

# Protecting First Responders

*Analysis of PPE guidelines distributed  
at the World Trade Center and Pentagon disaster sites*

**By William A. Groves, Raja V. Ramani, Mark C. Radomsky and Joseph P. Flick**

**E**NHANCING THE SAFETY AND HEALTH of emergency responders requires a post-response evaluation of the adequacy of equipment and procedures so that problems can be identified and corrected for future responses. This process is particularly important in the aftermath of the World Trade Center (WTC) and Pentagon attacks given the unprecedented nature of the emergency response—characterized by the large scale of operations, long duration and complex range of hazards present at these sites (Jackson, et al 19). These characteristics expanded the role of emergency responders to include nonroutine activities, which resulted in exposure to hazards that they may not have been properly trained or equipped to address. In fact, a recurring theme in many discussions and articles since those attacks involves problems with PPE, including unavailability of equipment, inadequate training, incompatibilities among different manufacturer's equipment and performance problems under the extreme conditions of the disaster sites (Jackson, et al 21).

Although generally accorded the lowest priority among recognized methods of hazard control (Plog 546), PPE plays an essential role in ensuring the safety and health of emergency responders. PPE selection and use must account for at least three important limitations:

1) As the hazard against which the PPE affords protection still exists, improper selection and use itself constitutes a potentially significant hazard to responder safety and health.

2) Whether a PPE ensemble is sufficient protection in an emergency depends on a good understanding of the emergency environment and emerging hazards. The potential for exposure to a complex range of hazards, including physical, chemical, biological and radiological agents, makes selecting an ensemble difficult since emergency responders often have limited information regarding the hazards present.

3) The PPE ensemble itself can introduce new hazards. For example, respiratory protection may interfere with the ability to communicate.

Inappropriate, improperly worn or poorly maintained PPE may not fully protect an emergency responder and may give the user a false sense of security. Therefore, regulations, standards and guidelines pertaining to PPE selection, use, maintenance and storage must be followed closely to ensure that adequate protection is achieved. Sources for this information include OSHA, NIOSH, American National Standards Institute (ANSI), National Fire Protection Assn. (NFPA) and PPE manufacturers.

Like many of the federal, state and local government agencies and organizations involved in the response to the Sept. 11, 2001, events, NIOSH initiated

projects intended to facilitate a review of emergency response procedures and equipment to identify potential areas for improvement. The agency has sponsored several conferences facilitated by the Rand Science and Technology Policy Institute to bring together individuals directly involved with these emergency responses in order to discuss ways to improve existing response plans in preparation for future events. These efforts led to the development of key documents summarizing lessons learned from the WTC and Pentagon responses (Jackson, et al; La-Tourette, et al). NIOSH also sponsored a project to compile a collection of PPE guidelines distributed to emergency responders at those sites. That study is described and summarized here (Ramani, et al).

## **Project Methods**

The goal of this project was to collect, categorize and com-

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(Top): An OSHA team discusses air sampling procedures at the World Trade Center site.

(Bottom): An iron worker cuts up pieces of twisted steel for removal from the World Trade Center site.

pile PPE guidelines that were distributed or intended to be distributed at the WTC and Pentagon sites immediately following the terrorist attacks. The purpose of this undertaking was threefold: 1) to document the procedures and guidelines that were provided to emergency responders; 2) to prepare a compilation of guidelines that could serve as a reference document; and 3) to

help identify shortcomings in the materials and information so that improvements can be made.

Early on, it became necessary to define who would be considered emergency responders, and at what point in time the WTC and Pentagon rescue operations became predominantly a recovery effort (i.e., a more sustained effort). Clearly, emergency medical services personnel, law enforcement personnel and firefighters constitute first responders. However, several other support groups and personnel (e.g., public health services, and local, state and federal agencies) also responded.

Defining the timeframe for rescue and recovery phases is problematic. The role of emergency responders changed over time—instead of serving only as emergency responders, these personnel often performed some aspects of recovery work. During this time, personnel from other disciplines (e.g., sanitation and construction workers) entered the sites to perform rescue and recovery work. The changing nature of the hazards with the spatial and temporal aspects of the working environment would affect types of PPE worn by personnel.

Therefore, it was decided that all potential sources for guidelines (e.g., public, private, companies, individuals) would be contacted and asked to provide PPE guidelines that were distributed or intended to be distributed to workers at the two sites at any time over the course of the operations. Information provided by these stakeholders was considered relevant to the study's goal of developing useful information for all emergency responder groups in the future, regardless of the actual time of the distribution.

#### Stakeholder Information

A letter was drafted describing the project's purpose and scope, and requesting that copies of PPE guidelines be provided including any written, electronic (e.g., CD-ROM), or web-based materials distributed or intended to be distributed at the disaster sites. Stakeholders were also asked to estimate the approximate date(s) of distribution and the target audience. This letter was sent to 192 individuals identified by NIOSH representatives and investigators as being likely to have played a relevant role in the dis-

tribution and/or use of PPE at these sites. These contacts represented a broad range of federal, state and local government agencies, as well as PPE manufacturers (a complete listing of all contacts is found in the final report submitted to NIOSH) (Ramani, et al 87).

Responses were received from 25 of those contacted (13 percent). Of these, 10 provided materials such as memos, faxes, pamphlets, documents, manuals, laminated cards, downloadable pages, CD-ROMs and material contained in other electronic formats (e.g., PDF files). A total of 58 separately titled documents were received. In addition, three OSHA web-based documents related to PPE selection and use were included in this compilation. While the OSHA documents were not provided by stakeholders who participated in the project, these documents were readily available to emergency responders and their organizations at both response sites. Of the 58 documents received, it was found that 42 were distributed or intended to be distributed to emergency responders. With the addition of the three OSHA documents, a total of 45 documents were initially considered for the compilation.

#### Analysis & Compilation of PPE Guidelines

All documents received, as well as the OSHA documents, were inventoried and analyzed for PPE guidelines. Several documents contained both PPE guidelines and references to other sources (e.g., OSHA, MSHA, NIOSH, NFPA, Safety Equipment Institute) for additional guidelines and information. An initial compilation consisting of all document pages that contained PPE guidelines was prepared. Each guideline was assigned to a category (e.g., head, hand, torso, eye) and provided with a document reference. Each document was analyzed according to 1) general content, 2) specific hazard, 3) type of responder and activity, and 4) key criteria. A final compilation of guidelines, organized by categories and subcategories, was then prepared.

#### General Content Analysis

Each document was analyzed with regard to the types of PPE addressed and the extent of the discussion. Some guidelines were general while others were quite detailed. During this evaluation process, no comparative evaluation of guidelines was made between documents. The extent of the discussion with regard to a particular type of PPE is relative to the discussion of other types in the same document. Table 1 summarizes the results of this general content analysis. Only a few documents refer to all PPE categories. Several documents contain only cursory coverage of PPE. Documents that address respiratory protection have extensive discussions compared to documents that address protection of other body parts. Nearly 50 percent of the documents refer to other PPE documents (e.g., OSHA's Respiratory Protection Standard, 29 CFR 1910.134) for further information.

#### Specific Hazard Analysis

Each document was also examined to identify

**Table 1**

**Content Analysis of Documents for PPE Guidelines\***

Document	Criteria										Refers to Other PPE Documents
	General	Head	Hearing	Hand	Foot	Resp.	Eye/Face	Torso	Fall	Other	
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
2	✓	✓	◆	✓	✓	✓	✓	✓	◆	◆	Yes
3	✓	✓	◆	✓	✓	✓	✓	✓	◆	◆	Yes
4	◆	✓	✓	✓	◆	◆	✓	✓	◆	◆	No
5	✓	◆	◆	◆	✓	✓	◆	✓	◆	◆	Yes
6	◆	◆	◆	◆	◆	◆	✱	◆	◆	◆	Yes
7	◆	✓	◆	✓	✓	✓	✓	✓	✱	◆	No
8	◆	◆	◆	◆	◆	◆	◆	◆	✱	◆	No
9	◆	◆	◆	◆	◆	✱	◆	◆	◆	◆	No
10	◆	◆	◆	◆	◆	◆	◆	◆	✓	◆	No
11	◆	◆	◆	◆	◆	✱	◆	◆	◆	◆	No
12	✱	◆	✓	◆	✓	✱	✓	✓	✱	◆	Yes
13 <sup>†</sup>	✓	◆	◆	◆	◆	✓	◆	✓	◆	◆	Yes
14 <sup>†</sup>	◆	◆	◆	◆	◆	✓	◆	✓	◆	◆	Yes
15 <sup>†</sup>	◆	◆	◆	◆	◆	✓	◆	✓	◆	◆	Yes
16 <sup>†</sup>	✓	◆	◆	✓	◆	✓	✓	◆	◆	◆	Yes
17 <sup>†</sup>	◆	◆	◆	✓	◆	✓	✓	✓	◆	◆	Yes
18 <sup>†</sup>	◆	◆	◆	◆	◆	◆	✓	✓	◆	◆	Yes
19 <sup>†</sup>	◆	✓	✓	✓	✓	✓	✓	✓	◆	◆	No
20 <sup>‡</sup>	◆	◆	◆	◆	◆	✓	◆	◆	◆	◆	Yes
21 <sup>†</sup>	◆	◆	◆	◆	✓	✱	◆	◆	◆	◆	No
22 <sup>†</sup>	◆	◆	◆	◆	◆	✱	◆	◆	◆	◆	No
23	✓	◆	◆	◆	◆	✓	◆	✓	◆	◆	No
24	✓	◆	◆	✱	✓	✱	◆	✱	◆	◆	Yes
25	◆	◆	◆	✓	✓	✓	◆	◆	◆	◆	No
26	◆	◆	◆	✓	✓	✓	◆	✓	◆	◆	No
27	◆	✓	✓	✓	✓	✓	✓	✓	◆	◆	No
28	◆	◆	◆	◆	◆	✱	◆	◆	◆	◆	No
29	✓	✓	◆	✓	✓	✓	✓	✓	✓	◆	No
30	◆	◆	◆	◆	◆	✱	◆	◆	◆	◆	No
31	◆	◆	◆	◆	◆	✱	◆	◆	◆	◆	Yes
32	◆	✓	◆	✓	✓	✱	◆	✓	◆	◆	Yes
33	◆	◆	◆	◆	◆	◆	◆	✱	◆	◆	Yes
34	✓	◆	◆	✓	✓	✓	◆	✓	◆	◆	No
35	✓	◆	◆	✱	◆	✱	◆	◆	◆	◆	Yes
36	✓	◆	◆	✓	◆	✱	◆	✓	◆	◆	No
37	✓	✓	◆	◆	✓	✓	✓	◆	◆	◆	No
38 <sup>§</sup>	◆	✓	✓	◆	◆	✓	✓	◆	◆	◆	No
39 <sup>§</sup>	✓	◆	◆	✓	◆	✱	✓	✓	◆	◆	Yes
40 <sup>  </sup>	◆	◆	◆	◆	◆	◆	◆	✱	◆	◆	Yes
41 <sup>¶</sup>	◆	◆	◆	◆	◆	✓	✓	✓	◆	◆	No
42	◆	✓	✓	✓	✓	✓	✓	✓	◆	◆	No
43 <sup>**</sup>	◆	◆	◆	◆	◆	✓	◆	◆	◆	✓	No
44	✱	✱	✱	✱	✓	✓	✱	✓	◆	✓	Yes
45	✓	✓	✓	✓	✓	✓	✓	✓	◆	◆	Yes

**Key**

✓PPE mentioned; brief or no discussion. ✱PPE mentioned; extended discussion. ◆PPE not mentioned.

\*This is a comparative evaluation of the PPE reference and discussion in a document, not an absolute evaluation of a document or a comparative evaluation of the documents.

†The International Union of Operating Engineers provided printed brochures from its national HazMat program, which addressed PPE for selected chemicals; not PPE documents.

‡NYC Dept. of Health provided a notice on respirator fit and orientation program; not a PPE document.

§DTOS/LPRT accident prevention program, which addresses hazards and PPE; not a PPE document.

|| A disk provided by Kapper in response to inquiry (Suit Smart: The Solution Software for Protective Apparel v2.0).

¶A letter response from FDNY's chief of safety; not a PPE document.

\*\*A letter response from PESH manager, DOL, State of New York; not a PPE document.

specific hazards addressed and the extent of the discussion of each of the following hazard sources:

- thermal stress;
- noise;
- vibration;
- dust (e.g., asbestos, silica, lead, cadmium);
- chemicals (e.g., PAHs, PCBs, VOCs, toxic gases, freons);
- radiation;
- pressure;
- trips/falls;
- biohazards (e.g., blood, body fluids, tissue);
- confined spaces;
- hazardous materials;
- electricity;
- machinery.

These hazard sources, alone or in combination, can result in illness or injury attributable to the following hazard event categories:

- struck-by;
- caught-in;
- caught-under;
- caught-between;
- exposures (chemical, physical and biological agents);
- emotional distress/fatigue.

Tables 2 and 3 present the results of the analysis of specific hazard sources and events.

Many of the documents (nearly 62 percent) address exposure hazards arising from dust, chemicals, noise, thermal stress, radiation or biomaterials, all of which represent the most common hazard sources. Some documents provided general coverage of a broad range of hazard sources while others were more focused on a specific hazard such as dust or noise. Several recognized emotional distress and fatigue as hazards, and these potentially significant factors have been recognized (Levin, et al 545; Krueger 41).

### **Analysis of Responder Type & Activity**

Documents were examined to determine their relevance to the different types of emergency responders and their activities (Tables 4 and 5). For this analysis, emergency responders were defined as: law enforcement personnel (e.g., police, port authority); emergency medical services personnel (e.g., paramedics, EMTs); firefighters; search-and-rescue personnel; others (e.g., equipment operators, skilled construction workers); and support personnel (federal, state and local public health officials). It should be noted that the results of a recent medical screening program for WTC workers identified several additional occupations that would benefit from PPE training and documentation; these include telecommunications technicians, laborers, iron workers, debris haulers, and various aid providers and volunteers (Herbert).

Emergency activities were defined as: victim rescue and recovery, debris removal, debris transport and debris disposal. Nearly all documents were considered relevant to most emergency responders and emergency activities. As Tables 4 and 5 shows, several documents were highly relevant to equipment opera-

tors, construction workers and support personnel, particularly regarding debris removal and disposal.

### **Key Criteria**

Each PPE document was also reviewed to assess the extent to which a set of key criteria was addressed. These criteria were framed as a set of questions:

- 1) How do I know when PPE is necessary?
- 2) How do I know which PPE to select?
- 3) How do I inspect the PPE?
- 4) How do I don the PPE?
- 5) If necessary, how do I adjust/test the PPE for the best fit?
- 6) How do I remove the PPE (e.g., earplugs)?
- 7) What are the limitations of the PPE?
- 8) How do I care for or maintain the PPE?
- 9) Does the PPE or a component have a service life?
- 10) How do I properly dispose of the PPE or component?

11) Is there any reference to OSHA, ANSI or other relevant standards?

The manner in which each criterion was addressed within a PPE document was characterized as explicit, implicit, not addressed or not applicable. In general, most documents implicitly or explicitly addressed the first two criteria, and approximately half made reference to applicable OSHA or other types of standards. Only three of the 45 documents addressed all of the key criteria either explicitly or implicitly. However, it should be noted that many of the documents received were of a summary nature, often containing references to other documents or regulatory standards for more detailed information. In addition, some documents were not directed at a specific type of PPE; therefore, coverage of the key criteria is either implicit or minimal. The three documents that addressed all key criteria were of a more-comprehensive nature; they include the Environmental Safety and Health Plan for the WTC Emergency Project (City of New York) and the WTC Worker Orientation Materials (IUOE).

### **Compilation of PPE Guidelines**

To develop the compilation from documents received, individual PPE guidelines were extracted and organized by various body part protected (e.g., head protection, hearing protection, respiratory protection). Some guidelines appeared to have a broader application than for a specific body part. These were placed into a general category. Within the main categories, each guideline was further associated with one of the following focus areas based on its apparent intent: management, equipment, use, training, decontamination and general. However, it was noted that in some cases it would be possible to assign a guideline to more than one focus area. Table 6 summarizes the distribution of individual PPE guidelines by main category and focus area.

A total of 329 individual PPE guidelines were extracted from the documents for compilation. The respiratory protection category contained the largest

**Table 2**

**Evaluation of Documents by Specific Hazard Types: Part 1**

Document	Hazard									
	Thermal Stress	Noise	Vibration	Dust <sup>1</sup>	Chemicals <sup>2</sup>	Radiation	Pressure	Trips/Falls	Biohazards <sup>3</sup>	Confined Area
1	*	*	◆	*	*	✓	◆	*	✓	*
2	◆	◆	◆	✓	◆	◆	◆	◆	◆	◆
3	◆	◆	◆	✓	◆	◆	◆	◆	◆	◆
4	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
5	◆	◆	◆	✓	◆	◆	◆	◆	◆	◆
6	◆	◆	◆	✓	◆	✓	◆	◆	◆	◆
7	◆	◆	◆	◆	◆	◆	◆	*	◆	◆
8	◆	◆	◆	◆	◆	◆	◆	*	◆	◆
9	◆	◆	◆	*	◆	◆	◆	✓	◆	◆
10	✓	◆	◆	✓	◆	◆	◆	◆	◆	◆
11	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
12	✓	✓	◆	*	*	◆	✓	*	✓	*
13 <sup>t</sup>	◆	◆	◆	*	◆	◆	◆	◆	◆	◆
14 <sup>t</sup>	◆	◆	◆	*	◆	◆	◆	◆	◆	◆
15 <sup>t</sup>	◆	◆	◆	*	◆	◆	◆	◆	◆	◆
16 <sup>t</sup>	◆	◆	◆	◆	*	◆	◆	◆	◆	◆
17 <sup>t</sup>	◆	◆	◆	◆	◆	◆	◆	◆	*	◆
18 <sup>t</sup>	◆	◆	◆	◆	*	◆	◆	◆	◆	◆
19 <sup>t</sup>	◆	◆	◆	✓	✓	◆	◆	◆	◆	◆
20 <sup>‡</sup>	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
21 <sup>t</sup>	◆	◆	◆	✓	✓	◆	◆	◆	◆	◆
22 <sup>t</sup>	◆	◆	◆	✓	✓	◆	◆	◆	◆	◆
23	◆	◆	◆	*	◆	◆	◆	◆	◆	◆
24	*	◆	◆	◆	*	◆	◆	◆	◆	◆
25	◆	◆	◆	✓	✓	✓	◆	◆	◆	◆
26	◆	◆	◆	*	◆	◆	◆	◆	◆	◆
27	◆	✓	◆	*	◆	◆	◆	◆	◆	◆
28	◆	◆	◆	✓	✓	◆	◆	◆	✓	◆
29	*	*	◆	*	*	◆	◆	✓	*	*
30	◆	◆	◆	*	*	◆	◆	◆	◆	◆
31	◆	◆	◆	◆	◆	*	◆	◆	◆	◆
32	◆	◆	◆	◆	✓	◆	◆	◆	◆	◆
33	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
34	◆	◆	◆	✓	◆	◆	◆	◆	*	◆
35	◆	◆	◆	✓	◆	◆	◆	◆	*	◆
36	◆	◆	◆	*	*	◆	◆	◆	*	◆
37	◆	✓	◆	✓	✓	◆	◆	✓	◆	◆
38 <sup>§</sup>	✓	◆	◆	◆	✓	◆	◆	✓	◆	◆
39 <sup>§</sup>	*	◆	◆	*	*	◆	◆	◆	*	✓
40 <sup>  </sup>	◆	◆	◆	*	*	◆	◆	◆	*	◆
41 <sup>¶</sup>	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
42	✓	✓	◆	✓	✓	◆	◆	✓	◆	◆
43 <sup>**</sup>	✓	◆	◆	◆	◆	◆	◆	◆	◆	◆
44	*	*	◆	*	*	◆	◆	◆	◆	◆
45	◆	✓	◆	◆	✓	✓	◆	✓	✓	◆

**Key**

✓Applicable; brief or no discussion. \*Applicable; extended discussion. ◆Not mentioned.

<sup>1</sup>Asbestos, silica, glass, metal dusts (lead, cadmium); <sup>2</sup>PAHs, PCBs, VOCs, toxic gases, freon; <sup>3</sup>blood, bodily fluids, tissues.

<sup>t</sup>The International Union of Operating Engineers provided printed brochures from its national HazMat program, which addressed PPE for selected chemicals; not PPE documents.

<sup>‡</sup>NYC Dept. of Health provided a notice on respirator fit and orientation program; not a PPE document.

<sup>§</sup>SDTOS/LPRT accident prevention program, which addresses hazards and PPE; not a PPE document.

<sup>||</sup>A disk provided by Kapper in response to inquiry (Suit Smart: The Solution Software for Protective Apparel v2.0).

<sup>¶</sup>A letter response from FDNY's chief of safety; not a PPE document.

<sup>\*\*</sup>A letter response from PESH manager, DOL, State of New York; not a PPE document.

number of guidelines with 99 (33 percent), followed by the general and eye/face categories with 59 (18 percent) and 45 (14 percent) guidelines, respectively. The category with the fewest number of guidelines was fall protection with 10 (three percent). The focus areas of management (26 percent), equipment (29 percent) and use (19 percent) composed nearly three quarters of the compilation. The largest number of PPE guidelines for a single category/focus area was 41 (12 percent) for respiratory protection/equipment.

The nature of the individual PPE guidelines was highly variable, ranging from sweeping generalizations such as: "When chemical contaminants are present, wear respirators and mask," to much more-detailed and specific guidelines: "In the Green Zone, wear a respirator with replaceable P100 organic vapor/acid mist cartridge. Replace filter when passage of air becomes difficult, or at least at the beginning of each shift. Store cartridges in a sealed container until ready for use."

A summary of the content of each PPE guideline category follows:

**General:** Responsibilities of management, first-line supervisors and contractors for PPE selection, use, maintenance, storage and training is emphasized in the documents of several agencies. The need for different types of PPE for different jobs and the specific types of PPE required are identified in many of the documents. Extensive guidelines are offered for decontamination of personnel and PPE. It is recognized in several documents that guidelines provided by different agencies may not be consistent—that the requirements of one agency may not satisfy those of another.

**Head Protection:** The importance of protecting the head from hazards at the WTC and Pentagon sites is well-recognized. Guidelines for selection, use and maintenance of head protection PPE are adequate.

**Hearing Protection:** The value of noise monitoring and the importance of implementing administrative and engineering controls where feasible is recognized.

**Hand Protection:** The importance of hazard assessment in the selection of the most appropriate hand protection is well-reflected in the submitted documents. Extensive guidelines on the use of gloves, particularly with regard to appropriate selection based on the task or hazard present, are offered.

**Foot Protection:** Adequate guidelines for identification and selection of appropriate foot protection have been presented in several documents.

**Respiratory Protection:** The importance of respiratory protection and applicable OSHA standards are well-recognized. Compliance with 29 CFR 1910.134 is often specified in general terms. When guidelines are considered collectively, key requirements of the OSHA standard have been explicitly specified, including a respiratory protection program; respirator selection; medical evaluation; fit-testing; use; identification of filters, cartridges and canisters; training; and recordkeeping.

The need for appropriate selection of respirators

and cartridges is acknowledged extensively and many task-, site- and substance-specific requirements are explicitly stated. Default respirator/cartridge combinations have been identified, with the most common arrangement consisting of either a half- or full-facepiece air-purifying respirator (APR) with a combination P100/organic vapor/acid gas cartridge. The need to monitor contaminant concentrations so that appropriate PPE can be selected is recognized and preference for engineering controls, where feasible, is acknowledged. Respirator inspection and cleaning is explicitly addressed and detailed procedures for decontamination have been described. Guidelines demonstrate awareness of the 42 CFR 84 filter classes and selection criteria; some inconsistencies between recommended minimum levels of protection (e.g., P100 vs. P99) likely reflect different levels of conservatism.

**Eye/Face Protection:** Many guidelines reinforce the need for proper selection and describe potential hazards. Management guidelines emphasize the responsibility for proper selection and enforcement of use. The need to clean and decontaminate is addressed as well.

**Torso/Full-Body Protection:** Guidelines clearly address the need to have torso/full-body protection professionally handled/launched after use. However, documents did not differentiate between types of hazardous work areas nor were specific types of torso/full-body protection specified for these areas. In addition, guidelines did not address specific criteria for donning and evaluating the effectiveness of torso/full-body protection.

**Fall Protection:** The need to inspect and use fall protection is clearly documented. The importance of tying-off is well-noted, in particular for manlift baskets; however, criteria for identifying and evaluating appropriate tie-off points are not adequately addressed. Furthermore, specific guidelines for the evaluation, donning, maintenance, care and storage procedures for fall protection were not provided.

## Discussion

Results of this analysis indicate that when considered collectively, adequate guidelines were available for the categories of head, hearing, hand, foot, respiratory and eye/face protection, while deficiencies were noted in the categories of torso/full-body and fall protection. It is not clear whether the lack of adequate fall protection guideline reflects a weakness of emergency response plans in general, or if it is a problem more specific to the unique nature of these disaster sites. The large piles of rubble and debris made it difficult to protect workers from falls given the lack of adequate tie-off points (Jackson, et al 13).

It is also important to note that this study did not include all documents that were distributed at the WTC and Pentagon sites, and that inclusion of a PPE document does not guarantee that it was actually distributed and available to emergency responders. In addition, the timeline for the distribution of documents is unclear.

## Evaluation of Documents by Specific Hazard Types: Part 2

Document	Hazard								
	HazMat	Electricity	Machinery	Struck-By	Caught-In	Caught-Under	Caught-Between	Exposure	Emtl. Distress
1	*	✓	✓	✓	✓	✓	✓	✓	✓
2	◆	◆	◆	◆	◆	◆	◆	◆	◆
3	◆	◆	◆	◆	◆	◆	◆	◆	◆
4	◆	◆	◆	*	◆	◆	◆	◆	◆
5	◆	◆	◆	◆	◆	◆	◆	◆	◆
6	◆	◆	◆	✓	◆	◆	◆	◆	◆
7	◆	◆	◆	◆	◆	◆	◆	◆	◆
8	◆	◆	◆	◆	◆	◆	◆	◆	◆
9	◆	✓	◆	◆	◆	◆	◆	◆	◆
10	◆	◆	◆	◆	◆	◆	◆	◆	◆
11	◆	◆	◆	◆	◆	◆	◆	◆	◆
12	◆	*	✓	✓	✓	✓	✓	*	✓
13 <sup>†</sup>	◆	◆	◆	◆	◆	◆	◆	*	◆
14 <sup>†</sup>	◆	◆	◆	◆	◆	◆	◆	*	◆
15 <sup>†</sup>	◆	◆	◆	◆	◆	◆	◆	*	◆
16 <sup>†</sup>	◆	◆	◆	◆	◆	◆	◆	*	◆
17 <sup>†</sup>	◆	◆	◆	◆	◆	◆	◆	*	◆
18 <sup>†</sup>	◆	◆	◆	◆	◆	◆	◆	*	◆
19 <sup>†</sup>	◆	◆	◆	◆	◆	◆	◆	◆	✓
20 <sup>‡</sup>	◆	◆	◆	◆	◆	◆	◆	◆	◆
21 <sup>†</sup>	◆	◆	◆	✓	◆	◆	◆	✓	◆
22 <sup>†</sup>	◆	◆	◆	◆	◆	◆	◆	✓	◆
23	◆	◆	◆	◆	◆	◆	◆	*	◆
24	◆	◆	◆	◆	◆	◆	◆	*	◆
25	◆	◆	◆	◆	◆	◆	◆	✓	◆
26	◆	◆	◆	◆	◆	◆	◆	◆	◆
27	◆	◆	◆	◆	◆	◆	◆	*	◆
28	◆	◆	◆	◆	◆	◆	◆	✓	◆
29	*	*	◆	*	◆	◆	◆	*	*
30	◆	◆	◆	◆	◆	◆	◆	*	◆
31	◆	◆	◆	*	◆	◆	◆	*	◆
32	◆	◆	◆	◆	◆	◆	◆	✓	◆
33	◆	◆	◆	◆	◆	◆	◆	◆	◆
34	◆	◆	◆	◆	◆	◆	◆	✓	◆
35	◆	◆	◆	◆	◆	◆	◆	◆	◆
36	◆	◆	◆	◆	◆	◆	◆	*	◆
37	◆	◆	✓	✓	◆	◆	◆	✓	◆
38 <sup>§</sup>	◆	◆	✓	✓	◆	◆	◆	✓	✓
39 <sup>§</sup>	◆	✓	*	◆	◆	◆	◆	*	✓
40 <sup>  </sup>	*	◆	◆	◆	◆	◆	◆	*	◆
41 <sup>¶</sup>	◆	◆	◆	◆	◆	◆	◆	◆	◆
42	◆	◆	✓	✓	◆	◆	◆	✓	◆
43 <sup>**</sup>	◆	◆	◆	◆	◆	◆	◆	✓	◆
44	◆	◆	◆	◆	◆	◆	◆	*	◆
45	✓	✓	◆	✓	◆	◆	◆	✓	◆

**Key**

✓Applicable; brief or no discussion. \*Applicable; extended discussion. ◆Not mentioned.

<sup>†</sup>The International Union of Operating Engineers provided printed brochures from its national HazMat program, which addressed PPE for selected chemicals; not PPE documents.

<sup>‡</sup>NYC Dept. of Health provided a notice on respirator fit and orientation program; not a PPE document.

<sup>§</sup>DTOS/LPRT accident prevention program, which addresses hazards and PPE; not a PPE document.

<sup>||</sup>A disk provided by Kapper in response to inquiry (Suit Smart: The Solution Software for Protective Apparel v2.0).

<sup>¶</sup>A letter response from FDNY's chief of safety; not a PPE document.

<sup>\*\*</sup>A letter response from PESH manager, DOL, State of New York; not a PPE document.

**Table 4**

## Evaluation of Documents: Type of Personnel

Document	Emergency Responder					
	Law Enforcement	EMS	Firefighter	Search & Rescue	Other	Support
1	✓	✓	*	*	*	*
2	✓	✓	*	*	*	*
3	✓	✓	*	*	*	*
4	✓	✓	✓	✓	*	✓
5	*	*	*	*	*	*
6	✓	✓	*	✓	*	✓
7	✓	✓	*	✓	*	✓
8		✓	✓	✓	*	✓
9				✓	*	✓
10					*	✓
11					*	✓
12	✓	✓	*	*	*	*
13 <sup>†</sup>	✓	✓	*	✓	*	*
14 <sup>‡</sup>	✓	✓	✓	✓	*	*
15 <sup>‡</sup>	✓	✓	✓	✓	*	*
16 <sup>‡</sup>	✓	✓	✓	✓	*	*
17 <sup>‡</sup>	*	*	*	*	*	*
18 <sup>‡</sup>	✓	✓	*	✓	*	✓
19 <sup>‡</sup>					*	*
20 <sup>‡</sup>					*	*
21 <sup>‡</sup>	✓	✓	✓	✓	*	✓
22 <sup>‡</sup>	✓	✓	✓	*	*	*
23	*	*	*	*	*	*
24	*	✓	✓	✓	✓	✓
25					*	✓
26	✓	✓	✓	✓	*	✓
27		✓		✓	✓	*
28	✓	*	✓	*	*	*
29	*	*	*	*	*	*
30					*	✓
31	✓	✓	✓	✓	✓	✓
32			*			
33	✓	✓	✓	✓	*	✓
34						✓
35		✓				✓
36	*	*		*		*
37	*	*	*	*	*	*
38 <sup>§</sup>				*	*	*
39 <sup>§</sup>				*	*	*
40 <sup>  </sup>		*	*	*		*
41 <sup>¶</sup>						
42					*	*
43 <sup>**</sup>					✓	✓
44	*	*	*	*	*	*
45	✓	✓	✓	✓	✓	✓

### Key

✓Potentially relevant. \*Highly relevant.

<sup>†</sup>The International Union of Operating Engineers provided printed brochures from its national HazMat program, which addressed PPE for selected chemicals; not a PPE document.

<sup>‡</sup>NYC Dept. of Health provided a notice on respirator fit and orientation program; not a PPE document.

<sup>§</sup>DTOS/LPRT accident prevention program, which addresses hazards and PPE; not a PPE document.

<sup>||</sup> A disk provided by Kapper in response to inquiry (Suit Smart: The Solution Software for Protective Apparel v2.0).

<sup>¶</sup>A letter response from FDNY's chief of safety; not a PPE document.

<sup>\*\*</sup>A letter response from PESH manager, DOL, State of New York; not a PPE document.

Regardless, the compilation of PPE guidelines serves as an important reference document that provides a broad range of directives for the different types of equipment employed. The compilation also demonstrates that despite the unprecedented nature and scale of the emergency response to these attacks, the fundamental principle of controlling exposures through the use of PPE remains unchanged: Appropriate, effective PPE must be identified and provided, and workers must be trained in its use.

It is interesting to consider the PPE compilation in the context of related work published following the terrorist attacks. Review of results from the various studies conducted to evaluate the emergency response at these sites shows that several problems related to PPE have been described; these include an initial lack of adequate quantities of many types of equipment; the subsequent arrival of a confusing array of PPE donated/supplied by many different agencies, distributors and manufacturers; a lack of interoperability among the different types of equipment; a lack of appropriate PPE ensembles and training practices for the broad range of hazards encountered; difficulty in wearing PPE for extended periods of time or during physically demanding labor; and inconsistent policies for PPE use which often resulted in poor compliance (Berrios-Torres, et al 82; Jackson, et al 21, 31, 45; Liroy and Gochfeld 563; Lippy 541; Prezant, et al 6; Spadafora 537; Vincoli, et al 23).

In fact, results of a survey of WTC rescue worker injuries and illnesses suggest that more than a quarter of all conditions treated in local emergency departments may have been associated with a lack of proper use of PPE (Berrios-Torres, et al). Respiratory symptoms accounted for 16 percent (816) of all visits; eye injuries represented another 13 percent (666); and musculoskeletal conditions



**Table 5**

**Evaluation of Documents: Type of Activity**

including strains, sprains, lacerations and contusions accounted for 19 percent (1,009) of the total visits recorded for the one-month period following the attacks. The timeline for these injuries is also troubling since it shows a relatively constant rate of occurrence for several weeks following the initial collapse of the buildings, which suggests that proper use of PPE did not occur for some time following the first response.

A lack of on-site information and training for PPE has frequently been identified as a significant problem at the WTC site (Jackson, et al 41; Lioy and Gochfeld 563; Lippy 542). Although emergency responders generally receive extensive training, it was observed that 1) standard training procedures did not adequately prepare responders for a disaster of the scope found at the WTC site; and 2) many on site were construction workers or volunteers who would have had minimal if any prior training in PPE selection and proper use.

These factors combined to create a critical need for on-site information and training that was probably not fully met until formal training programs were established more than a month after the initial attacks (Lippy 541). The initial lack of adequate quantities of appropriate PPE left many responders unprotected regardless of any training that could have been presented; however, a relatively long period clearly passed between the time that additional PPE began to arrive at the disaster site and the time that formal training programs were implemented.

While generally applicable to all classes of PPE, the cited problems were most pronounced—and have been more extensively discussed—for the category of respiratory protection. Evidence of the importance of respiratory protection to emergency responders is provided by the relatively large number of guidelines (99, 30

Document	Emergency Activity				
	Rescue Victims	Recover Victims	Debris Removal	Debris Transport	Debris Disposal
1	*	*	*	*	✓
2	*	*	*	✓	✓
3	*	*	*	✓	✓
4	✓	✓	*	*	✓
5	*	*	*	*	*
6	✓	✓	*	✓	*
7	✓	✓	*	*	✓
8	✓	✓	*	*	✓
9		✓	*	*	✓
10			*	*	
11		*	*	✓	✓
12	✓	*	*		
13 <sup>t</sup>	✓	✓	*	✓	*
14 <sup>t</sup>	✓	✓	*	✓	*
15 <sup>t</sup>	✓	✓	*	✓	*
16 <sup>t</sup>	✓	✓	*	✓	*
17 <sup>t</sup>	*	*	*	✓	*
18 <sup>t</sup>	✓	✓	*	✓	*
19 <sup>t</sup>	✓	✓	*	✓	*
20 <sup>‡</sup>			*	✓	*
21 <sup>t</sup>	✓	✓	*	*	✓
22 <sup>t</sup>	*	*	*	✓	*
23	*	*	*	✓	*
24	✓	✓			
25			*	✓	
26	✓	✓	*	✓	✓
27	✓	*	✓	✓	
28	✓	✓	*	✓	✓
29	*	*	*	*	*
30			*	*	*
31	✓	✓	✓	✓	✓
32	*	*			
33	✓	✓	*	✓	✓
34					
35					
36	*	*	*	*	*
37	*	*	*	✓	✓
38 <sup>§</sup>	*	*	*		
39 <sup>§</sup>	*	*	*	✓	
40 <sup>  </sup>	*	*	*	*	*
41 <sup>¶</sup>					
42			*	*	*
43 <sup>**</sup>			*	*	*
44	*	*	*	*	*
45	✓	✓	✓	✓	✓

**Key**

✓Potentially relevant. \*Highly relevant.

<sup>t</sup>The International Union of Operating Engineers provided printed brochures from its national HazMat program, which addressed PPE for selected chemicals; not PPE documents.

<sup>‡</sup>NYC Dept. of Health provided a notice on respirator fit and orientation program; not a PPE document.

<sup>§</sup>DTOS/LPRT accident prevention program, which addresses hazards and PPE; not a PPE document.

<sup>||</sup>A disk provided by Kapper in response to inquiry (Suit Smart: The Solution Software for Protective Apparel v2.0).

<sup>¶</sup>A letter response from FDNY's chief of safety; not a PPE document.

<sup>\*\*</sup>A letter response from PESH manager, DOL, State of New York; not a PPE document.

**Table 6**

**Distribution of Individual PPE Guidelines**

Protection Category	Focus Area						Totals*
	General	Management	Equipment	Use	Training	Decontamination	
General	-	18	21	5	5	10	59 (18%)
Head	5	-	2	5	-	-	12 (3.6%)
Hearing	5	2	1	4	-	-	12 (3.6%)
Hand	-	3	1	9	-	-	13 (4%)
Foot	-	-	6	-	-	6	12 (3.6%)
Respiratory	5	20	41	19	3	11	99 (30%)
Eye/Face	9	8	12	10	2	4	45 (14%)
Torso/Body	4	7	3	6	-	12	32 (10%)
Fall	1	2	4	2	1	-	10 (3%)
Other†	-	26	6	2	-	1	35 (11%)
<b>Totals*</b>	<b>29 (8.8%)</b>	<b>86 (26%)</b>	<b>97 (29%)</b>	<b>62 (19%)</b>	<b>11 (3.3%)</b>	<b>44 (13%)</b>	<b>329</b>

\*Percentages do not total 100 percent due to rounding.

†Vehicle operation, cold environments, working on/near water, bacillus anthracis, preventing injury and deaths to firefighters.

percent) compiled for this category of equipment. Despite this emphasis, it has been widely reported that respirator use was inconsistent and highly variable among the different trades and locations at the WTC site (Berrios-Torres, et al 82; Levin, et al 545; Lioy and Gochfeld 563; Lippy 539; Prezant, et al 6).

While use of respiratory protection was certainly hindered by initial shortages of equipment, several studies have noted that compliance with respiratory protection requirements was low even several weeks after the first response (Lippy 539; Prezant, et al 6). One researcher observed that generally less than one-half of heavy equipment operators working on the WTC site wore respirators one month after the attack (Lippy). Centers for Disease Control and Prevention reported that as many as 15 percent of firefighters were not using any respiratory protection two weeks after the initial response (Prezant, et al 6).

In responding to the WTC attack, OSHA determined that the agency's role under the Federal Response Plan was to serve as a consultant to Federal Emergency Management Agency (FEMA) (Clark 550; Lippy 541). OSHA adopted a strategy of forming partnerships with SH&E professionals in order to provide assistance and consultation to prevent further tragedy (Clark 550; Vincoli, et al 25). The agency's role as an advisory/partnering agency, while applauded by many involved with the rescue-and-recovery operations (Lippy 542; Vincoli, et al 28), may have helped to create an environment that was less-conducive to ensuring compliance with requirements for routine PPE use (Shufro 558; Umbrell 19). It has also been suggested that the lack of a clear command structure made it difficult to enforce PPE use (Jackson, et al 45).

Lack of compliance with respiratory protection requirements is cause for concern given the reported prevalence of adverse respiratory health effects among WTC responders (Berrios-Torres, et al 82;

Levin, et al 545). One study found that respiratory conditions, including congestion, sore throat, cough, and smoke/dust inhalation accounted for 816 (16 percent) of the 5,222 rescue worker visits to local emergency rooms and disaster medical assistance team facilities (DMAT) during the one-month period following the attacks (Berrios-Torres, et al). Approximately equal numbers of firefighters (n=225, 28 percent), police officers (n=276, 34 percent) and construction workers (n=276, 34 percent) accounted for 96 percent of those treated for respiratory problems (Berrios-Torres, et al 82).

Another study of WTC emergency services police officers found that 78 percent of the 240 officers examined experienced respiratory symptoms, with cough being most commonly cited (62 percent) (Salzman, et al). Symptoms improved or resolved in approximately 75 percent of the officers within three months of the exposure, leaving one-fourth of the officers with ongoing complaints. Examination of long-term health effects is underway as part of the World Trade Center Worker & Volunteer Medical Screening Program, which is a federally funded program under the direction of the Mount Sinai Center for Occupational & Environmental Medicine. Preliminary findings show that approximately one-half of the participating responders experienced persistent lung, ear, nose and throat symptoms 10 months to one year after the attacks (Mount Sinai).

Given the prevalence and potential persistence of respiratory symptoms among emergency responders, future response plans must better address problems associated with distributing respiratory protection and enforcing its proper use. Considering the relatively large emphasis on guidelines for respiratory protection in the PPE documents examined, this situation is a clear reminder that written policies and procedures alone cannot protect workers. Improvements in the areas of PPE performance and availability,

training and information distribution, and site management are required in order to ensure the safety and health of emergency responders in the future.

### Conclusions & Recommendations

The events of Sept. 11, 2001, while horrific and disastrous, must not be viewed as one-time events. The need to be better prepared for such events and to protect the lives of first responders cannot be overemphasized. These attacks focused attention on the critical need to develop improved PPE ensembles, PPE guidelines and logistical frameworks for more effective delivery of these materials to first responders.

Advances in information technology have facilitated development of training materials in formats ranging from videotapes to DVDs, CD-ROMs and computer-based virtual reality models. These training techniques should be evaluated to determine their efficacy for large-scale emergency response scenarios. Web-based PPE guidelines may constitute one of the best approaches to addressing the need for quick access to expert information in the case of complex emergencies.

The framework for delivery of information should build from general to specific, incorporating guidelines and applicable regulations, descriptions of equipment, use, maintenance and limitations, and links to additional sources of information (e.g., toolbox talk outlines that could be used when training emergency personnel on site).

Although no documents discussed the physiological, psychological and biomechanical aspects of wearing PPE, training in these areas is important as well. Finally, it should be re-emphasized that PPE guidelines and training materials serve little purpose in the absence of mechanisms to evaluate program effectiveness and ensure compliance. ■

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