstone of most workplace HazMat emergency response plans (OSHA, 2008a). The advanced planning and education of employees required by this standard contributes to emergency prevention and response, and it is the knowledge of facility employees who work with hazardous materials that can help prevent secondary contamination in the EMS and hospital systems (Berkowitz, Horton & Kaye, 2004). While the HazWOPER standard thoroughly covers HazMat scene safety and directs attention to issues such as spill response and recovery, its coverage of emergency decontamination and HazMat victim care is limited, even though the standard contains provisions that require planning for medical monitoring and first aid.

Where HazWOPER lacks specifics on emergency decontamination and HazMat victim care, standard first aid and other emergency decontamination references provide few details on these subjects and typically exclude reference to site control and the wider response. First-aid training courses

Photo 3: Technical decontamination of victim (training exercise with manikin). EMS responders have removed and contained the victim's clothing and jewelry to significantly reduce external contamination. Next, EMS responders will systematically rinse, wash and re-rinse both the front and back side of a victim before preparing him/her for ambulance transport to the appropriate receiving hospital.



Photo 4: Definitive decontamination of victim (training exercise with manikin). Hospital first receivers in Level C PPE provide definitive decontamination of a HazMat victim before admission into the facility to avoid secondary contamination of hospital personnel, other patients and equipment.



emphasize emergency decontamination as the primary action for HazMat exposure: remove the contaminants from the victim as soon as possible (Markenson, Ferguson, Chameides, et al., 2010; Koenig, 2003).

Many SH&E professionals are familiar with boilerplate language in the typical safety data sheet, advising 15-minute eye and skin flushing and medical care if employees are exposed. Although general in their language, the authors agree with the references and standards for workplace first aid and emergency eyewash and shower equipment that recommend site- and substance-specific emergency training for employees, hazard-specific procedures and hazard-specific response hardware (ANSI, 2009; ASTM, 2009; OSHA, 2006). Table 4 summarizes relationships among these various standards related to HazMat emergencies and victim response.

Cardiac Chain of Survival

While individually strong, numerous HazMat emergency and HazMat victim response sources are either silent or only provide hints about how they can work together. The cardiac chain of survival provides a comparison for cardiac emergencies; it is explicit on the connection between victim care and the wider response (Travers, Rea, Bobrow, et al., 2010).

- 1) early notification to EMS;
- 2) early CPR;
- 3) early defibrillation;
- 4) early advanced emergency medical care.

HazMat Victim Chain of Survival

If the workplace emergency and victim response standards suffer in isolation, then a HazMat victim chain of survival, similar to the established cardiac chain of survival, provides a conceptual framework for bridging these critical emergency response steps:

- 1) Early notification to EMS: Every second delayed before calling EMS (e.g., 9-1-1 in most U.S. locations) results in delayed dispatch and arrival. As with cardiac and other medical emergencies, workplace responders to HazMat victim emergencies can fall into tunnel vision performing immediate response activities. Early notification allows site responders to get EMS en route before proceeding to more complicated tasks such as establishing hot, warm and cold operational zones.
- 2) Early emergency decontamination: Every delayed second starting emergency decontamination allows hazardous materials to injure exposed employees by burning, absorption or inhalation. The span between these first and second steps should be as short as possible, and preferably done simultaneously by multiple employees and/or workplace emergency response team members.
- 3) Early scene control and HazMat characteriza-

Figure 1

Emergency Decontamination Performance Support Tool for Site Emergency Responders

Location address:	1234 Street, City, State	
Location phone number:	(555) 555-5555	
Department/Area:	Metal Finishing	
Primary entry/EMS arrival location:	Shipping/receiving	
Name(s) of exposed employee(s):		
Name(s) of exposed chemical(s):		
Time employee(s) in emergency shower/eyewash:		
	Name	Time
9-1-1 notified:		
Site emergency responders notified:		
Spill scene identified/marked:		
SDS printed/pulled for EMS:		
Emergency responder(s) to primary entry for EMS:		

tion: Uncontrolled scenes can permit unauthorized entry and potential exposure to other employees. Gaps in information or communication lapses can delay immediately required response actions such as topical application of calcium gluconate for hydrofluoric acid exposure, topical application of polyethylene glycol for phenol exposure, administration of hydrogen cyanide antidote or other applicable treatments.

4) Accurate communication to EMS: Gaps in information, if unresolved on EMS arrival, can cause further delays in technical decontamination, medical stabilization, ambulance transportation, definitive decontamination and treatment.

Like the cardiac chain of survival, the HazMat victim chain of survival is relatively simple, facilitating training and retention for workplace emergency responders. The concepts easily work their way into a performance support tool (Figure 1), which can be added to site emergency response hardware (e.g., spill equipment storage units, first-aid kits) mounted at walls near emergency eyewash and shower equipment.

Conclusion

Consider this concluding example:

A nonroutine task with inadequate energy isolation results in a pressurized chemical pipe spraying liquid onto an employee. He screams and staggers into an emergency shower as others close the valve. His colleagues refer to a checklist posted outside the shower, begin to page site emergency responders and call 9-1-1. The supervisor directs one employee to print the safety data sheet, another employee to mark the floor contamination with traffic cones and caution tape, and another employee to go to the primary entrance to direct EMS personnel to the emergency scene. The supervisor and other employees tell the victim to stay in the shower and that EMS is on the way.

When EMS personnel arrive, they drive to the employee waving at the primary entrance. Inside, the supervisor briefs EMS personnel on the emergency and the hazardous material involved, points out the marked spill zone and hands them the safety data sheet. Aware of the hazards, the hazardous area and the amount of time the victim has been in the shower, EMS personnel begin their response in an environment of rapid emergency decontamination and clearly communicated information promoting responder safety and prompt victim care.

Workplace emergency responders who complete such a performance support tool, have all the elements in place for rapid notification to internal and external responders, rapid emergency decontamination of HazMat victims and accurate information to arriving EMS personnel who can proceed to victim care with fewer delays for self-protective scene evaluation. **PS**

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