Guideline for the Decontamination of Chemical Protective Clothing and Equipment

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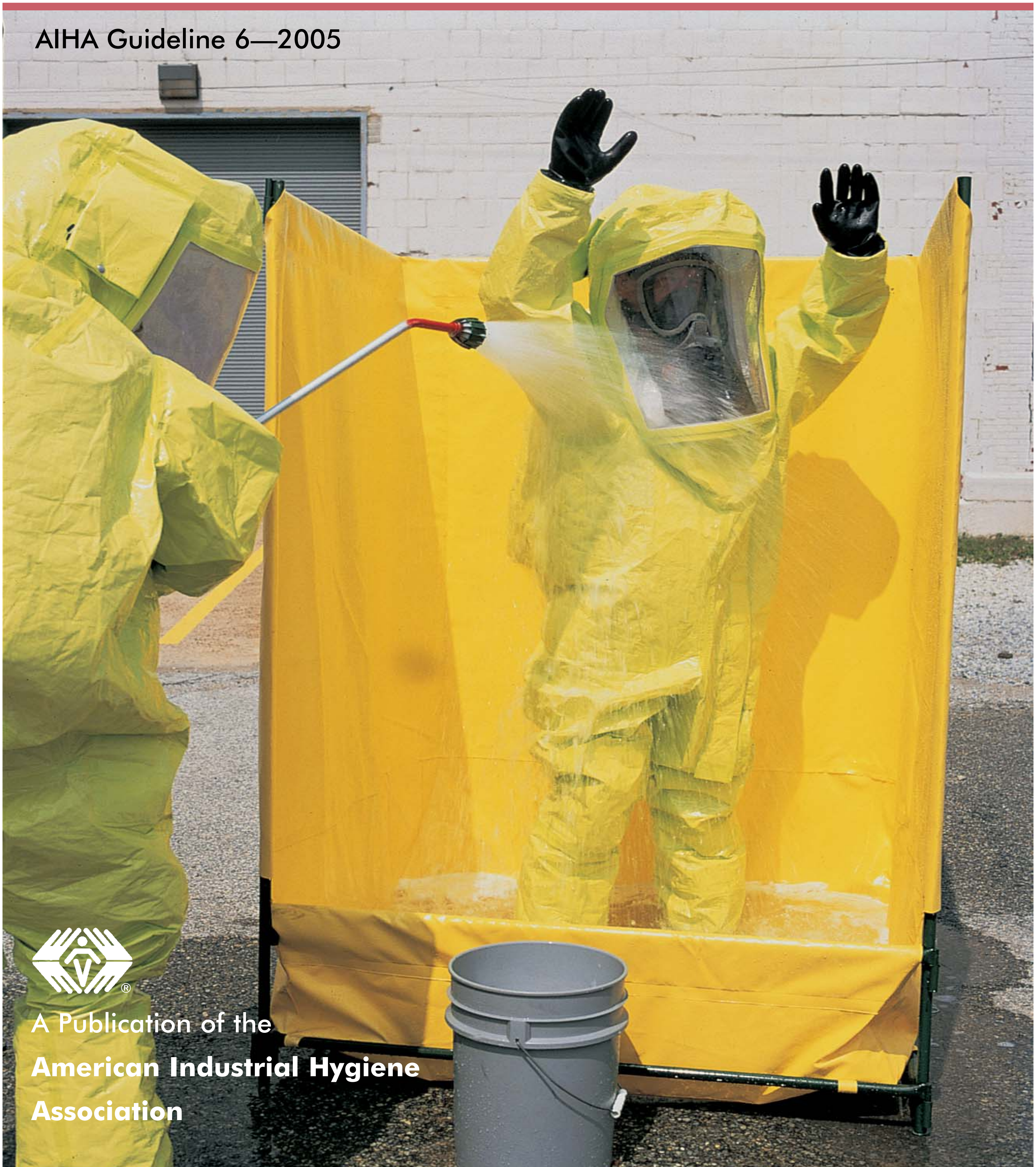

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Guideline for the Decontamination of Chemical Protective Clothing and Equipment

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Guideline for the Decontamination of Chemical Protective Clothing and Equipment

1. Purpose

Decontamination is an important issue for both reusable and disposable chemical protective clothing (CPC). It is also one of the most complex and controversial issues facing end-users, manufacturers, regulators, and safety professionals. The Occupational Safety and Health Administration (OSHA) has requirements for CPC decontamination in a number of its standards. The most general of these are 29 CFR 1910.132 and 29 CFR 1910.120. Although the standards require decontamination, they do not specify how this decontamination should be done. The purpose of this guideline is to provide information for making decisions on decontamination method selection, plans, decontamination facility, reuse of decontaminated CPC and equipment, and a variety of other considerations that must be included for an effective and safe decontamination program.

2. Scope

This guideline includes various methodologies for decontaminating CPC and equipment. These methods can be used in routine applications or during emergency response situations. Information on current practices, regulatory compliance, decontamination work plan, facility, waste management, hazard and risk assessment, CPC reuse, quality assurance, and training, as well, is provided.

This guideline is intended for use by industrial hygienists and safety professionals to assist in the execution of effective decontamination methods. It is also intended to assist employees to ensure user safety, employers to improve survivability of their employees, regulators to provide basis for interpreting related regulations, and perhaps others to avoid secondary or cross-contamination from contaminated CPC and equipment.

3. Definitions & Abbreviations

For the purposes of this guideline document, the following terms and definitions apply. The AIHA *Glossary of Occupational Hygiene Terms* should be referenced for any terms not defined in this section.

3.1. ASTM – American Society for Testing and Materials.

3.2. ATSDR – Agency for Toxic Substances and Disease Registry.

3.3. Breakthrough detection time (BDT) – The elapsed time measured from the start of the permeation test to the time at which the permeant is first detected. The BDT depends on the detection limit of the permeation testing system.

3.4. Chemical agents – The agents that may be present as contaminants in the air, in water, and on work surfaces. They may be present as gases, vapors, dusts, fumes, mists, fibers, particulates, or other aerosols, such as pure bulk materials or as contaminants in other bulk materials.

3.5. Contaminant – Any physical, chemical, biological, or radiological substance or matter that may be harmful to human health or environment, or is unwanted.

3.6. CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act.

3.7. CPC – Chemical Protective Clothing.

3.8. CRZ – Contamination Reduction Zone that is a buffer zone between the exclusion zone and the support zone.

3.9. CWA – Chemical Warfare Agents.

3.10. Decontamination – The process of removing, isolating or reducing contaminants that are known or suspected to be present on or in CPC, such as neutralization with an acid or base, or complexing with Borax and hydrofluoric acid.

3.11. Degradation – A deleterious change in one or more properties of a material.

3.12. Demonstration – The showing by actual use of equipment or procedures.

3.13. Detergent – A surfactant-based chemical mixture intended for cleaning. In addition to the surfactant, it may include water, other solvents, and solids such as suspending agents.

3.14. DOT – Department of Transportation.

3.15. EH&S – Environmental health and safety.

3.16. EPA – Environmental Protection Agency.

3.17. Gross decontamination – Removing as much contaminant as possible using simple means.

3.18. Hazardous chemicals – Chemicals that are harmful to humans or the environment, such as carcinogens, reproductive toxicants, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, mutagens, etc.

3.19. Hazardous waste – Waste which is harmful to humans and the environment, because it can be classified as ignitable, corrosive, reactive, and toxic).

3.20. ICPS – International Programme on Chemical Safety.

3.21. ISO – International Organization for Standardization.

3.22. Matrix contamination – The consequence of a contaminant that permeates into the molecular matrix of the protective barrier.

3.23. NFPA – National Fire Protection Association.

3.24. NIOSH – National Institute for Occupational Safety and Health.

3.25. Nonpolar compound – A chemical compound whose molecules do not have a positive or negative electric charge.

3.26. Normalized Breakthrough Detection Time (NBDT) – The time elapsed from the start of a permeation test until a defined level of permeation is reached. Based on ASTM method F 739-99a, this level is a rate of 0.1 µg/ cm^2/min for open-loop tests, or a cumulative total permeation of 0.25µg/cm^2 for closed-loop tests. Based on CEN method 374, used in Europe, the level is a rate of 1.0 µg/cm^2/min.

3.27. OSHA – Occupational Safety and Health Administration.

3.28. Oxidizing agent – Any substance containing oxygen, or substance similar to oxygen or chlorine, that will readily take on electrons. The opposite is a reducing agent that can act as an electron donor.

3.29. Permeation – The process by which a chemical moves through a protective clothing material on a molecular level.

3.30. Permeation Rate – The rate or speed of the movement of the chemical through the barrier (i.e., protective clothing). This is commonly expressed in micrograms of chemical per square centimeter of exposed area per minute of exposure time.

3.31. Permissible Exposure Limit (PEL) – The concentration level of an agent above which an employer may not expose his employees. The PEL is typically stated in terms of an 8-hour time-weighted average (TWA) of exposure. PEL(s) are part of the OSHA regulations and are enforceable by law.

3.32. Personal Protective Equipment (PPE) – Control devices worn or used while working to protect employees from exposure to hazards. PPE includes items such as gloves, respirators, safety glasses, earmuffs, etc.

3.33. Polar compound – A chemical compound whose molecules exhibit electrically positive characteristics at one extremity and negative characteristics at the other.

3.34. Polymer – A substance made of many repeating chemical units or molecules. The term polymer is often used in place of plastic, rubber or elastomer.

3.35. R&D – Research and development.

3.36. Surface contamination – The consequence of a contaminant that adheres to the surface of CPC without entering any pores or the molecular matrix.

3.37. Surfactant – A substance such as a soap that lowers the surface tension of a solvent (usually water).

3.38. USAMRICD – U.S. Army Medical Research Institute of Chemical Defense.

4. Referenced Documents

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5. Significance & Uses

CPC has been marketed as disposable (use one time and discard), limited-reusable (use several times prior to disposal), or reusable (multiple uses, decontaminations, repairs, and reuses prior to disposal). Reusable CPC must be decontaminated adequately such that the user is not subjected to any residual contamination. Improper decontamination and handling of contaminated CPC, whether single-use or re-useable can create serious health and/or environmental consequences.

There are generally two types of contamination: surface contamination and matrix contamination. Surface contamination is usually easy to remove, while matrix contamination is much more difficult to deal with. As all materials are permeable to some degree, the matrix is always being contaminated, which represents a potential risk to the next person using the CPC.

Decontamination of CPC is necessary to avoid secondary or cross-contamination to personnel, equipment, and/or the environment created by transference of the contaminant(s) from the contaminated CPC. However, decontamination can be used for a variety of purposes.

- Re-useable, and in some cases single-use, CPC must be properly and adequately decontaminated before it is put back into service. Note that some single use CPC is reused, such as chemical protective gloves that are intended for single use but are reused.
- Even for disposal, surface contamination should be removed from CPC in order to facilitate safe handling in preparation for disposal.

6. Objectives of Decontamination

Protecting the safety of the worker wearing CPC against the dangers associated with exposure to toxic chemicals either by inhalation, skin, or oral routes is the primary purpose of CPC. Decontamination of used CPC prevents further contamination by the chemicals that the CPC came in contact with during the course of its use. It is also a means of prolonging the product life of the CPC. The economic advantages are obvious. CPC is costly and the greatest value comes from using CPC to the fullest extent. However, no CPC is designed to last forever and should be discarded long before wearing out.

The primary objective of CPC decontamination is to protect the worker from contamination during doffing of the CPC, and to protect the subsequent wearer of the CPC if it is going to be reused. Decontamination must result in a safe level of exposure for most CPC users. The decontamination procedure must not carry the chemical contaminants through to the inside of the CPC. In some cases, damaged CPC could potentially jeopardize workers health. Change in chemical resistance is a major consideration when deciding whether to reuse contaminated CPC after decontamination. ASTM F 739-99a Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases under Conditions of Continuous Contact calls for an 8-hour test.

There is not a lot of information on just how long an item of CPC can be worn after the initial eight hours if no breakthrough has occurred. After exposure, with a mixture of chemicals, permeation continues to occur even after the exposure has concluded because of diffusion of the absorbed chemicals inside the CPC and subsequent desorption of the chemicals through to the inside of the CPC material where exposure to the wearer occurs. If a product cannot be effectively decontaminated, the CPC must be discarded and new CPC must be worn.

A second consideration is that the disposal of contaminated CPC is very costly. The risk of exposure to disposal personnel must be evaluated. The run-off from rinsing the CPC must be contained and disposed of properly. The disposal of the contaminated CPC must follow the EPA and DOT guidelines for the transport and disposal of hazardous waste. If the CPC is decontaminated, to a level that is considered non-hazardous, the disposal is much less complicated. Testing and documentation of the method and effectiveness of decontamination is needed.

Therefore, the objective of decontamination is to eliminate or reduce the level of chemical contamination to a level that is safe for re-wearing or handling the CPC during disposal.

7. Current Practices

7.1 Routine Use Applications of PPE

In many large workplaces where chemicals are present, decontamination of CPC is managed through an independent protective equipment program. In smaller workplaces, the CPC program may be rolled into programs of safe practices or into chemical management schemes. Decontamination procedures are normally addressed through programs which implement job safety analyses for development of safe practices and those safe practices are transmitted to employees through routine safety training programs. Multiple-use clothing items all require inspection and cleaning or decontamination, as do many single use garments.

7.2 Emergency Response Applications

The decontamination process related to emergency response is typically well defined by regulations and/or common practices of many emergency response related organizations such as the Occupational Safety & Health Administration (OSHA), the National Fire Protection Association (NFPA), and the International Programme on Chemical Safety (ICPS). Since the proliferation of incident planning, training, and command structures in the years following the Bhopal tragedy and other highly publicized chemical incidents, the development of safety and health plans for emergency response to such incidents has grown. Decontamination plans and their execution are considered a critical part of the emergency response plan. Broadly the decontamination program protects critical personnel, eliminates risk of secondary contamination, and is a critical part of handling exposed victims to both mitigate exposure and allow medical treatment personnel safe access to their patients.

Decontamination plans are a critical part of the safety plan for first response teams. This plan defines:

- The design, location, and numbers of decontamination stations.

- The equipment necessary for decontamination.
- The appropriate methods to be used.
- Procedures to prevent contaminant spread, and to facilitate appropriate disposal of all materials and residues from the process.
- Health and safety related practices for decontamination personnel.
- Personnel and practices for conducting hazard analysis and adjustment of practices on the scene.
- Success criteria by which decontamination will be measured (e.g. visual, physical, or chemical).
- Training of all personnel and their qualifications.

7.3 Regulatory Compliance

Regulations vary regarding the requirements for the selection, use, and maintenance of CPC. Some regulations require written programs, while others are very performance based.

OSHA (29 CFR, 1910. 132) requires that all employees using PPE as a general requirement be trained on the use, inspection, care, and storage of PPE. The care terms of the training requirement have been interpreted to include decontamination as an element. Certain specific chemical regulations also specifically address the use and care of PPE such as the lead and asbestos standards. Other U.S standards which address PPE and care and cleaning include the Bloodborne Pathogens Standard (29 CFR, 1910.1030) and the Hazardous Waste Operations and Emergency Response Standard (29 CFR, 1910.120).

In the U.K., the Personal Protective Equipment at Work Regulations (1992) established requirements for the inspection and cleaning of protective equipment. As in the U.S., other specific workplace standards also call out provisions for use and care of PPE, such as:

- The Control of Lead at Work Regulation
- The Control of Asbestos at Work Regulation
- The Control of Substances Hazardous to Health Regulation.

In Mexico, NOM-017-STPS-2001 on PPE has a section dedicated to cleaning procedures which requires cleaning, decontamination, or disinfection of equipment after each use be performed following instructions or recommendations of the manufacturer or supplier or based on characteristics of the contaminant.

7.4 Non-Governmental Organizations

Emphasis by non-governmental organizations has extended beyond environmental issues to labor and quality of work-life issues, including occupational safety and health. There is a trend on increased involvement by multi-national companies and non-governmental organizations to apply industry common or best practices when doing business outside of the E.U. and U.S. This is prompting increased emphasis on areas of chemical management and basic safe practices, as well as increasing use of the British Standards Institute (BSI) 18001 and other EH&S management systems as a benchmark. This has resulted in increased expectations for multi-national businesses when developing 3rd party relationships with manufacturers in developing countries. This has caused an upsurge in regulatory development and a desire to take Western regulatory standards and apply them in countries such as Chile, Argentina, and Peru, as well as the Carribean basin. As an example, Peru has regulated 471 chemicals under standard D.S. 258-75-SA. This standard provides selective inspection authority offering compliance checklists to officers of the government which specifically ask questions regarding personal protective equipment use and care including cleaning and decontamination procedures.

8. The Decontamination Planning Process

8.1 Decontamination Work Plan

A decontamination work plan is needed before any remediation can take place. Whether it's routine use or in an emergency response situation, administrative controls such as policies, Standard Operating Procedures and documented training programs related to your decontamination work plan should exist. The following are plan components that should be considered.

- Hazard assessment – What are the situational risks?
- Contaminant identification – Is the contaminant known? What needs to be decontaminated – equipment, PPE, a physical location?
- Decontamination method selection – What decontamination method is most appropriate?
- Location – Whether routine vs. emergency application, is the area appropriate? Does the area have a mechanism for collected wastewater? Good ventilation? Capture particulate matter, if required? Is the area deconnable post-activity?
- PPE selection – What is the most appropriate PPE? Are personnel adequately trained? Is training documented?
- Medical surveillance – Are personnel medical files current? How is heat stress controlled? In an emergency application, are provisions for 'Rest and Rehab' included?
- Critical Incident Stress Management – In an emergency application, is debriefing and defusing available?
- Regulatory requirements – Is waste disposal considered? Are all regulatory reporting processes completed (such as DOT or EPA requirements)?

- Sterility testing – Is sterility testing required? If so, what is the process?
- Weather factors – Are weather conditions considered? If the weather is hot and humid, work in a Level A suit would be additionally strenuous. If the weather is cold and snowy, wet decontamination methods may be limited.

8.2 Decontamination Methodology

The various methods for decontaminating CPC and equipment fall into two basic categories: physical methods and chemical methods.

8.2.1 Physical Methods

Physical methods remove contaminants from CPC or equipment using mechanical and/or thermal energy, such as wiping, dislodging, wringing, heating, or through evaporating (airing).

8.2.1.1 Gross Decontamination

Gross decontamination means removing as much contaminant as possible using simple means, such as kicking mud from boots before showering inside a decontamination facility. This preliminary step helps extend the life of decontamination equipment and save decontamination agents.

8.2.1.2 Wiping

If dust contaminants are involved, remove the contaminants from the surfaces or interface areas of CPC or equipment using a dry mechanical method such as a soft bristle brush, or a wet method using water with or without a surfactant. Sometimes vacuuming the surfaces with HEPA filters prior to the wiping may be needed if a bristle brush is unable to reach the contaminants directly. However, the technique used may depend upon the hazardous nature of the particulate. For example, in the pharmaceutical industry, the particulate may be an active drug compound, which may have a charge associated with it, making it hard to remove. A booth equipped with a blow-down insside can be used to remove the particulate prior to washing the suites in a shower.

8.2.1.3 Water Rinsing

If contaminants are inorganic compounds, salts, organic acids or other water-soluble compounds, water rinsing of contaminated CPC is generally an effective method to remove the contaminants from the barrier materials. For instance, dimethyl formamide or 2-ethoxyethanol can be removed from natural rubber by simple water rinsing.

When using water rinsing, detergents with surfactants that lower surface tension of water are able to lower pesticide residues in agricultural workers' clothing more completely than water alone. The water-rinsing process can be sped up using hot water (~80°C or 176°F) or spraying water at high pressures (= 3,000 PSI). If cold water is used, the CPC should be dried in a temperature up to 45°C (113°F). However, hot water with high pressure should not be applied to ensembles with a person inside.

8.2.1.4 Evaporation and Heated Air Drying

Volatile chemical contaminants such as organic solvents may be removed simply by evaporation. This usually takes a long time for an effective decontamination down to a "zero" residual level. Application of heated air drying between 50°C and 70°C (122°F and 158°F) will shorten the time and improve the decontamination effectiveness. For example, research has shown that several solvents can be removed from butyl rubber by drying at 50°C (122°F) for 24 hours. Be careful not to overheat the CPC which could lead to degradation of some materials. Visual inspection can be used to confirm no discoloration, wrinkling or stiffening of the equipment has taken place. These are all visual signs of degradation. If applicable, degradation can be quantitatively measured based on changes in certain physical properties, such as weight, volume, cut resistance, puncture resistance, tensile properties, or others. Theoretically, time needed to remove any level of contamination is less than or equal to the time needed to decontaminate a saturated CPC. This can be determined in the laboratory prior to the actual decontamination.

8.2.1.5 Dry Decontamination

Dry decontamination is needed where wet methods are inappropriate. Such situations include removal of water-reactive contamination, the inability to contain liquid decontamination run off, the lack of available wet decontamination substances, or weather conditions that cause water-soluble decontamination liquids to freeze. It can be done using brushing, blotting, vacuuming techniques, or with dry powders (such as earth or flour). Dry decontamination alone may be sufficient to effectively remove certain contaminants, or can be used as an interim step followed by additional removal methods.

8.2.1.6 Additional Techniques

Other contaminants such as glues, cements, resins, or mud that adheres to CPC may require additional techniques such as scraping, solidification, freezing, absorption or adsorption. Caution should be used to avoid introducing new hazards by tearing or scraping the CPC or by causing the user to inhale powdered adsorbent spill cleanup products.

8.2.2 Chemical Methods

Chemical methods may be needed if physical methods are unable to effectively remove the contaminants. Chemical removal usually involves the use of organic solvents that are compatible with the contaminated CPC or equipment.

8.2.2.1. Solvent Washing

Solvent washing simply applies the principle of "like dissolve like", i.e., polar compounds dissolve in polar compounds and nonpolar dissolve in nonpolar. For example, water and ethyl alcohol are completely miscible because both are polar molecules with hydrogen bonding between molecules. Organic compounds like n-hexane and benzene are miscible in one another because both are nonpolar. Theoretically, there is no limit to the possible concentration of one in the other. Chemical agents can be removed from the surface by washing the molecules away using alcohol, diesel fuel, ethers, Freon TF, ketones, perchloroethylene, Stoddard solvent or others. The solvents can be recycled for further use in additional cycles before being discarded and detoxified.

Halogenated solvents can be used for decontaminating equipment when other cleaning agents do not work effectively. However, halogenated solvents are generally incompatible with CPC materials and more toxic than some organic solvents, and thus should not be used for CPC decontamination.

8.2.2.2 Solvent Extraction

Organic solvents such as methanol, acetone, or toluene can be used to remove matrix contaminants by extraction, especially for low volatility or viscous chemicals that are difficult to remove by other methods. The selected solvents should be compatible with the barrier materials. The decontamination personnel should consult the manufacturers or literature for such information. The method is particularly useful for decontaminating small CPC articles, such as chemical protective gloves since only a relatively small amount of the solvent is required. The process is conducted at room temperature (no more than 40°C or 104°F) to avoid material degradation. Use of a water bath shaker or an ultrasonic bath may increase extraction effectiveness. Multiple extractions may be needed to completely remove the contaminants. Following the extraction, residue solvents should be removed from the CPC by evaporation or heated air drying, as described in Section 8.2.1.4.

8.2.2.3. Neutralization

Neutralization may be needed when water rinsing is unable to completely remove the acidic or basic compounds. Commercially available buffers can be used for the neutralization of basic (caustic) compounds, such as amines, hydrazines, or acidic compounds such as phenols, thiols, and some nitro and sulfonic compounds. Complexing with Borax and hydrofluoric acid can be used to convert some hazardous agents to a non-hazardous form.

8.2.2.4. Solidification Agents

Solidification agents completely solidify or gel contaminants, making the physical removal process easier. Most solidification agents act by removing moisture using absorbents such as ground clay or powdered lime. Others polymerize liquids through chemical reactions via polymerization catalysts and chemical reagents, while others freeze materials using ice water. Solidification agents are more suited for equipment and surfaces than for CPC.

8.2.2.5. Oxidizing Agents

Oxidizing agents are used when contaminants cannot be removed by the methods described earlier. This usually applies to biological agents and some chemical warfare agents.

8.3. Selection of Appropriate Methods

The decontamination method should be selected based on the contaminant (extent, physical state, toxicity, flammability, persistence, decontamination site, etc.), vulnerability of the item being contaminated, cost of the items vs. cost of decontamination process, and most importantly, the threat posed to the decontamination personnel, the public, or the environment.

A decontamination method must be compatible with the material that is being decontaminated. For instance, sodium hypochlorite is not compatible with stainless steel; paraformaldehyde is not compatible with electronics; steam sterilization is not compatible with plastics.

8.4. Hazard and Risk Assessment

A decontamination process depends not only on the reactivity of the decontamination methods and substances, but the specific characteristics of the surface as well. The process of decontamination could damage the treated surface or even change its characteristics. Some toxic agents and substances are easily soluble and penetrate many different types of material, such as coatings, plastics and rubber, all of which renders decontamination more difficult. If the toxic substances have penetrated sufficiently deep, then toxic gases could be released from the material for long periods of time. Therefore, careful hazard and risk assessment is recommended. If decontamination is not cost-effective, the protective clothing should be disposed of properly. Despite all of the efforts complete (100%) decontamination cannot be achieved. Typically, a small amount of the toxic substance will remain in the matrix of the material, no matter which decontamination method is used.

The person conducting hazard and risk assessments should consider the following:

- The safety of the personnel involved
- The cost of the CPC
- The cost of the decontamination
- Time and materials involved
- Disposal cost

9. Decontamination Facility

9.1 Management and Personnel Considerations

As with any aspect of EH&S management, organizational support and leadership is the key to a successful protective equipment decontamination program. Whether a routine use or emergency response application, management support is essential to provide the physical resources and facilities as well as to establish the leadership expectations enabling the program to succeed. The establishment of a protective equipment decontamination program requires planning, preparation, and training.

Considerations for the EH&S professional charged with creating and management of the program must consider the following aspects:

- The number and layout of decontamination stations
- Decontamination equipment needed
- Appropriate decontamination methods
- Procedures to prevent contamination of clean areas
- Methods and procedures to minimize worker contact with contaminants during the removal of PPE
- Methods for disposal of clothing and equipment that cannot be completely decontaminated
- Selection and training of personnel
- The event that an entrant is experiencing problems and needs to be decontaminated more expeditiously than the planned methodology

Personnel involved in the decontamination program must be willing workers. Clear health, safety, and environmental procedures which explain a given organizations expectations and the roles and responsibilities for all its employees are critical. In routine industrial, R&D, and health care organizations, these requirements may be general and broad and driven by performance based regulations as well as industry best practices. It is important to realize that in emergency response situations and in hazardous waste operations the selection, medical clearance, and qualification/training of personnel involved in decontamination is defined by regulation (e.g. OSHA part 1910.120).

9.2 Staging and Layout

The location, staging, and layout of decontamination facilities is driven by particular application and will be discussed in this section under the headings of routine use applications of personal protective equipment and emergency response applications.

9.2.1 Routine Use Applications

Facilities for the decontamination of CPC and equipment used in routine industrial, commercial, R&D, and health care applications should be located convenient to the work area to facilitate personnel compliance with established procedures. The facilities and fixtures should be separate from toilet facilities, wash rooms, or changing/locker facilities to prevent secondary contamination of non-process or non-laboratory areas of the facility.

9.2.2 Emergency Response Applications

Planning and organization is critical to mounting a successful response to a hazardous material release. Emergency response requires ongoing planning, preparation, and training to prepare for a possible incident and coordinated activity throughout the phases of the response, from the response phase to site-remediation, and returning to normal operations.

Decontamination of PPE during an emergency response scenario has many facets. The decontamination program involves protecting first responders, medical response personnel, as well as all personnel involved in extrication, triage, transport and extended treatment of victims. For the first responder the priority upon arrival to the scene is to evaluate the incident and protect response personnel so that they can begin to extricate victims and control the incident. The incident commander will first organize the scene into zone of control to limit access to essential personnel for the extrication of the exposed. Egress from the area must also be controlled to prevent potentially contaminated personnel whether responders or victims from extending contamination beyond the scene of the incident to medical personnel, equipment, and other facilities.

The organization of the hazardous material incident zones are routinely referred to as the hot (red) zone, the warm (yellow) zone and the cold or support (green) zone. The exact location and dimensions of the zones is defined by the properties of, and hazards posed by the chemical, as well as the environmental and meteorological conditions that are controlling the dispersion of the chemical to the environs of the incident scene. The diagram shown in Figure 1 (see page 9) illustrates the zones based on ATSDR's Medical Management Guidelines for Acute Chemical Exposures (1992).

The hot zone is the area immediately around the incident scene which poses the greatest risk of exposure. Only hazardous material responders or specially trained firefighters should enter and operate in this zone. The contamination reduction zone is established to permit specialized responders (e.g. supply line, safety) and decontamination personnel to operate. This zone is established to minimize exposure but personnel still require protective clothing and equipment because of their possible need to enter the hot zone or their potential as is the case of the decontamination personnel for secondary exposure due to handling victims. Details of the decontamination corridor are displayed as shown in Figure 2 (see page 9), based on ATSDR's Medical Management Guidelines for Acute Chemical Exposures.

9.3 Contamination Control Measures

The particular decontamination processes and the risk of secondary contamination are dependent upon the nature of the agent, the route of exposure, and the degree of contamination. A key consideration for a successful decontamination strategy includes contamination control measures. This aspect can impact the selected method of decontamination (e.g. wipe down, spray down, immersion) as well as the materials used to decontaminate CPC and equipment. In large scale emergency response operations for example significant amounts of water may be used in the process of decontaminating PPE of first responders, their equipment, as well as victims. Dependent upon the contaminant, that water may need to be treated or disposed of in a particular way. Hence, containment and more importantly material of construction of the containment should be factored into decision making processes in the early stages of the response phase of the emergency operation.

As a practical matter, when the material is unknown or information is lacking on the nature of the chemical, then one must proceed to establish a conservative decontamination and contaminant control procedure.

9.4 Training

Whether personnel are involved in routine applications for PPE or emergency response operations they need basic safe operating procedures for the application, decontamination, and maintenance of CPC as it is a last line of defense. All personnel involved in decontaminating CPC and equipment should receive training in these fundamental areas commensurate with the level of risk they might encounter:

- The hazards of the material they could encounter;
- The PPE and practices to protect themselves during decontamination procedures;
- The proper methods of decontamination
- Evaluation of the effectiveness of the decontamination steps;
  - o Visual inspection of the PPE (discoloration, tearing, alterations, visible traces,
  - o Wipe sampling when available, and
- Disposal and contaminant control methods

Within the realm of OSHA 1910.120(q)(6)(v), a person charged with decontamination during an emergency response operation is considered a HAZMAT specialist. This standard outlines specific training requirements and qualification procedures for those personnel.

10. Waste Management and Reuse Issues

10.1 Waste Segregation

Wastes, whether PPE or other, are segregated by compatibilities. Incompatibles are never containerized or mixed together. All wastes are labeled properly for transport and disposal in accordance with EPA and DOT regulations, as well as any applicable state and local requirements.

Although not specifically required, PPE is typically containerized, labeled, and prepared for disposal separately from other forms of waste. This practice helps facilitate handling of the PPE waste.

10.2 Laundering

Commercial launderers require clients to fill out a reconditioning profile that lists the exact description of the item of CPC and the source of contaminants with exclusions.

The contaminants must be specified including:

- Machine tool cutting oil
- Machine hydraulic oil
- Motor oil

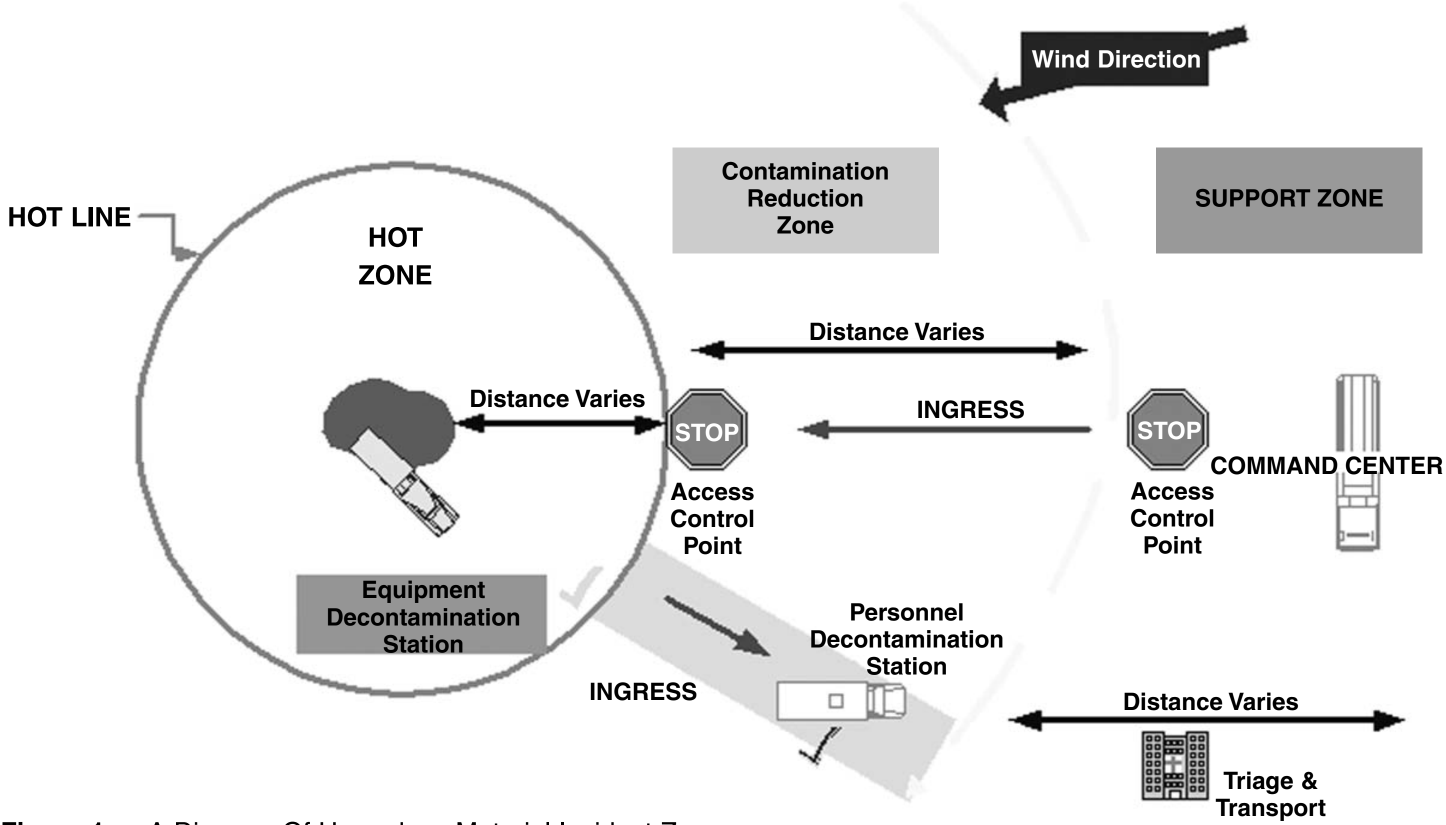

Figure 1 — A Diagram Of Hazardous Material Incident Zones.

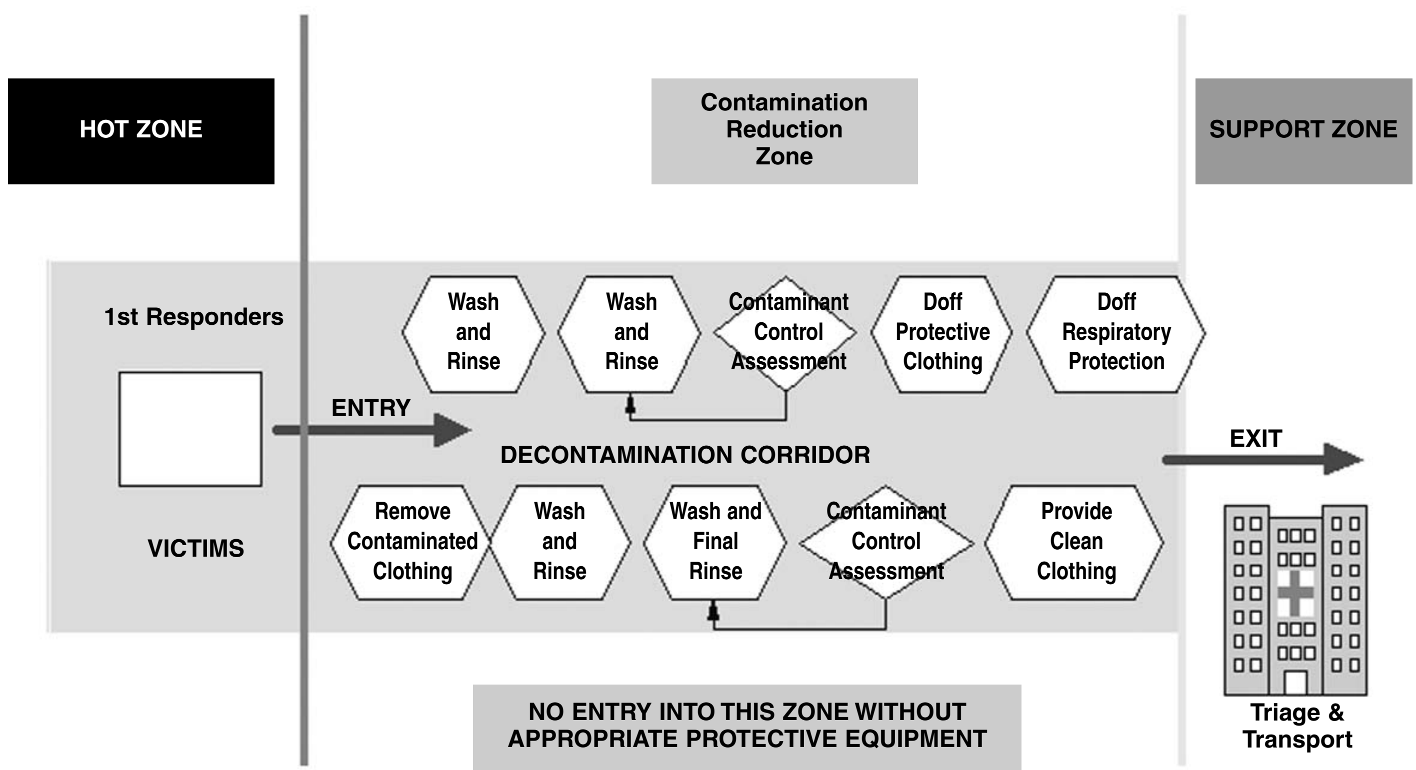

Figure 2 — A diagram of Decontamination Corridor.

- Corrosives (must identify)
- Solvents (must identify)
- Mixtures (must identify)

Commercial laundries require a signed affidavit that the contamination does not include such chemicals as:

- PCBs (polychlorinated biphenyls)
- Dioxins
- Furans
- Mercury or mercury compounds
- Nitric Acid (70% or greater concentrations)
- Perchlorates
- Di- and Tri- nitrated organic chemicals
- Cyanide compounds
- Isocyanates
- Mercaptans
- Hydrofluoric acid
- Peroxide formers
- Pathogenic or infectious materials
- Pyrophorics
- Water reactives
- Radioactive material

Laundries do not generally accept containers containing free-liquids.

Sometimes with certain CPC, for instance, the cost of laundering may be greater than the cost of a new pair of gloves, depending on the particular polymer used to make the CPC or gloves.

Laundries will not accept overtly contaminated hazardous materials.

If the launderer does not consider the related issues addressed in this section, a different launderer should be found for the purpose.

10.3 Reuse of CPC

CPC is manufactured as reusable or single-use (some single-use CPC is reusable as stated earlier). Either type requires some level of decontamination prior to reuse or disposal.

10.3.1 Reusable CPC must be decontaminated adequately to ensure that CPC still functions correctly and the materials do not fail after decontamination.

10.3.2 Single-use CPC may also be considered for limited reuse under very specific conditions. If the CPC was not subjected to a contaminant during its use or if it is minimally contaminated and has been effectively decontaminated following use, it may be reused if it passes stringent visual inspection and is approved for reuse by the Incident Commander (operation manager) and the Health and Safety Officer.

If the CPC is a Level A suit, it must also pass a pressure test.

10.4 Off-site Transport for Disposal or Decontamination

10.4.1 Transportation of CPC or Equipment for Decontamination

The contaminated CPC or equipment needs to be sealed in a container before transport off-site for decontamination, together with a detailed log that includes the following information:

- Place and date of exposure
- Location and extent of exposure on the product
- Exposure types, such as liquid splash, liquid deluge, mist, spray, gas, vapor, or solid
- The task being performed when the exposure occurred
- The generic chemical name of the contaminant
- Manufacturer's trade name; chemical formula, and
- Whether or not the contaminant is flammable, toxic, corrosive, or a suspected carcinogen. Such information can be found in the Material Safety Data Sheet (MSDS)

10.4.2 After decontamination, a complete Certificate of Decontamination is needed for return shipment It should include the following information:

- Date of decontamination,
- Person performing the decontamination,
- Decontamination methods used, and
- The methods used to evaluate decontamination efficacy.

If the article can not be reused and should be disposed as hazardous waste, relevant Federal regulations must be followed. If necessary, the item should be stored in a closed container in an adequate aisle space. It should be labeled with the words "HAZARDOUS WASTE" and a clear description of the waste. Related EPA regulations should be followed.

10.5 Quality Assurance and Control

The normal Quality Assurance and Control protocols for manufacturers of CPC include inspection of either 100% of the products or a statistical sampling plan where a statistically significant representative is inspected for each manufacturer lot number. These sampling plans and inspection procedures often follow the sampling plans established by ISO 9001 or 9002 quality management systems requirements.

Manufacturers may recommend laundering of CPC and provide specific instructions. These must be followed and temperature recommendations must not be exceeded. The type of detergent or cleaning agent must also follow the manufacturer's recommendations. If a manufacturer recommends certain laundering instructions, they may still guarantee CPC as long as the washing instructions are followed up to a certain number of washings.

If a manufacturer does not provide laundering instructions, the guarantees and limited warranties may not extend past the workmanship at the time of manufacture.

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