JUSTIFICATION FOR SELECTING LEVEL A VS. LEVEL B PERSONAL PROTECTIVE EQUIPMENT TO REMEDIATE A ROOM CONTAINING CONCENTRATED ACIDS, BASES AND RADIOLOGICAL CONSTITUENTS

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ABSTRACT

Selecting the appropriate personal protective equipment (PPE) is based on providing an adequate level of employee protection relative to the task-specific conditions and hazards. PPE is categorized into four ensembles, based on the degree of protection afforded; e.g., Levels A (most restrictive), B, C, and D (least restrictive). What is often overlooked in preparing an ensemble is that the PPE itself can create significant worker hazards; i.e., the greater the level of PPE, the greater the associated risks. Furthermore, there is confusion as to whether a more "conservative approach" should always be taken since Level B provides the same level of respiratory protection as Level A but less skin protection. This paper summarizes the Occupational Safety and Health Administration regulations addressing Level A versus Level B, and provides justification for selecting Level B over Level A without under-protecting the employee during a particular remediation scenario. The scenario consisted of an entry team performing 1) an initial entry into a room containing concentrated acids (e.g., hydrofluoric acid), bases, and radiological constituents; 2) sampling and characterizing container contents; and 3) retrieving characterized containers. The invasive nature of the hydrofluoric acid sampling and characterization scenario created a high potential for splash, immersion, and exposure to hazardous vapors, requiring additional skin protection. The hazards associated with this scenario and the chemical nature of hydrofluoric acid provided qualitative evidence to justify Level A. Once the hydrofluoric acid was removed from the room, PPE performance was evaluated against the remaining chemical inventory. If chemical breakthrough from direct contact was not expected to occur and instrument readings

confirmed the absence of any hazardous vapors, additional skin protection afforded by wearing a vapor-tight, totally-encapsulated suit was not required. Therefore, PPE performance and instrument data provided quantitative evidence to justify Level B.

INTRODUCTION

Personal protective equipment (PPE) is used to shield or isolate employees from expected or potential hazards associated with site activities. Selecting the appropriate PPE is based on providing an adequate level of protection relative to the requirements and limitations of the task-specific conditions, duration, and hazards associated with site activities. In order to protect the worker from site-specific hazards, the individual PPE components (e.g., clothing, equipment) must be assembled into a full protective ensemble.

What is often overlooked in preparing an ensemble is that the PPE itself can create significant worker hazards. The greater the level of PPE (i.e., over-protection), the greater the associated risks, such as heat stress, physical stress, impaired vision, mobility, and communication. Furthermore, there is confusion as to whether a more "conservative approach" should always be taken, such as selecting Level A over Level B, since Level B provides the same level of respiratory protection as Level A but less skin protection. This paper summarizes the Occupational Safety and Health Administration (OSHA) regulations addressing Level A versus Level B, and provides justification for selecting Level B over Level A without under-protecting employees tasked with remediating a room containing concentrated acids, bases, and radiological constituents.

REGULATORY REQUIREMENTS AND GUIDANCE DOCUMENTS EVALUATED FOR THE LEVEL A VS. LEVEL B DECISION

Regulatory requirements for selecting and using an appropriate PPE ensemble are provided by the OSHA regulations found in Title 29 of the Code of Federal Regulations, Part 1910.120 - Hazardous Waste Operations and Emergency Response (HAZWOPER) (29 CFR 1910.120) (1). Specifically, 29 CFR 1910.120(c)(5), 29 CFR 1910.120(c)(5)(i) and 29 CFR 1910.120(c)(5)(iii), respectively, state in part that:

> *Personal protective equipment (PPE) shall be provided and used during initial site entry in accordance with the following requirements:*
>
> *Based upon the results of the preliminary site evaluation, an ensemble of PPE shall be selected and used during initial site entry which will provide protection to a level of exposure below permissible exposure limits and published exposure levels for known or suspected hazardous substances and health hazards and which will provide protection against other known and suspected hazards identified during the preliminary site evaluation.*
>
> *If the preliminary site evaluation does not produce sufficient information to identify the hazards or suspected hazards of the site an ensemble providing equivalent to Level B PPE shall be provided as minimum protection, and direct reading instruments shall be used as appropriate for identifying IDLH[a] conditions.*

[a]: Immediately dangerous to life or health (IDLH) is defined as an atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere.

Selecting an appropriate PPE ensemble relative to its application and durability is found in 29 CFR 1910.120(g)(3)(ii):

> *Personal protective equipment selection shall be based on an evaluation of the performance characteristics of the PPE relative to the requirements and limitations of the site, the task-specific conditions and duration, and the hazards and potential hazards identified at the site.*

Depending on the site-specific conditions and potential for chemical exposure, a separate air supply is required according to 29 CFR 1910.120(g)(3)(iii):

> *Positive pressure self-contained breathing apparatus, or positive pressure air-line respirators equipped with an escape air supply shall be used when chemical exposure levels present will create a substantial possibility of immediate death, immediate serious illness or injury, or impair the ability to escape.*

The potential for skin absorption from toxic vapors would require upgrading to a vapor-tight, totally-encapsulated suit according to 29 CFR 1910.120(g)(3)(iv):

> *Totally-encapsulating chemical protective suits (protection equivalent to Level A protection as recommended in Appendix B) shall be used in conditions where skin absorption of a hazardous substance may result in a substantial possibility of immediate death, immediate serious illness or injury, or impair the ability to escape.*

PPE ENSEMBLES

Although Level A and Level B are identified specifically in 29 CFR 1910.120(g)(3)(iv) and 29 CFR 1910.120(c)(5)(iii), respectively, there are four PPE ensembles based on the degree of protection afforded; e.g., Levels A (most restrictive), B, C, and D (least restrictive). Level A is the highest level of protection consisting of the employee wearing a self-contained breathing apparatus (SCBA) along with a vapor-tight, totally-encapsulated suit. Level B consists of an SCBA or supplied air with an escape pack, and donning a non-vapor-tight chemical resistant suit. It is the minimum level of PPE recommended for performing initial site entries until the hazards have been identified adequately. Level C typically consists of company-issued clothing (e.g., coveralls) along with a full-face, air-purifying respirator and chemical resistant suit. The types of air contaminants encountered must be identified and measured, and direct contact with

hazardous chemicals must not adversely affect any exposed skin. Level D typically consists of company-issued clothing, safety boots, safety glasses and hard hats and is used when the atmosphere contains no known hazard. Level D should be used when the work functions preclude any type of splash, immersion, or the potential for unexpected inhalation or contact with hazardous chemicals.

Level A and Level B Ensembles

Part 1910.120 Appendix B, Part A (2) and the OSHA Technical Manual (3) provide specific information about selecting either Level A or Level B ensembles.

Part 1910.120 Appendix B, Part A(I) states that Level A is:

> *To be selected when the greatest level of skin, respiratory, and eye protection is required.*

Part 1910.120 Appendix B, Part B(I) states that Level A protection should be used when:

1. *The hazardous substances have been identified and requires the highest level of protection for skin, eyes, and the respiratory system based on either the measured (or potential for) high concentrations of atmospheric vapors, gases, or particulates; or the site operations and work functions involve a high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates of materials that are harmful to skin or capable of being absorbed through the skin.*
2. *Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible, or*
3. *Operations must be conducted in confined, poorly ventilated areas, and the absence of conditions requiring Level A have not yet been determined.*

Furthermore, Table VIII:1-1, EPA Levels of Protection: Levels A, B, C, and D, found in Section VIII: Chapter 1 of the OSHA Technical Manual, provides information about Level A PPE protection, uses, and limitations.

> *Protection Provided: Highest available level of respiratory, skin, and eye protection from solid, liquid and gaseous chemicals.*
>
> *Used When: The chemical(s) have been identified and have high level of hazards to respiratory system, skin and eyes. Substances are present with known or suspected skin toxicity or carcinogenity. Operations must be conducted in confined or poorly ventilated areas.*
>
> *Limitations: Protective clothing must resist permeation by the chemical or mixtures present. Ensemble items must allow integration without loss of performance.*

In comparison to Level A, Part 1910.120 Appendix B, Part A(II) states that Level B is to be used when:

> *The highest level of respiratory protection is necessary but a lesser level of skin protection is needed.*

Part 1910.120 Appendix B, Part B(II) states that for Level B protection:

> 1. *The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection, but less skin protection.*
> 2. *The atmosphere contains less than 19.5 percent oxygen; or*
> 3. *The presence of incompletely identified vapors or gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the skin.*
>
> - *Note: This involves atmospheres with IDLH concentrations of specific substances that present severe inhalation hazards and that do not represent a severe skin hazard; or that do not meet the criteria for use of air-purifying respirators.*

Also, Table VIII:1-1, EPA Levels of Protection: Levels A, B, C, and D, found in Section VIII: Chapter 1 of the OSHA Technical Manual, provides information about Level B PPE protection, uses, and limitations.

> *Protection Provided: Provides same level of respiratory protection as Level A, but less skin protection. Liquid splash protection, but no protection against chemical vapors or gases.*
>
> *Used When: The chemical(s) have been identified but do not require a high level of skin protection. Initial site surveys are required until higher levels of hazards are identified. The primary hazards associated with site entry are from liquid and not vapor contact.*
>
> *Limitations: Protective clothing items must resist penetration by the chemicals or mixtures present. Ensemble items must allow integration without loss of performance.*

Whereas the OSHA regulations address the entire PPE ensemble, regulations governing radiological constituents primarily focus on respiratory protection requirements only. These requirements are used to limit employee doses from inhaling airborne radioactive materials. These requirements are found in Title 10 of the Code of Federal Regulations, Part 20 - Standards for the Protection Against Radiation, Subpart H - Respiratory Protection and Controls to Restrict Internal Exposure in Restricted Areas, (10 CFR 20,

Subpart H) (4), and Title 10 of the Code of Federal Regulations, Part 835.403 - Occupational Radiation Protection, Air Monitoring, (10 CFR 835.403) (5).

THE REMEDIATION SCENARIO

In this remediation scenario, site activities consisted of an entry team performing 1) an initial entry into a room containing concentrated acids, bases, and radiological constituents; 2) sampling and characterizing container contents; and 3) retrieving characterized containers. A breach in any one of these containers and mixing of chemicals, specifically hydrofluoric acid, nitric acid, sodium hydroxide and bleach would have created an extremely hazardous environment (6).

QUANTITATIVE JUSTIFICATION FOR USING LEVEL B – INITIAL ROOM ENTRY AND RETRIEVING CHARACTERIZED CONTAINERS

During the initial room entry and retrieving characterized containers, the entry team used Level B, consisting of a positive-pressure air-line respirator equipped with an escape air supply. The standby-rescue team members were equipped with positive-pressure SCBAs. As stated in the regulation and guidance documents, Level A is justified when there is a need to provide the highest level of protection for the skin, eyes, and respiratory protection system; prevent skin contact from splashing, immersion, or absorption; or when operations are going to be conducted in confined or poorly ventilated areas. However, these conditions did not exist in the room as evidenced by: 1) previous entries to collect radiological surveys and photographs; 2) occupied contiguous office space; 3) air flowing out through a vent from the room into the common area; and 4) engineering controls, such as a negative air machine (NAM) providing adequate ventilation during all room entries. Furthermore, a lesser level of skin protection was needed because of the non-invasive nature of these activities, and the Level B PPE was found to resist chemical breakthrough without loss of performance. Previous information about the location and direct reading instrument results confirmed the absence of any hazardous vapors. The quantitative results consisting of chemical breakthrough information and instrument readings confirmed that additional skin protection was not required, thereby justifying Level B. Furthermore, given the physical configuration of the potentially hazardous material containers, the very limited space for movement of personnel, and the number of personnel expected to perform their respective activities (e.g., surveillances, criticality evaluations, and sampling), the need for mobility was of utmost importance. The Level A PPE would not have provided this mobility, even generating additional hazards from bumping, tipping, or spilling container contents accidentally.

QUALITATIVE JUSTIFICATION FOR USING LEVEL A – SAMPLING & CHARACTERIZATION OF HYDROFLUORIC ACID

During the sampling and characterization of hydrofluoric acid, the PPE was upgraded to Level A. This was based on the known hazard associated with the hydrofluoric acid, combined with the concentrated acids and bases identified during the initial entry. Many

of the original containers were corroded, and the hydrofluoric acid, for example, had to be transferred into a new container before it could be removed from the room. The invasive nature of the hydrofluoric acid transfer increased the likelihood of a container breach, as well as splashing, and exposure to harmful vapors. Since hydrofluoric acid can be absorbed through the skin and is very toxic, a vapor-tight, totally-encapsulated suit was used. Level A provided the highest available level of respiratory, skin, and eye protection. Once the hydrofluoric acid was removed and the room contents segregated according to chemical compatibility, the PPE was downgraded to Level B.

ADDITIONAL CONTROLS

Selecting a PPE ensemble is just one part of a comprehensive program to protect an employee against all site-specific hazards. According to 29 CFR 1910.120(g)(i):

> *Engineering controls, work practices, personal protective equipment, or a combination of these shall be implemented in accordance with this paragraph to protect employees from exposure to hazardous substances and safety and health hazards.*

The following engineering and administrative controls were used during the entire course of the remediation scenario to maintain a work environment conducive to using Level B when applicable.

Engineering controls

- Use of ventilation (e.g., NAM) to remove vapors, gases, and particulates generated from all activities and potential chemical reactions.
- Use of berms and tarps to maintain segregation of acids and bases.
- Availability of decontamination equipment such as showers and eye wash stations.

Administrative controls

- The elements of a PPE program are found in 29 CFR 1910.120(g)(5)(i) through (x). These elements consider many of the site-specific hazards, PPE use and limitations, and work duration issues identified in regulations and guidance documents mentioned in previous sections:
  (g)(5)(i) - PPE selection based upon site hazards,
  (g)(5)(ii) - PPE use and limitations of the equipment,
  (g)(5)(iii) - Work mission duration,
  (g)(5)(iv) - PPE maintenance and storage,
  (g)(5)(v) - PPE decontamination and disposal,
  (g)(5)(vi) - PPE training and proper fitting,
  (g)(5)(vii) - PPE donning and doffing procedures,
  (g)(5)(viii) - PPE inspection procedures prior to, during, and after use,
  (g)(5)(ix) - Evaluation of the effectiveness of the PPE program, and
  (g)(5)(x) - Limitations during temperature extremes, heat stress, and other appropriate medical considerations.

- Program management requirements for developing and implementing a written respiratory protection program are addressed in Title 29 of the Code of Federal Regulations, Part 1910.134, Respiratory Protection (29 CFR 1910.134) (7).
- Performing industrial hygiene and health physics monitoring prior to room entry, and continuously during all activities. This monitoring identified oxygen content and other potential respiratory hazards. The entry team and standby-rescue team members used supplied air while performing all room entries.
- Work plans, health and safety plans, emergency response plans and other programmatic documents.

CONCLUSION

The OSHA regulations and guidance documents identify requirements for selecting and using a PPE ensemble relative to its level of protection, application, and durability in connection with site activities. Of the four PPE ensembles (e.g., Levels A, B, C and D), Level A provides the highest level of protection consisting of an SCBA and a vapor-tight, totally-encapsulated suit. Since Level B provides the same level of respiratory protection as Level A, but less skin protection, Level A should be considered only when substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible. Because of the hazards associated with the hydrofluoric acid and invasive nature of sampling and characterization scenario, the entry team determined that skin contact was possible, therefore providing qualitative justification to use Level A.

A separate evaluation was used to justify using Level B. When the remaining chemical inventory of the room was compared to the vendor-supplied PPE chemical breakthrough information, the fastest breakthrough time was greater than 240 minutes (i.e., four hours) for a hydrochloric acid/nitric acid mixture. Since the maximum stay time for wearing this type of PPE was less than 120 minutes (i.e., two hours), the Level B was found to resist chemical breakthrough without loss of performance. With the addition of chemically-resistant gloves and aprons, skin contact was not possible. The chemical breakthrough information and instrument readings confirmed the absence of any vapors providing quantitative justification to use Level B for all remediation activities not involving hydrofluoric acid.

Whenever new chemicals were identified and the work activities created the potential for these chemicals to come in direct contact with the skin, chemical breakthrough times and toxicities were evaluated accordingly. Depending on the chemical, if either 1) the breakthrough time could be exceeded, or 2) a high degree of hazard to the skin was known or suspected to be present, the PPE was upgraded to Level A automatically.

REFERENCES

1. Title 29 of the Code of Federal Regulations, Part 1910.120 - Hazardous Waste Operations and Emergency Response (HAZWOPER), Department of Labor, Washington, DC, March 7, 1996.

2. Title 29 of the Code of Federal Regulations, Part 1910.120, Appendix B - General Description and Discussion of the Levels of Protection and Protective Gear, Department of Labor, Washington, DC, August 22, 1994.

3. OSHA Technical Manual, Department of Labor, Washington , DC, January 20, 1999.

4. Title 10 of the Code of Federal Regulations, Part 20 - Standards for the Protection Against Radiation, Subpart H - Respiratory Protection and Controls to Restrict Internal Exposure in Restricted Areas, U.S. Nuclear Regulatory Commission, Washington, DC, October 7, 1999.

5. Title 10 of the Code of Federal Regulations, Part 835.403 - Occupational Radiation Protection, Air Monitoring, U.S. Department of Energy, Washington, DC, November 4, 1998.

6. D.D. Watson, C.E. Johnson, Jr., J.M. Hylko, J.F. Walter, and C.T. Wagner, "Experiences Using Level A and B Personal Protective Equipment To Remove High-Hazard Radioactive and Hazardous Constituents From A USDOE Material Storage Area," <http://127.0.0.1:6017/21a/21a-5.pdf>, Waste Management '01, Tucson, AZ, February 25-March 1, 2001.

7. Title 29 of the Code of Federal Regulations, Part 1910.134 - Respiratory Protection, Department of Labor, Washington , DC, April 23, 1998.

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