NFPA 471

Recommended Practice for Responding to Hazardous Materials Incidents

2002 Edition

NFPA, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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NFPA 471

Recommended Practice for

Responding to Hazardous Materials Incidents

2002 Edition

This edition of NFPA 471, *Recommended Practice for Responding to Hazardous Materials Incidents*, was prepared by the Technical Committee on Hazardous Materials Response Personnel and acted on by NFPA at its November Association Technical Meeting held November 10–14, 2001, in Dallas, TX. It was issued by the Standards Council on January 11, 2002, with an effective date of January 31, 2002, and supersedes all previous editions.

This edition of NFPA 471 was approved as an American National Standard on January 31, 2002.

Origin and Development of NFPA 471

At the July 1985 NFPA Standards Council meeting, approval was given to the concept of a new project on Hazardous Materials Response Personnel. The Council directed that a proposed scope and start-up roster for the new Committee be prepared, taking into account the need to expand the Committee membership beyond the fire service and the application beyond "professional qualifications."

The first meeting of the Technical Committee on Hazardous Materials Response Personnel took place in October 1986. The Committee proceeded to develop the first edition of NFPA 471 in conjunction with the first edition of NFPA 472, *Standard on Professional Competence of Responders to Hazardous Materials Incidents*. Both documents were first released as 1989 editions.

Interest in the subject of hazardous materials, especially as it relates to the emergency responder, continued at a high level. Some of this interest was due to an increased awareness of the magnitude of the problem; much of it can be credited to federal regulations in the United States that have had an impact on all responders.

Revisions were made to both NFPA documents in 1992 editions. At the same time the Committee introduced a new related document, NFPA 473, *Standard for Professional Competencies for EMS Personnel Responding to Hazardous Materials Incidents*.

In 1993 the Committee again began reviewing NFPA 471 for the purpose of revising it. The Committee made several changes to the resulting 1997 edition in order to ensure that the document remained consistent with NFPA 472, which had gained wide international acceptance.

The 2002 edition contains additional minor revisions for continued consistency with NFPA 472. Some changes were the result of conformance with the 2000 edition of the NFPA *Manual of Style*.

The gratitude of the Committee is extended to all who participated in the development and review process, and especially to the individuals not on the Committee who helped so much.

The Committee would like to dedicate this recommended practice to the fallen heroes of the terrorist attack of September 11, 2001. Many lives were saved because of their efforts. These individuals gave the ultimate sacrifice in the line of duty and stand alone in their bravery and dedication to their jobs and their country. Our thoughts and prayers are with their families, friends, and co-workers. Let us never forget these brave individuals and the other emergency responders who have died in the line of duty. The Committee especially wishes to honor Committee member John J. Fanning, FDNY, who died in the line of duty on September 11.

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This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet between the paragraphs that remain.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, Annex D lists the complete title and edition of the source documents for both mandatory and nonmandatory extracts. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the appropriate technical committee.

Information on referenced publications can be found in Chapter 2 and Annex D.

Chapter 1 Administration

1.1* Scope. This recommended practice applies to all organizations that have responsibilities when responding to hazardous materials incidents and recommends standard operating guidelines for responding to such incidents. Planning procedures, policies, and application of procedures for incident levels, personal protective equipment, decontamination, safety, and communications are specifically covered in this recommended practice.

1.2 Purpose. The purpose of this document is to outline the minimum requirements that should be considered when dealing with responses to hazardous materials incidents and to specify operating guidelines for responding to hazardous materials incidents. It is not the intent of this recommended practice to restrict any jurisdiction from using more stringent guidelines.

1.3 Application. The recommendations contained in this document should be followed by organizations that respond to hazardous materials incidents and by incident commanders responsible for managing hazardous materials incidents.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this recommended practice and should be considered part of the recommendations of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 70, *National Electrical Code®,* 2002 edition.

NFPA 472, *Standard for Professional Competence of Responders to Hazardous Materials Incidents,* 2002 edition.

NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials Incidents,* 2002 edition.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program,* 2002 edition.

NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service,* 1997 edition.

NFPA 1982, *Standard on Personal Alert Safety Systems (PASS),* 1998 edition.

NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies,* 2000 edition.

NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies,* 2000 edition.

2.3 Other Publications.

2.3.1 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM F 716, *Method of Testing Sorbent Performance of Absorbents,* 1993.

ASTM F 726, *Method of Testing Sorbent Performance of Adsorbents,* 1999.

2.3.2 U.S. Government Publication. U.S. Government Printing Office, Superintendent of Documents, Washington, DC 20402.

Title 29, *Code of Federal Regulations,* Part 1910.120.

Title 40, *Code of Federal Regulations,* Part 311.

Title 42, *United States Code,* Chapter 116.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter apply to the terms used in this recommended practice. Where terms are not included, common usage of the terms applies.

3.2 NFPA Official Definitions.

3.2.1* Authority Having Jurisdiction (AHJ). The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

3.2.2 Recommended Practice. A document that is similar in content and structure to a code or standard but that contains only nonmandatory provisions using the word "should" to indicate recommendations in the body of the text.

3.2.3 Should. Indicates a recommendation or that which is advised but not required.

3.3 General Definitions.

3.3.1* Absorption. The process in which materials hold liquids through the process of wetting.

3.3.2* Adsorption. The process in which a sorbate (hazardous liquid) interacts with a solid sorbent surface.

3.3.3 Confinement. Those procedures taken to keep a material, once released, in a defined or local area.

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3.3.4 Containment. The actions taken to keep a material in its container (e.g., stop a release of the material or reduce the amount being released).

3.3.5 Contaminant. A hazardous material that physically remains on or in people, animals, the environment, or equipment, thereby creating a continuing risk of direct injury or a risk of exposure. [**472:**3.3]

3.3.6 Contamination. The process of transferring a hazardous material from its source to people, animals, the environment, or equipment, which may act as a carrier.

3.3.6.1 Secondary Contamination. The process by which a contaminant is carried out of the hot zone and contaminates people, animals, the environment, or equipment. [**472:**3.3]

3.3.7 Control. The procedures, techniques, and methods used in the mitigation of a hazardous materials incident, including containment, extinguishment, and confinement. [**472:**3.3]

3.3.8* Control Zones. The areas at a hazardous materials incident that are designated based upon safety and the degree of hazard.

3.3.9 Decontamination (Contamination Reduction). The physical and/or chemical process of reducing and preventing the spread of contamination from persons and equipment used at a hazardous materials incident.

3.3.9.1 Emergency Decontamination. The physical process of immediately reducing contamination of individuals in potentially life-threatening situations with or without the formal establishment of a decontamination corridor. [**472:**3.3]

3.3.9.2* Gross Decontamination. The initial phase of the decontamination process during which the amount of surface contaminant is significantly reduced.

3.3.10 Decontamination Corridor. The area usually located within the warm zone where decontamination procedures take place. [**472:**3.3]

3.3.11 Degradation. (a) A chemical action involving the molecular breakdown of a protective clothing material or equipment due to contact with a chemical. (b) The molecular breakdown of the spilled or released material to render it less hazardous during control operations.

3.3.12* Disinfection. The process used to destroy recognized pathogenic microorganisms.

3.3.13 Emergency. A fire, explosion, or hazardous condition that poses an immediate threat to the safety of life or damage to property. [**1:**2-1]

3.3.14 Environmental Hazard. A condition capable of posing an unreasonable risk to air, water, or soil quality and to plants or wildlife.

3.3.15* Exposure. The process by which people, animals, the environment, and equipment are subjected to or come in contact with a hazardous material. [**472:**3.3]

3.3.16 Hazard/Hazardous. Capable of posing an unreasonable risk to health, safety, or the environment; capable of causing harm.

3.3.17* Hazard Sector. That function within an overall incident management system that deals with the mitigation of a hazardous materials incident.

3.3.18 Hazardous Materials Sector Officer. The person responsible for the management of the hazard sector.

3.3.19* Hazardous Material. A substance (solid, liquid, or gas) that when released is capable of creating harm to people, the environment, and property. [**472:**3.3]

3.3.20 Incident. An emergency involving the release or potential release of a hazardous material, with or without fire. [**295:**1.3]

3.3.21* Incident Commander. The person who is responsible for all decisions relating to the management of the incident and is in charge of the incident site. [**472:**3.3]

3.3.22* Incident Management System. An organized system of roles, responsibilities, and standard operating procedures used to manage and direct emergency operations. [**1021:**1.4]

3.3.23 Mitigation. Actions taken to prevent or reduce product loss, human injury or death, environmental damage, and property damage due to the release or potential release of hazardous materials.

3.3.24 Monitoring Equipment. Instruments and devices used to identify and quantify contaminants.

3.3.25* National Contingency Plan. Policies and procedures of the federal agency members of the National Oil and Hazardous Materials Response Team.

3.3.26 Neutralization. The process of applying acids or bases to a corrosive product to form a neutral salt.

3.3.27 Penetration. The movement of a material through a suit's closures, such as zippers, buttonholes, seams, flaps, or other design features of chemical-protective clothing, and through punctures, cuts, and tears.

3.3.28 Permeation. A chemical action involving the movement of chemicals, on a molecular level, through intact material.

3.3.29* Protective Clothing. Equipment designed to protect the wearer from heat and/or hazardous materials contacting the skin or eyes. [**472:**3.3]

3.3.30* Response. That portion of incident management in which personnel are involved in controlling (defensively or offensively) a hazardous materials incident.

3.3.31 Sampling. The process of collecting a representative amount of gas, liquid, or solid for analytical purposes.

3.3.32 Solidification. The process whereby a hazardous liquid is treated chemically so that solid material results.

3.3.33 Stabilization. The point in an incident at which the adverse behavior of the hazardous material is controlled.

3.3.34 Sterilization. The process of destroying all microorganisms in or on an object.

3.3.35 Waste Minimization. Treatment of hazardous spills by procedures or chemicals designed to reduce the hazardous nature of the material and to minimize the quantity of waste produced.

Chapter 4 Incident Response Planning

4.1 Developing an Incident Response Plan.

4.1.1 Planning is an essential part of emergency preparedness. The development of both facility response plans and

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community emergency plans is required by numerous state and federal laws, including Superfund Amendments and Reauthorization Act (SARA), Title III, "The Emergency Planning and Community Right to Know Act of 1986" in 42 USC 116. Planning guides and reference materials are listed in Annex B.

4.1.2 A planning team is necessary for developing the hazardous materials emergency plan. Local, state, and federal planning guidelines should be reviewed and consulted by the planning team when preparing plans for hazardous materials incidents.

4.2 Review and Training.

4.2.1 As a minimum, an annual review and update of the hazardous materials emergency plan should be conducted.

4.2.2 As a minimum, a training exercise should be conducted annually to determine the adequacy and effectiveness of the hazardous materials emergency plan.

Chapter 5 Response Levels

5.1* Planning Guide. Table 5.1 is a planning guide intended to assist the user in determining incident levels for response and training.

5.2 Potential Applications. Potential applications to a jurisdiction's response activities can include development of standard operating procedures; implementation of a training program using the competency levels of NFPA 472, *Standard for Professional Competence of Responders to Hazardous Materials Incidents;* acquisition of necessary equipment; and development of community emergency response plans. When consulting this table, the user should refer to all of the incident condition criteria to determine the appropriate incident level.

Table 5.1 Planning Guide for Determining Incident Levels for Response and Training

Incident Conditions	Incident Level		
	One	Two	Three
Product identifications	Placard not required, NFPA 0 or 1 all categories, all Class 9 and ORM-D	DOT placarded, NFPA 2 for any categories, PCBs without fire, EPA regulated waste	Class 2, Division 2.3—poisonous gases, Class 1, Division 1.1 and 1.2—explosives, organic peroxide, flammable solid, materials dangerous when wet, chlorine, fluorine, anhydrous ammonia, radioactive materials, NFPA 3 & 4 for any categories including special hazards, PCBs & fire, DOT inhalation hazard, EPA extremely hazardous substances, and cryogenics
Container size	Small [e.g., pail, drums, cylinders except 910-kg (1-ton), packages, bags]	Medium [e.g., 910-kg (1-ton) cylinders, portable containers, nurse tanks, multiple small packages]	Large (e.g., tank cars, tank trucks, stationary tanks, hopper cars/trucks, multiple medium containers)
Fire/explosion potential	Low	Medium	High
Leak severity	No release or small release contained or confined with readily available resources	Release may not be controllable without special resources	Release may not be controllable even with special resources
Life safety	No life-threatening situation from materials involved	Localized area, limited evacuation area	Large area, mass evacuation area
Environmental impact (potential)	Minimal	Moderate	Severe
Container integrity	Not damaged	Damaged but able to contain the contents to allow handling or transfer of product	Damaged to such an extent that catastrophic rupture is possible

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Chapter 6 Site Safety

6.1 Emergency Incident Operations.

6.1.1 Emergency incident operations should be conducted in compliance with Chapter 8 of NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, or 29 CFR 1910.120 or EPA's 40 CFR 311.

6.1.2* An incident management system should be implemented at all hazardous materials incidents. Operations should be directed by a designated incident commander and follow established written standard operating procedures.

6.1.2.1 Personnel Accountability. The incident management system should include a standard personnel identification system to maintain accountability for each member engaged in activities at an incident scene. This personnel identification system should have the ability to provide a rapid accounting of all members on the incident scene.

6.1.2.1.1 The personnel identification system should include a means to specifically identify and keep track of members entering and leaving the hot zone and any area where special protective equipment is required.

6.1.2.1.2 The incident management system should include a standard operating procedure to evacuate personnel from an area where an imminent hazard condition is found to exist and account for the safety of personnel. This system should include a method to immediately notify all personnel in the affected area of an imminent hazard condition by means of audible warning devices.

6.1.2.2 Rest and Rehabilitation. The incident commander should consider the circumstances of each incident and make suitable provisions for rest and rehabilitation for members operating at the scene. These considerations should include medical evaluation and treatment, food and fluid replenishment, and relief from extreme climatic conditions, according to the circumstances of the incident. All incident commanders should maintain an awareness of the condition of members operating within their span of control and ensure that adequate steps are taken to provide for their safety and health. The command structure should be utilized to request relief and reassignment of fatigued members.

6.1.3 An emergency response plan describing the general safety procedures that are to be followed at an incident should be prepared in accordance with 29 CFR 1910.120. These procedures should be thoroughly reviewed and tested.

6.2 Ignition Sources. Ignition sources should be eliminated whenever possible at incidents involving releases, or probable releases, of ignitable materials. Whenever possible, electrical devices used within the hot zone should be certified as intrinsically safe by recognized organizations.

6.3 Control Zones. Control zone names have not been consistently applied at incidents. The intent of this section is to show areas of responder control. The various zones or areas at a typical emergency response site are shown in Figure 6.3.

6.3.1* Hot Zone. The hot zone is the area immediately surrounding a hazardous materials incident, extending far enough to prevent adverse effects from hazardous materials releases to personnel outside the zone. This zone is also referred to as the exclusion zone or restricted zone in other documents.

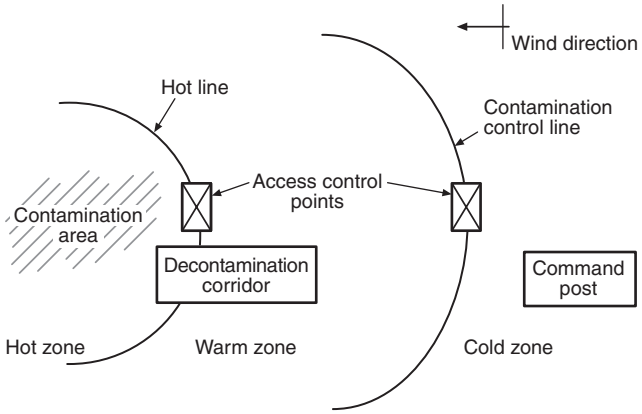

FIGURE 6.3 Diagram of Control Zones.

6.3.2 Warm Zone. The warm zone is the area where personnel and equipment decontamination and hot zone support take place. It includes control points for the access corridor and thus assists in reducing the spread of contamination. This zone is also referred to as the decontamination, contamination reduction, or limited access zone in other documents.

6.3.3 Cold Zone. The cold zone contains the command post and such other support functions as are deemed necessary to control the incident. This zone is also referred to as the clean zone or support zone in other documents.

6.4 Communications.

6.4.1 When personal protective clothing or remote operations inhibit communications, an effective means of communication, such as radios, should be established.

6.4.2 The frequencies employed in these radios should be "dedicated" and not used or shared with other local agencies.

6.4.3 Communication should be supplemented by a prearranged set of hand signals and hand-light signals to be used when primary communication methods fail. Hand-lights employed for this purpose should be in accordance with NFPA 70, *National Electrical Code®*, for use in hazardous environments.

6.5 Monitoring Equipment.

6.5.1 Monitoring equipment operates on several different principles and measures different aspects of hazardous materials releases. Examples of this equipment include the following:

(1) Oxygen meters
(2) Combustible gas indicator (explosimeter)
(3) Carbon monoxide meter
(4) pH meter
(5) Radiation detection instruments
    (a) Personal dosimetry [film or thermoluminescent dosimetry (TLD), or electronic dosimetry]
    (b) Survey instruments for contamination (count rate) or exposure (dose rate)
(6) Colorimetric detector tubes
(7) Organic vapor analyzer
(8) Photoionization meter
(9) Air sampling devices
(10) Other meters to measure specific products such as chlorine, hydrogen sulfide, or ethylene oxide
(11) pH paper or strips

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(12) Organic vapor badge or film strip
(13) Mercury badge
(14) Formaldehyde badge or strip

6.5.2 All monitoring equipment should be operationally checked prior to use and periodically calibrated in accordance with manufacturers' specifications.

Chapter 7 Personal Protective Equipment

7.1 General. It is essential that personal protective equipment meeting NFPA and OSHA standards be provided, maintained, and used. Protection against physical, chemical, and thermal hazards should be considered when selecting personal protective equipment.

7.1.1 A written personal protective equipment program should be established in accordance with 29 CFR 1910.120. Elements of the program should include personal protective equipment selection and use; storage, maintenance, and inspection procedures; and training considerations. The selection of personal protective clothing should be based on the hazardous materials and conditions present.

7.1.2 Protective clothing and equipment used to perform fire suppression operations, beyond the incipient stage, should meet the requirements of Chapter 5 of NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program.* Structural fire-fighting protective clothing is not intended to provide chemical protection to the user.

7.2 Respiratory Protective Equipment.

7.2.1 Self-contained breathing apparatus (SCBA) should meet the requirements of NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service.*

7.2.2 Personal alert safety systems should meet the requirements of NFPA 1982, *Standard on Personal Alert Safety Systems (PASS).*

7.2.3 Air purifying respirators are devices worn to filter particulates and contaminants from the air. They should be worn only in atmospheres where the type and quantity of the contaminants are known and sufficient oxygen is known to be present.

7.3 Chemical-Protective Clothing.

7.3.1 Chemical-protective clothing (CPC) is made from special materials and is designed to prevent the contact of chemicals with the body. CPC is of two types: liquid splash and vapor-protective.

7.3.2 A variety of materials are used to make the fabric from which chemical-protective clothing is manufactured. Each material provides protection against certain specified chemicals or mixtures of chemicals but might afford little or no protection against certain other chemicals. It is most important to note that there is no material that provides satisfactory protection from all chemicals. Protective clothing material needs to be compatible with the chemical substances involved, consistent with manufacturers' instructions.

7.3.3* Performance requirements need to be considered in selecting the chemical-protective material. These requirements would include chemical resistance, permeation, penetration, flexibility, abrasion, temperature resistance, shelf life, and sizing criteria.

7.4 Thermal Protection.

7.4.1 Proximity Suits. These suits provide short duration and close proximity protection at radiant heat temperatures as high as 1093°C (2000°F) and can withstand some exposure to water and steam. Respiratory protection equipment needs to be provided with proximity suits.

7.4.2 Fire Entry Suits. These suits provide protection for brief entry into a total flame environment at temperatures as high as 1093°C (2000°F). They are not effective or meant to be used for rescue operations. Respiratory protection equipment needs to be provided with fire entry suits.

7.4.3 Overprotection Garments. These garments are worn in conjunction with chemical-protective encapsulating suits.

7.4.3.1 Flash Cover Protective Suits. Flash cover suits are neither proximity nor fire entry suits. They provide limited overprotection against flashback only. They are worn outside of other protective suits and are used only when the risks require them.

7.4.3.2 Low Temperature Suits. Low temperature suits provide some degree of protection of the encapsulating chemical-protective clothing from contact with low temperature gases and liquids. They are worn outside of the encapsulating chemical-protective clothing and are used only when the risks require them.

7.5 Levels of Protection. Personal protective equipment is divided into four categories based on the degree of protection afforded.

7.5.1 Level A. Level A equipment is to be selected when the greatest level of skin, respiratory, and eye protection is required. The following constitute Level A equipment:

(1) Pressure-demand, full facepiece, SCBA, or pressure-demand air line respirator with escape SCBA, approved by the National Institute of Occupational Safety and Health (NIOSH)
(2) Vapor-protective suits: totally encapsulating chemical-protective suits (TECP suits) constructed of protective clothing materials that meet the following criteria:
    (a) Cover the wearer's torso, head, arms, and legs
    (b) Include boots and gloves that may either be an integral part of the suit or separate and tightly attached
    (c) Completely enclose the wearer by itself or in combination with the wearer's respiratory equipment, gloves, and boots
    (d) All components of a TECP suit, such as relief valves, seams, and closure assemblies, should provide equivalent chemical resistance protection. Vapor-protective suits should meet the requirements in NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies.*
(3) Coveralls (optional)
(4) Long underwear (optional)
(5) Gloves, outer, chemical-resistant
(6) Gloves, inner, chemical-resistant
(7) Boots, chemical-resistant, steel toe and shank
(8) Hard hat (under suit) (optional)
(9) Disposable protective suit, gloves, and boots (depending on suit construction, can be worn over totally encapsulating suit)
(10) Two-way radios (worn inside encapsulating suit)

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7.5.2 Level B. Level B personal protective equipment should be used when the highest level of respiratory protection is necessary but a lesser level of skin protection is needed. The following constitute Level B equipment:

(1) Pressure-demand, full facepiece, SCBA, or pressure-demand air line respirator with escape SCBA, NIOSH approved
(2) Hooded chemical-resistant clothing that meets the requirements of NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies* (overalls and long-sleeved jacket, coveralls, one- or two-piece chemical-splash suit, disposable chemical-resistant overalls)
(3) Coveralls (optional)
(4) Gloves, outer, chemical-resistant
(5) Gloves, inner, chemical-resistant
(6) Boots, outer, chemical-resistant, steel toe and shank
(7) Boot covers, outer, chemical-resistant (disposable) (optional)
(8) Hard hat
(9) Two-way radios (worn inside encapsulating suit)
(10) Face shield (optional)

7.5.3* Level C. Level C personal protective equipment should be used when the concentration(s) and type(s) of airborne substance(s) is known and the criteria for using air purifying respirators are met. The following constitute Level C equipment:

(1) Full-face or half-mask, air purifying respirators, NIOSH approved
(2) Hooded chemical-resistant clothing (overalls, two-piece chemical-splash suit, disposable chemical-resistant overalls)
(3) Coveralls (optional)
(4) Gloves, outer, chemical-resistant
(5) Gloves, inner, chemical-resistant
(6) Boots, outer, chemical-resistant, steel toe and shank
(7) Boot covers, outer, chemical-resistant (disposable) (optional)
(8) Hard hat
(9) Escape mask (optional)
(10) Two-way radios (worn under outside protective clothing)
(11) Face shield (optional)

7.5.4 Level D. A work uniform affording minimal protection, Level D personal protective equipment should be used for nuisance contamination only. The following constitute Level D equipment:

(1) Coveralls
(2) Gloves (optional)
(3) Boots/shoes, chemical-resistant, steel toe and shank
(4) Boots, outer, chemical-resistant (disposable) (optional)
(5) Safety glasses or chemical-splash goggles
(6) Hard hat
(7) Escape mask (optional)
(8) Face shield (optional)

7.6 Types of Hazards. The types of hazards for which Levels A, B, C, and D protection are appropriate are described in this section.

7.6.1 Level A protection should be used under any of the following conditions:

(1) When the hazardous material has 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 concentration 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 material that are harmful to skin or capable of being absorbed through the intact skin
(2) When substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible
(3) When operations need to be conducted in confined, poorly ventilated areas, and the absence of conditions requiring Level A has not yet been determined

7.6.2 Level B protection should be used under any of the following conditions:

(1)* When the type and atmospheric concentration of substances have been identified and require a high level of respiratory protection but less skin protection
(2) When the atmosphere contains less than 19.5 percent oxygen
(3) When the presence of incompletely identified vapors or gases is indicated by a direct-reading organic vapor detection instrument, but the vapors and gases are known not to contain high levels of chemicals harmful to skin or capable of being absorbed through the intact skin
(4) When the presence of liquids or particulates is indicated, but they are known not to contain high levels of chemicals harmful to skin or capable of being absorbed through the intact skin

7.6.3 Level C protection should be used under any of the following conditions:

(1) When the atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect or be absorbed through any exposed skin
(2) When the types of air contaminants have been identified, concentrations have been measured, and an air purifying respirator is available that can remove the contaminants
(3) When all criteria for the use of air purifying respirators are met
(4)* Atmospheric concentration of chemicals must not exceed immediately dangerous to life and health (IDLH) levels. The atmosphere must contain at least 19.5 percent oxygen.

7.6.4 Level D protection should be used when both of the following conditions exist:

(1) The atmosphere contains no known hazard
(2)* Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals

Chapter 8 Incident Mitigation

8.1 Control. This chapter addresses those actions necessary to ensure confinement and containment, which is the first line of defense, in a manner that will minimize risk to both life and the environment in the early, critical stages of a spill or leak. Both natural and synthetic methods can be employed to limit the releases of hazardous materials so that effective recovery and treatment can be accomplished with minimum additional risk to the environment or to life.

8.2 Types of Hazardous Materials.

8.2.1 Chemical Materials. Chemical materials are those materials that pose a hazard based upon their chemical and physical properties.

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8.2.2 Biological Materials. Biological materials are those organisms that have a pathogenic effect on life and the environment and can exist in normal ambient environments.

8.2.3 Radioactive Materials. Radioactive materials are those materials that emit ionizing radiation.

8.3 Physical States of Hazardous Materials. Hazardous materials can be classified into three states, namely gases, solids, and liquids. They can be stored or contained at a high or low pressure. All three states can be affected by the environment in which the incident occurs. The emergency responder needs to take into account such conditions as heat, cold, rain, or wind, each of which can have a significant effect on the methods used to accomplish a safe operation.

8.4 Methods of Mitigation. There are two basic methods for mitigation of hazardous materials incidents: physical and chemical. Table 8.4.1 lists many physical methods and Table 8.4.2 lists many chemical methods for mitigation of hazardous materials incidents. Recommended practices should be implemented only by personnel prepared by training, education, or experience.

8.4.1* Physical Methods. Physical methods of control involve any of several processes or procedures to reduce the area of the spill, leak, or other release mechanism. In all cases, methods used should be approved by the incident commander. The selection of personal protective clothing should be based on the hazardous materials and/or conditions present and should be appropriate for the hazards encountered. *(See Table 8.4.1.)*

8.4.1.1* Absorption. Absorption is the process in which materials hold liquids through the process of wetting. Absorption is accompanied by an increase in the volume of the sorbate/sorbent system through the process of swelling. Some of the materials typically used as absorbents are sawdust, clays, charcoal, and polyolefin-type fibers. These materials can be used for confinement, but it should be noted that the sorbed liquid can be desorbed under mechanical or thermal stress. When absorbents become contaminated, they retain the properties of the absorbed hazardous liquid and are, therefore, considered to be hazardous materials and must be treated and disposed of accordingly. *(See ASTM F 716, Method of Testing Sorbent Performance of Absorbents, for further information.)*

8.4.1.2 Covering. Covering is a temporary form of mitigation for radioactive, biological, and some chemical substances such as magnesium. It should be done after consultation with a certified health physicist (in the case of radioactive materials) or other experts.

8.4.1.3 Dikes, Dams, Diversions, and Retention. These terms refer to the use of physical barriers to prevent or reduce the quantity of liquid flowing into the environment. Dikes or dams usually refer to concrete, earth, and other barriers temporarily or permanently constructed to hold back a spill or leak. Diversion refers to the methods used to physically change the direction of flow of the liquid. Vapors from certain materials, such as liquefied petroleum gas (LPG), can be dispersed by means of a water spray.

Table 8.4.1 Physical Methods of Mitigation of Hazardous Materials Incidents

	Chemical				Biological				Radioactive			
	Gases				Gases				Gases			
Method	LVP*	HVP**	Liq.	Sol.	LVP	HVP	Liq.	Sol.	LVP	HVP	Liq.	Sol.
Absorption	yes	yes	yes	no	no	no	yes[4]	no	no	no	yes	no
Covering	no	no	yes	yes	no	no	yes	yes	no	no	yes[3]	yes[3]
Dikes, dams, diversions, and retention	yes	yes[5]	yes	yes	no	no	yes	yes	no	no	yes	yes
Dilution	yes	yes[5]	yes	yes	no	no	no	no	yes	no	yes	yes
Overpack	yes	no	yes	yes	yes	no	yes	yes	yes	no	yes	yes
Plug/patch	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Transfer	yes	no	yes	yes	yes	no	yes	yes	yes	no	yes	yes
Vapor suppression (blanketing)	no	no	yes	yes	no	no	yes	yes	no	no	no	no
Vacuuming	no	no	yes	yes	no	no	yes	yes	no	no	yes	yes
Venting[1]	yes	yes	yes	no	yes	no	no	no	yes[2]	no	no	no

Note: For substances involving more than one type, the most restrictive control measure should be used.

*Low Vapor Pressure

**High Vapor Pressure

[1]Venting of low-vapor-pressure gases is recommended only when an understanding of the biological system is known. Venting is allowed when the bacteriological system is known to be nonpathogenic, or if methods can be employed to make the environment hostile to pathogenic bacteria.

[2]Venting of low-vapor-pressure radiological gases is allowed when the gas(es) is/are known to be alpha or beta emitters with short half-lives. Further, this venting is only to be allowed after careful consultation with a radiation protection technologist, the technician with a radioactive material specialty, or certified health physicist.

[3]Covering should be done only after consultation with experts.

[4]Absorption of liquids containing bacteria is permitted where the absorption medium or environment is hostile to the medium.

[5]Water dispersion on certain vapors and gases only.

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8.4.1.4 Dilution. Dilution is the application of water to water-miscible hazardous materials. The goal is to reduce the hazard to safe levels.

8.4.1.5 Overpacking. The most common form of overpacking is accomplished by the use of an oversized container. Overpack containers should be compatible with the hazards of the materials involved. If the material is to be shipped, DOT specification overpack containers need to be used. (The spilled materials still should be treated or disposed of properly.)

8.4.1.6 Plug and Patch. Plugging and patching is the use of compatible plugs and patches to reduce or temporarily stop the flow of materials from small holes, rips, tears, or gashes in containers. The repaired container should not be reused without inspection and certification.

8.4.1.7 Transfer. Transfer is the process of moving a liquid, gas, or some forms of solids, either manually, by pump, or by pressure, from a leaking or damaged container or tank. Care needs to be taken to ensure the pump, transfer hoses and fittings, and container selected are compatible with the hazardous material. When a product transfer presents fire or explosion hazard, concern for electrical continuity, such as bonding/grounding, needs to be observed.

8.4.1.8 Vacuuming. Many hazardous materials may be placed in containment simply by vacuuming them up. This has the advantage of not causing an increase in volume. Care needs to be taken to ensure compatibility of materials. The exhaust air can be filtered, scrubbed, or treated as needed. The method of vacuuming will depend on the nature of the hazardous material.

8.4.1.9 Vapor Dispersion. Vapors from certain materials can be dispersed or moved by means of a water spray. With other products, such as LPG, the gas concentration may be reduced below the lower flammable limit through rapid mixing of the gas with air, using the turbulence created by a fine water spray. Reducing the concentration of the material through the use of water spray may bring the material into its flammable range.

8.4.1.10 Vapor Suppression (Blanketing). Vapor suppression is the reduction or elimination of vapors emanating from a spilled or released material through the most efficient method or application of specially designed agents. A recommended vapor suppression agent is an aqueous foam blanket. *(See Annex C for more information.)*

8.4.1.11 Venting. Venting is a process that is used to deal with liquids or liquefied compressed gases where a danger, such as an explosion or mechanical rupture of the container or vessel, is considered likely. The method of venting will depend on the nature of the hazardous material. In general, it involves the controlled release of the material to reduce and contain the pressure and diminish the probability of an explosion.

8.4.2* Chemical Methods. Chemical methods of control involve the application of chemicals to treat spills of hazardous materials. Chemical methods may involve any one of several actions to reduce the involved area affected by the release of a hazardous material. *(See Table 8.4.2.)* In all cases, methods used should be acceptable to the incident commander. The selection of personal protective clothing should be based on the hazardous materials and/or conditions present and should be appropriate for the hazards encountered.

8.4.2.1* Adsorption. Adsorption is the process in which a sorbate (hazardous liquid) interacts with a solid sorbent surface. *(See ASTM F 726, Method of Testing Sorbent Performance of Adsorbents, for further information.)* The principal characteristics of this interaction are the following:

(1) The sorbent surface, unlike absorbents, is rigid and no volume increase occurs.
(2) The adsorption process is accompanied by heat of adsorption whereas absorption is not.
(3) Adsorption occurs only with activated surfaces, e.g., activated carbon, alumina, etc.

8.4.2.2 Controlled Burning. For purposes of this practice, controlled combustion is considered a chemical method of

Table 8.4.2 Chemical Methods of Mitigation of Hazardous Materials Incidents

	Chemical				Biological				Radioactive			
	Gases				Gases				Gases			
Method	LVP*	HVP**	Liq.	Sol.	LVP	HVP	Liq.	Sol.	LVP	HVP	Liq.	Sol
Adsorption	yes	yes	yes	no	yes[3]	yes	yes[3]	no	no	no	no	no
Burn	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	no
Dispersion/ emulsification	no	no	yes	yes	no	no	yes[3]	no	no	no	no	no
Flare	yes	yes	yes	no	yes	yes	yes	no	no	no	no	no
Gelatin	yes	no	yes	yes	yes[3]	no	yes[3]	yes[3]	no	no	no	no
Neutralization	yes[1]	yes[4]	yes	yes[2]	no	no	no	no	no	no	no	no
Polymerization	yes	no	yes	yes	no	no	no	no	no	no	no	no
Solidification	no	no	yes	no	no	no	yes[3]	no	no	no	yes	no
Vapor suppression	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Vent/Burn	yes	yes	yes	no	yes	yes	yes	no	no	no	no	no

*Low Vapor Pressure
**High Vapor Pressure
[1]Technique may be possible as a liquid or solid neutralizing agent, and water can be applied.
[2]When solid neutralizing agents are used, they must be used simultaneously with water.
[3]Technique is permitted only if resulting material is hostile to the bacteria.
[4]The use of this procedure requires special expertise and technique.

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control. However, it should be used only by qualified personnel trained specifically in this procedure. In some emergency situations where extinguishing a fire will result in large, uncontained volumes of contaminated water, or threaten the safety of responders or the public, controlled burning is used as a technique. It is recommended that consultation be made with the environmental authorities when this method is used.

8.4.2.3 Dispersants, Surface Active Agents, and Biological Additives. Certain chemical and biological agents can be used to disperse or break up the materials involved in liquid spills. The use of these agents results in a lack of containment and generally results in spreading the liquid over a much larger area. Dispersants are most often applied to spills of liquids on water. The dispersant breaks down a liquid spill into many fine droplets, thereby diluting the material. Use of this method may require the prior approval of the environmental authority.

8.4.2.4 Flaring. Flaring is a process that is used with high-vapor-pressure liquids or liquefied compressed gases for the safe disposal of the product. Flaring is the controlled burning of material in order to reduce or control pressure and/or dispose of a product.

8.4.2.5 Gelation. Gelation is the process of forming a gel. A gel is a colloidal system consisting of two phases, a solid and a liquid. The resulting gel is considered to be a hazardous material and needs to be disposed of properly.

8.4.2.6 Neutralization. Neutralization is the process of applying acids or bases to a spill to form a neutral salt. The application of solids for neutralizing can often result in confinement of the spilled material. Special formulations are available that do not result in violent reactions or local heat generation during the neutralization process. In cases where special neutralizing formulations are not available, special considerations should be given to protecting persons applying the neutralizing agent, as heat is generated and violent reactions can occur. One of the advantages of neutralization is that a hazardous material can be rendered nonhazardous.

8.4.2.7 Polymerization. Polymerization is a process in which a hazardous material is reacted in the presence of a catalyst, in the presence of heat or light, or with itself or another material to form a polymeric system.

8.4.2.8 Solidification. Solidification is the process whereby a hazardous liquid is treated chemically so that a solid material results. Adsorbents can be considered an example of a solidification process. There are other materials that can be used to convert hazardous liquids into nonhazardous solids. Examples are applications of special formulations designed to form a neutral salt in the case of spills of acids or caustics. The advantage of the solidification process is that a spill of small scale can be confined relatively quickly and treatment effected immediately.

8.4.2.9 Vapor Suppression. Vapor suppression is the use of solid activated materials to treat hazardous materials so as to effect suppression of the vapor off-gasing from the materials. This process results in the formation of a solid that affords easier handling but that may result in a hazardous solid that must be disposed of properly.

8.4.2.10 Venting and Burning. This process involves the use of shaped charges to vent the high vapor pressure at the top of the container and then the use of additional charges to release and burn the remaining liquid in the container in a controlled fashion.

Chapter 9 Decontamination

9.1 Decontamination Plan. At every incident involving hazardous materials, there is a possibility that personnel, their equipment, and members of the general public will become contaminated. The contaminant poses a threat, not only to the persons contaminated, but to other personnel who may subsequently come into contact with the contaminated personnel and equipment. The entire process of decontamination should be directed toward confinement of the contaminant within the hot zone and the decontamination corridor to maintain the safety and health of response personnel, the general public, and the environment. Sound judgment should be exercised and the potential effects of the decontamination process upon personnel should be considered when developing the decontamination plan.

9.1.1 Although decontamination is typically performed following site entry, the determination of decontamination methods and procedures needs to be considered before the incident as part of the overall pre-incident planning and hazard and risk evaluation process. No entry into the hot zone should be permitted until decontamination methods are determined and established based on the hazards present, except in those situations where a rescue may be possible and emergency decontamination is available.

9.1.2 Emergency response personnel should be familiar with the definitions of the following terminology:

(1) Contaminant
(2) Contamination
(3) Decontamination (contamination reduction)
(4) Decontamination corridor
(5) Emergency decontamination
(6) Exposure
(7) Gross decontamination
(8) Secondary contamination

9.2 Decontamination. Decontamination consists of reducing and preventing the spread of contamination from persons and equipment used at a hazardous materials incident by physical and/or chemical processes. Emergency response personnel should implement a thorough, technically sound decontamination procedure until it is determined or judged to be no longer necessary.

9.2.1 Emergency response personnel should have an established procedure to minimize contamination or contact, to limit migration of contaminants, and to dispose of contaminated materials. The primary objective of decontamination is to avoid becoming contaminated or contaminating other personnel or equipment outside of the hot zone. If contamination is suspected, decontamination of personnel, equipment, and apparatus should be performed.

9.2.2 Procedures for all phases of decontamination need to be developed and implemented to reduce the possibility of contamination to personnel and equipment. Initial procedures should be upgraded or downgraded as additional information is obtained concerning the type of hazardous materials involved, the degree of hazard, and the probability of exposure of response personnel. Reference guides for the development of decontamination procedures can be found in Annex B. Assuming protective equipment is grossly contaminated, decontamination methods should be used for the chemicals encountered.

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9.2.3 The decision to implement all or part of a decontamination procedure should be based upon a field analysis of the hazards and risks involved. This analysis generally consists of referring to technical reference sources to determine the general hazards, such as flammability and toxicity, and then evaluating the relative risks. Decontamination procedures should be implemented upon arrival at the scene, should provide an adequate number of decontamination stations and personnel, and should continue until the incident commander determines that decontamination procedures are no longer required.

9.2.4 There are occasions when an apparently normal alarm response turns into a hazardous materials incident. Frequently, most of the initial assignment crews will have already gone into the incident area and exposed themselves to the contamination threat.

9.2.4.1 It is essential that all members so involved remove themselves from the area at once, call for decontamination capability, and stay together in one location. They must not wander around, climb on and off apparatus, and mix with other personnel since there is a potential for them to be contaminated.

9.2.4.2 Fire fighters so exposed should be given gross decontamination as a precautionary measure. Knowledgeable hazardous materials personnel, such as the decontamination sector officer, in conjunction with the incident commander, should determine whether more definitive decontamination is necessary.

9.2.4.3 The primary objective of decontamination is to avoid contaminating anyone or anything beyond the hot zone. When in doubt about contamination, decontaminate all involved personnel, equipment, and apparatus.

9.3 Decontamination Methods.

9.3.1 Physical Methods. Physical methods generally involve the physical removal of the contaminant from the contaminated person or object and containment of the contaminant for disposal. While these methods can reduce the contaminant's concentration, generally the containment remains chemically unchanged. Examples of physical decontamination methods include the following:

(1) Absorption
(2) Brushing and scraping
(3) Isolation and disposal
(4) Vacuuming
(5) Washing

9.3.2 Chemical Methods. Chemical methods are used on equipment, not people, and generally involve decontamination by changing the contaminant through some type of chemical reaction in an effort to render the contaminant less harmful. In the case of etiologic contaminants, chemical methods are actually biologically "killing" the organism. Examples of chemical methods include the following:

(1) Adsorption
(2) Chemical degradation
(3) Disinfection or sterilization
(4) Neutralization
(5) Solidification

9.3.3 Prevention Methods. If contact with a contaminant can be controlled, the risk of exposure is reduced and the need for decontamination can be minimized. The following points should be considered to prevent contamination:

(1) Stress work practices that minimize contact with hazardous substances.
(2) Wear limited-use or disposable protective clothing and equipment, where appropriate.

9.4 Decontaminating Personal Protective Equipment (PPE). During doffing of PPE, the clothing should be removed in such a manner that the outside surfaces do not touch or make contact with the wearer. A log of PPE used during the incident should be maintained. Personnel wearing disposable PPE should proceed through the decontamination process setup in the decontamination area, and the disposable protective equipment should be containerized and identified for disposal in accordance with established procedures.

9.4.1 The physical and chemical compatibility of decontamination solutions needs to be determined before they are used. Any decontamination method that permeates, degrades, damages, or otherwise impairs the safe function of PPE should not be used unless there are plans to isolate and dispose of the PPE.

9.4.2 Water or other solutions for washing or rinsing may have to be confined, collected, containerized, and analyzed for treatment and disposal. Consult with environmental and public health agencies or other reference sources and guidelines to determine the need for confinement and the disposal methods for collected decontamination fluids and PPE.

9.4.3 Decontamination methods vary in their effectiveness for removing different substances. The effectiveness of any decontamination method should be assessed throughout the decontamination operation. If decontamination does not appear to be effective, a different method should be selected and implemented. Before initiating decontamination, the following questions should be considered:

(1) Can decontamination be conducted safely?
(2) Are existing resources adequate and immediately available to perform decontamination of personnel and equipment? If not, where can they be obtained, and how long will it take to get them?

9.4.4 Criteria that can be used for evaluating decontamination effectiveness during field operations include the following:

(1) Contamination levels are reduced as personnel move through the decontamination corridor.
(2) Contamination is confined to the hot zone and decontamination corridor.
(3) Contamination is reduced to a level that is as low as reasonably achievable.

9.4.5* Methods that may be useful in assessing the effectiveness of decontamination include the following:

(1) Visual observation (stains, discolorations, corrosive effects, etc.)
(2) Monitoring devices [Devices such as photoionization detectors (PIDs), detector tubes, radiation monitors, and pH paper strips/meters can show that contamination levels are at least below the device's detection limit.]
(3) Wipe sampling (Such sampling provides after-the-fact information on the effectiveness of decontamination. Once a wipe swab is taken, it is analyzed by chemical means, usually in a laboratory. Both protective clothing, equipment, and skin may be tested using wipe samples.)

9.4.6 Large items of equipment, such as vehicles and trucks, should be subjected to decontamination by washes, high-

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pressure washes, steam, or special solutions. Water or other solutions used for washing or rinsing may have to be confined, collected, containerized, analyzed, and treated prior to disposal. Consult with environmental and public health agencies to determine the appropriate disposition. If a large number of vehicles need to be decontaminated, the following recommendations should be considered:

(1) Establish a decontamination pad as a primary wash station. The pad may be a coarse gravel pad, concrete slab, or a pool liner. It may be necessary to collect these decontamination fluids, and the decontamination pad may be bermed or diked with a sump or some form of water recovery system.
(2) Completely wash and rinse vehicles several times with detergent. Pay particular attention to wheel wells, radiators, engines, and chassis. Depending on the nature of the contaminant, it may be necessary to collect all runoff water from the initial gross rinse, particularly if there is contaminated mud and dirt on the underside of the chassis.
(3) Vehicles should be inspected thoroughly by qualified personnel for possible mechanical or electrical damage. Areas of concern include air intakes, filters, cooling systems, and air-operated systems.
(4) Empty completely and thoroughly wash any outside compartments that were opened. The equipment should be washed and rinsed prior to being replaced.
(5) Equipment sprayed with acids should be flushed or washed as soon as possible with a neutralizing agent such as baking soda and then flushed again with rinse water.
(6) If vehicles have been exposed to minimal contaminants such as smoke and vapors, they may be decontaminated on-site and then driven to an off-site car wash for a second, more thorough washing. Car washes may be suitable if the drainage area is fully contained and all runoff drains into a holding tank.
(7) Verification of adequacy of decontamination may consist of samples collected from the cab and exterior surfaces that are analyzed in an off-site laboratory.

9.4.7 Personnel assigned to the decontamination team should wear an appropriate level of PPE and may require decontamination themselves. PPE can be upgraded or downgraded as additional information is obtained concerning the type of hazardous materials involved, the degree of hazard, and the probability of exposure of response personnel.

9.4.8 If personnel display any symptoms of heat exhaustion or possible exposure, emergency measures need to be implemented to doff PPE, while protecting the individual from contaminants and preventing the spread of any contaminants. These individuals should be transferred to the care of emergency medical services personnel who have completed training in accordance with applicable standards such as NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials Incidents.*

9.4.9 A debriefing should be held for those involved in decontamination as soon as practical. Exposed persons should be provided with as much information as possible about the delayed health effects of the hazardous materials involved in the incident. If necessary, follow-up examinations should be scheduled with medical personnel.

9.4.10 Exposure records should be maintained for future reference by the individual's personal physician and employer.

Chapter 10 Medical Monitoring

10.1 Introduction.

10.1.1 Purpose. The purpose of this chapter is to provide guidelines for local jurisdictions to perform medical monitoring for hazardous materials response personnel. It is not the intent of this recommended practice to restrict any jurisdiction's medical authority from using different or modified guidelines. Locally established guidelines for medical monitoring should not be negated by a decision of command personnel.

10.1.2 Definition. Medical monitoring is the ongoing, systematic evaluation of response personnel who are at risk of suffering adverse effects of heat/cold exposure, stress, or hazardous materials exposure. This monitoring is done for the purpose of achieving early recognition and prevention of these effects in order to maintain the optimal health and safety of on-scene personnel.

10.1.3 Objectives. Medical monitoring is performed at the site of a hazardous materials incident for the following reasons:

(1) To obtain baseline vital signs and physical assessment
(2) To identify and preclude from participation in the hot zone and warm zone activities individuals at increased risk for sustaining injury and illness as a result of on-scene activities
(3) To provide early recognition and treatment of personnel with adverse physiological responses as a result of on-scene activities

10.1.4 Pre-Entry. Pre-entry medical monitoring should be completed on all individuals wearing chemical liquid splash- and vapor-protective clothing and performing hazardous materials operations. It should be completed within one hour prior to entry.

10.2 Components of Pre-Entrance Medical Monitoring.

10.2.1 Vital Signs. Pre-entrance medical monitoring should include the evaluation of the following vital signs:

(1) Blood pressure
(2) Pulse
(3) Respiratory rate
(4) Temperature
(5) EKG rhythm strip (10 seconds), if available

10.2.2 Skin Evaluation. Pre-entrance medical monitoring should include an examination of the individual's skin for the following:

(1) Rashes
(2) Open sores/wounds

10.2.3 Mental Status. The individual should be alert and oriented to time and place, have clear speech and a normal gait, and be able to respond appropriately to the situation.

10.2.4 Medical History. A recent medical history should be obtained that includes the following:

(1) Medications, including over the counter, taken within the past 72 hours
(2) Alcohol consumption within the past 24 hours
(3) Any new medical treatment or diagnosis made within the past two weeks
(4) Symptoms of fever, nausea, vomiting, diarrhea, or cough within the past 72 hours

10.2.5 Weight. The individual's weight should be recorded.

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10.2.6 Hydration. It should be determined whether the individual has consumed 240 ml to 480 ml (8 oz to 16 oz) of water or diluted activity drink.

10.3 Exclusion Criteria. The following exclusion criteria should be applied to findings of all medical monitoring completed on hazardous materials response personnel. These following criteria provide the EMS Control Officer and the Hazardous Materials Branch Officer with guidelines to determine medical/physical fitness for entry:

(1) Blood pressure — diastolic greater than 105 mm Hg
(2) Pulse — greater than 70 percent of the maximum heart rate (220 – age) *(See Table 10.3.)*
(3) Respiratory rate — greater than 24 per minute
(4) Temperature — greater than 37.5°C (99.5°F) (oral) or greater than 38°C (100.5°F) (core) or less than 36°C (97.0°F) (oral) or less than 37°C (98.0°F) (core)
(5) Weight — no pre-entry exclusion
(6) EKG — dysrhythmia not previously detected (must be cleared by medical control)
(7) Skin evaluation — open sores, large area of rash or significant sunburn
(8) Mental status — altered mental status such as slurred speech, clumsiness, or weakness
(9) Recent medical history:
    (a) Presence of nausea, vomiting, diarrhea, fever, upper respiratory infection, heat illness, or heavy alcohol intake within past 72 hours, all of which contribute to dehydration
    (b) New prescription medications taken within past two weeks or over the counter medications such as cold, flu, or allergy medicines, taken within past 72 hours (must be cleared through local medical control or hazardous materials medical director)
    (c) Any alcohol within past six hours
    (d) Pregnancy

Table 10.3 Age-Predicted Heart Rates

Age	70 Percent
20 – 25	140
25 – 30	136
30 – 35	132
35 – 40	128
40 – 45	125
45 – 50	122

10.4 Components of Medical Monitoring During Entry.

10.4.1 Changes in gait, speech, or behavior that require entry personnel to undergo immediate decontamination, doffing of protective clothing, and assessment should be monitored.

10.4.2 If entry personnel complain of chest pain, dizziness, shortness of breath, weakness, nausea, or headache, they should undergo immediate decontamination, doffing of protective clothing, and assessment.

10.5 Post-Entry Medical Monitoring.

10.5.1 Objectives. Post-entry medical monitoring is performed to determine the following:

(1) Whether an individual has suffered any immediate effects from exposure to a hazardous material or the environment
(2) An individual's health status for future assignment during or following incident (This assessment should include both physiological and psychological considerations.)

10.5.2 Components of post-entry medical monitoring should include the following:

(1) History — any symptom of hazardous material exposure, environmental exposure, or cardiovascular collapse
(2) Vital signs:
    (a) Blood pressure
    (b) Pulse
    (c) Respiratory rate
    (d) Temperature
    (e) EKG (if available)
(3) Weight
(4) Skin evaluation
(5) Mental status

10.6 Post-Medical Monitoring Follow-Up. Post-medical monitoring follow-up should include the following:

(1) Repeat monitoring of vital signs every 5–10 minutes until they return to less than 85 percent of maximum pulse rate. If at 10 minutes the signs have not returned to within 10 percent of baseline, perform orthostatic vital signs.
(2) Determine from medical control what information regarding latent reactions/symptoms should be communicated to response personnel.
(3) If any of the following symptoms are present, contact medical control for direction and preparation for possible transport to a medical facility:
    (a) Body weight loss of greater than 3 percent or positive orthostatic (pulse increase by 20 beats per minute or systolic blood pressure decrease by 20 mm of Hg at two minutes standing)
    (b) Greater than 85 percent maximum pulse at 10 minutes
    (c) Temperature greater than 38°C (101°F) (oral) or 39°C (102°F) (core)
    (d) Nausea, vomiting, diarrhea, altered mental status, or respiratory, cardiac, or dermatologic complaints

10.7 Treatment Protocol for Hazardous Materials Team Members.

10.7.1 Rest time for all personnel should equal at least minimum suit time. Individuals may require additional time for oral rehydration. All personnel should be informed of signs and symptoms to watch for.

10.7.2 If the team member is not within 10 percent of baseline within 10 minutes, orthostatic vital signs should be taken.

10.7.3 If personnel experience greater than 3 percent body weight loss [2 kg (4½ lb) in a 68-kg (150-lb) person]; positive orthostatic (pulse increases by 20 beats per minute or systolic blood pressure decreases by 20 mm of Hg at two minutes standing); greater than 85 percent of maximum pulse at 10 minutes; temperature greater than 38°C (101°F) oral [39°C (102°F) core]; nausea, altered mental status, or any other symptoms, the following treatment should be performed:

(1) Intravenous fluids hydration with Ringers lactate or normal saline at rate (usually wide open) to get pulse less than 100 beats per minute, systolic blood pressure greater than 110 mm of Hg
(2) Administration of oxygen 4 L to 6 L per minute via nasal cannula, may increase as needed
(3) Consultation of reference protocols or medical control for treatment of specific symptoms/types of exposure

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Annex A Explanatory Material

Annex A is not a part of the recommendations of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1 Many of the recommendations in this document are based on U.S. federal laws and regulations that were in effect at the time of adoption. Users should carefully review laws and regulations that may have been added or amended or that may be required by other authorities. Users outside the jurisdiction of the United States should determine what requirements may be in force at the time of application of this document.

A.3.2.1 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.3.1 Absorption. Absorption is accompanied by an increase in the volume of the sorbate/sorbent system through the process of swelling. Some of the materials typically used as absorbents are sawdust, clays, charcoal, and polyolefin-type fibers. These materials can be used for confinement, but it should be noted that the sorbed liquid can be desorbed under mechanical or thermal stress. When absorbents become contaminated, they retain the properties of the absorbed liquid and are, therefore, considered to be hazardous materials and must be treated and disposed of accordingly. *(See ASTM F 716, Method of Testing Sorbent Performance of Absorbents, for further information.)*

A.3.3.2 Adsorption. The principal characteristics are the following: (a) The sorbent surface is rigid and no volume increase occurs as is the case with absorbents. (b) The adsorption process is accompanied by heat of adsorption whereas absorption is not. (c) Adsorption occurs only with activated surfaces, e.g., activated carbon, alumina, etc. *(See ASTM F 726, Method of Testing Sorbent Performance of Adsorbents, for further information.)*

A.3.3.8 Control Zones. Many terms are used to describe the zones involved in a hazardous materials incident. For purposes of this document, these zones are defined as the hot, warm, and cold zones.

A.3.3.9.2 Gross Decontamination. This phase can include mechanical removing and initial rinsing.

A.3.3.12 Disinfection. Proper disinfection results in a reduction in the number of viable organisms to some acceptable level. It may not totally destroy 100 percent of the microorganisms.

A.3.3.15 Exposure. The magnitude of exposure is dependent primarily upon the duration of exposure and the concentration of the hazardous material. This term is also used to describe a person, an animal, the environment, or a piece of equipment. The exposure may be external, internal, or both.

A.3.3.17 Hazard Sector. It is directed by a sector officer and deals principally with the technical aspects of the incident.

A.3.3.19 Hazardous Material. There are many definitions and descriptive names being used for the term *hazardous material*, each of which depends on the nature of the problem being addressed.

Unfortunately, there is no one list or definition that covers everything. The U.S. agencies involved, as well as state and local governments, have different purposes for regulating hazardous materials that, under certain circumstances, pose a risk to the public or the environment. *(See Annex B for more information on these definitions.)*

A.3.3.21 Incident Commander. This term is equivalent to the on-scene incident commander.

A.3.3.22 Incident Management System. Such systems are sometimes referred to as incident command systems (ICS).

A.3.3.25 National Contingency Plan. This document provides guidance for responses, remedial action, enforcement, and funding mechanisms for hazardous materials incident responses. See 40 CFR 300, Subchapters A through J.

A.3.3.29 Protective Clothing. Protective clothing is divided into three types: (1) Structural fire-fighting protective clothing; (2) High temperature-protective clothing; (3) Chemical-protective clothing; (a) Liquid splash-protective clothing; (b) Vapor-protective clothing.

A.3.3.30 Response. The activities in the response portion of a hazardous materials incident include analyzing the incident, planning the response, implementing the planned response, and evaluating progress.

A.5.1 These incidents can be considered as requiring either offensive or defensive operations.

Offensive operations include actions taken by a hazardous materials responder, in appropriate chemical-protective clothing, to handle an incident in such a manner that contact with the released material may result. These actions include patching or plugging to slow or stop a leak; containing a material in its own package or container; and cleanup operations that may require overpacking or transfer of a product to another container.

Defensive operations include actions taken during an incident where there is no intentional contact with the material involved. These actions include elimination of ignition sources, vapor suppression, and diking or diverting to keep a release in a confined area. Defensive operations require notification and possible evacuation, but does not involve plugging, patching, or cleanup of spilled or leaking materials.

Jurisdictions have the responsibility to develop standard operating procedures that equate levels of response to levels of training indicated in NFPA 472, *Standard for Professional Competence of Responders to Hazardous Materials Incidents*. Depending on the capabilities and training of personnel, the first responder operational level may equate to incident level one and the technician level may equate to incident level two.

Response personnel should operate only at that incident level that matches their knowledge, training, and equipment. If conditions indicate a need for a higher response level, then

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additional personnel, appropriate training, and equipment should be summoned.

A.6.1.2 Although 29 CFR 1910.120 is cited in the text, it should be understood that some states will adopt these regulations under state OSHA plans and others will adopt these regulations through adoption of a similar regulation established by EPA and appropriate state agencies.

A.6.3.1 Access into the hot zone is to be limited to those persons necessary to control the incident. A log is to be maintained at the access control point to record entry and exit time of all personnel in the hot zone. For radioactive materials, the hot zone should encompass not only any area of contamination, but also any area where exposures exceed 20 μSv/hr (2 mR/hr).

A.7.3.3 Chemical resistance is the ability of the material from which the protective garment is made to prevent or reduce degradation and permeation of the fabric by the attack chemical. Degradation is a chemical action involving the molecular breakdown of the material due to contact with a chemical. The action may cause the fabric to swell, shrink, blister, or discolor; become brittle, sticky, or soft; or deteriorate. These changes permit chemicals to penetrate the suit more rapidly or increase the probability of permeation.

Permeation is a chemical action involving the movement of chemicals, on a molecular level, through intact material. There is usually no indication that this process is occurring. Permeation is defined by two terms, *permeation rate* and *breakthrough time*. Permeation rate is the quantity of chemical that will move through an area of protective garment in a given period of time, usually expressed as micrograms of chemical per square centimeter per minute. Breakthrough time is the time required for the chemical to be measured on the inside surface of the fabric. The most desirable protective fabric is one that has the longest breakthrough time and a very low permeation rate. Breakthrough times and permeation rates are not available for all the common suit materials and the variety of chemicals that exist. Manufacturers' data and reference sources should be consulted. Generally, if a material degrades rapidly, permeation will occur rapidly.

Penetration is the movement of material through a suit's closures, such as zippers, buttonholes, seams, flaps, or other design features. Torn or ripped suits will also allow penetration.

A.7.5.3 Refer to OSHA 29 CFR 1910.134.

A.7.6.2(1) This situation involves atmospheres with IDLH (immediately dangerous to life and health) concentrations of specific substances that do not represent a severe skin hazard or that do not meet the criteria for use of air purifying respirators.

A.7.6.3(4) Refer to OSHA 29 CFR 1910.134.

A.7.6.4(2) Combinations of personal protective equipment other than those described for Levels A, B, C, and D protection may be more appropriate and may be used to provide the proper level of protection.

A.8.4.1 Procedures described in 8.4.1.1 through 8.4.1.11 should be completed only by personnel trained in those procedures.

A.8.4.1.1 Absorbents saturated with volatile liquid chemicals can create a more severe vapor hazard than the spill alone because of severely enlarged surface area for vapor release.

A.8.4.2 The procedures described in 8.4.2.1 through 8.4.2.10 should be used only by personnel trained in those procedures.

A.8.4.2.1 Spontaneous ignition can occur through the heat of adsorption of flammable materials and caution should be exercised.

Adsorbents saturated with volatile liquid chemicals can create a more severe vapor hazard than the spill alone because of the severely enlarged surface area for vapor release.

A.9.4.5 It should be noted that for etiologic hazards and many chemical hazards, there is no real-time way to determine the effectiveness of decontamination in the field.

Annex B Hazardous Materials Definitions

This annex is not a part of the recommendations of this NFPA document but is included for informational purposes only.

B.1 General Terms.

B.1.1 Hazardous Materials. The U.S. Department of Transportation (DOT) uses the term *hazardous materials* to cover 11 hazard classes, some of which have subcategories called divisions. DOT includes in its regulations hazardous substances and hazardous wastes as Class 9 (Miscellaneous Hazardous Materials), both of which are regulated by the U.S. Environmental Protection Agency (EPA), if their inherent properties would not otherwise be covered.

B.1.2 Hazardous Substances. EPA uses the term *hazardous substances* for the chemicals that, if released into the environment above a certain amount, must be reported, and, depending on the threat to the environment, federal involvement in handling the incident can be authorized. A list of the hazardous substances is published in Table 302.4 of 40 CFR 302. The U.S. Occupational Safety and Health Administration (OSHA) uses the term *hazardous substance* in 29 CFR 1910.120, which resulted from Title I of the Superfund Amendments and Reauthorization Act (SARA) and covers emergency response. OSHA uses the term differently than EPA does. Hazardous substances, as used by OSHA, cover every chemical regulated by both DOT and EPA.

B.1.3 Extremely Hazardous Substances. EPA uses the term *extremely hazardous substances* for chemicals that must be reported to the appropriate authorities if released above the threshold reporting quantity. Each substance has a threshold reporting quantity. The list of extremely hazardous substances is identified in Title III of SARA of 1986 (40 CFR 355).

B.1.4 Toxic Chemicals. EPA uses the term *toxic chemicals* for chemicals whose total emissions or releases must be reported annually by owners and operators of certain facilities that manufacture, process, or otherwise use a listed toxic chemical. The list of toxic chemicals is identified in Title III of SARA.

B.1.5 Hazardous Wastes. EPA uses the term *hazardous wastes* for chemicals that are regulated under the Resource, Conservation, and Recovery Act (40 CFR 261.33). Hazardous wastes in transportation are regulated by DOT (49 CFR 170–179).

B.1.6 Hazardous Chemicals. OSHA uses the term *hazardous chemicals* to denote any chemical that would be a risk to employees if exposed in the workplace. Hazardous chemicals cover a broader group of chemicals than the other chemical lists.

B.1.7 Dangerous Goods. In international transportation, hazardous materials are called dangerous goods.

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B.2 Other Terms.

B.2.1 Class 1 (Explosives). An explosive is any substance or article, including a device, that is designed to function by explosion (i.e., an extremely rapid release of gas and heat) or that, by chemical reaction within itself, is able to function in a similar manner even if not designed to function by explosion. Explosives in Class 1 are divided into six divisions. Each division will have a letter designation.

B.2.1.1 Division 1.1. Division 1.1 consists of explosives that have a mass explosion hazard. A mass explosion is one that affects almost the entire load instantaneously.

Examples of Division 1.1 explosives include black powder, dynamite, and TNT.

B.2.1.2 Division 1.2. Division 1.2 consists of explosives that have a projection hazard but not a mass explosion hazard.

Examples of Division 1.2 explosives include aerial flares, detonating cord, and power device cartridges.

B.2.1.3 Division 1.3. Division 1.3 consists of explosives that have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.

Examples of Division 1.3 explosives include liquid-fueled rocket motors and propellant explosives.

B.2.1.4 Division 1.4. Division 1.4 consists of explosive devices that present a minor explosion hazard. No device in the division may contain more than 25 g (0.9 oz) of a detonating material. The explosive effects are largely confined to the package, and no projection of fragments of appreciable size or range are expected. An external fire must not cause virtually instantaneous explosion of almost the entire contents of the package.

Examples of Division 1.4 explosives include line-throwing rockets, practice ammunition, and signal cartridges.

B.2.1.5 Division 1.5. Division 1.5 consists of very insensitive explosives. This division is comprised of substances that have a mass explosion hazard but are so insensitive that there is very little probability of initiation or of transition from burning to detonation under normal conditions of transport.

Examples of Division 1.5 explosives include prilled ammonium nitrate fertilizer–fuel oil mixtures (blasting agents).

B.2.1.6 Division 1.6. Division 1.6 consists of extremely insensitive articles that do not have a mass explosive hazard. This division is comprised of articles that contain only extremely insensitive detonating substances and that demonstrate a negligible probability of accidental initiation or propagation.

B.2.2 Class 2 (Gases).

B.2.2.1 Division 2.1. Division 2.1 (flammable gas) consists of any material that is a gas at 20°C (68°F) or less and 101.3 kPa (14.7 psi) of pressure, a material that has a boiling point of 20°C (68°F) or less at 101.3 kPa (14.7 psi), and that

(1) Is ignitable at 101.3 kPa (14.7 psi) when in a mixture of 13 percent or less by volume with air
(2) Has a flammable range at 101.3 kPa (14.7 psi) with air of at least 12 percent regardless of the lower limit
(3) Examples of Division 2.1 gases include inhibited butadienes, methyl chloride, and propane.

B.2.2.2 Division 2.2. Division 2.2 (nonflammable, nonpoisonous compressed gas, including compressed gas, liquefied gas, pressurized cryogenic gas, and compressed gas in solution) consists of any material (or mixture) that exerts in the packaging an absolute pressure of 280 kPa (41 psia) at 20°C (68°F).

A cryogenic liquid is a refrigerated liquefied gas having a boiling point colder than –90°C (–130°F) at 101.3 kPa (14.7 psi) absolute.

Examples of Division 2.2 gases include anhydrous ammonia, cryogenic argon, carbon dioxide, and compressed nitrogen.

B.2.2.3 Division 2.3. Division 2.3 (poisonous gas) consists of a material that is a gas at 20°C (68°F) or less and a pressure of 101.3 kPa (14.7 psi or 1 atm), a material that has a boiling point of 20°C (68°F) or less at 101.3 kPa (14.7 psi), and that

(1) Is known to be so toxic to humans as to pose a hazard to health during transportation
(2) In the absence of adequate data on human toxicity, is presumed to be toxic to humans because, when tested on laboratory animals, it has an LC_{50} value of not more than 5,000 ppm

Examples of Division 2.3 gases include anhydrous hydrogen fluoride, arsine, chlorine, and methyl bromide.

Hazard zones associated with Division 2.3 materials are the following:

(1) Hazard zone A — LC_{50} less than or equal to 200 ppm
(2) Hazard zone B — LC_{50} greater than 200 ppm and less than or equal to 1,000 ppm
(3) Hazard zone C — LC_{50} greater than 1,000 ppm and less than or equal to 3,000 ppm
(4) Hazard zone D — LC_{50} greater than 3,000 ppm and less than or equal to 5,000 ppm

B.2.3 Class 3 (Flammable Liquid). Flammable liquid is any liquid having a flash point of not more than 60.5°C (141°F).

Examples of Class 3 liquids include acetone, amyl acetate, gasoline, methyl alcohol, and toluene.

B.2.4 Combustible Liquid. Combustible liquid is any liquid that does not meet the definition of any other hazard class and has a flash point above 60°C (140°F) and below 93°C (200°F). Flammable liquids with a flash point above 38°C (100°F) may be reclassified as a combustible liquid.

Examples of combustible liquids include mineral oil, peanut oil, and No. 6 fuel oil.

B.2.5 Class 4 (Flammable Solids).

B.2.5.1 Division 4.1. Division 4.1 (flammable solid) consists of any of the following three types of materials:

(1) Wetted explosives — explosives wetted with sufficient water, alcohol, or plasticizers to suppress explosive properties
(2) Self-reactive materials — materials that are liable to undergo, at normal or elevated temperatures, a strongly exothermic decomposition caused by excessively high transport temperatures or by contamination
(3) Readily combustible solids — solids that may cause a fire through friction and any metal powders that can be ignited

Examples of Division 4.1 materials include magnesium (pellets, turnings, or ribbons) and nitrocellulose.

B.2.5.2 Division 4.2. Division 4.2 (spontaneously combustible material) consists of any of the following materials:

(1) Pyrophoric material — a liquid or solid that, even in small quantities and without an external ignition source, can ignite within 5 minutes after coming in contact with air

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(2) Self-heating material — a material that, when in contact with air and without an energy supply, is liable to self-heat

Examples of Division 4.2 materials include aluminum alkyls, charcoal briquettes, magnesium alkyls, and phosphorus.

B.2.5.3 Division 4.3. Division 4.3 (dangerous when wet material) consists of materials that, by contact with water, are liable to become spontaneously flammable or to give off flammable or toxic gas at a rate greater than 1 L/kg of the material per hour.

Examples of Division 4.3 materials include calcium carbide, magnesium powder, potassium metal alloys, and sodium hydride.

B.2.6 Class 5 (Oxidizers and Organic Peroxides).

B.2.6.1 Division 5.1. Division 5.1 (oxidizer) consists of materials that can, generally by yielding oxygen, cause or enhance the combustion of other materials.

Examples of Division 5.1 materials include ammonium nitrate, bromine trifluoride, and calcium hypochlorite.

B.2.6.2 Division 5.2. Division 5.2 (organic peroxide) consists of any organic compound containing oxygen (O) in the bivalent -O-O- structure that may be considered a derivative of hydrogen peroxide, where one or more of the hydrogen atoms have been replaced by organic radicals.

Division 5.2 (organic peroxide) materials are assigned to one of the following seven types:

(1) Type A — organic peroxide that can detonate or deflagrate rapidly as packaged for transport. Transportation of Type A organic peroxides is forbidden.
(2) Type B — organic peroxide that neither detonates nor deflagrates rapidly, but that can undergo a thermal explosion.
(3) Type C — organic peroxide that neither detonates nor deflagrates rapidly and cannot undergo a thermal explosion.
(4) Type D — organic peroxide that detonates only partially or deflagrates slowly, with medium to no effect when heated under confinement.
(5) Type E — organic peroxide that neither detonates nor deflagrates and shows low, or no, effect when heated under confinement.
(6) Type F — organic peroxide that will not detonate, does not deflagrate, shows only a low, or no, effect if heated when confined, and has low, or no, explosive power.
(7) Type G — organic peroxide that will not detonate, does not deflagrate, shows no effect if heated when confined, and has no explosive power, is thermally stable, and is desensitized.

Examples of Division 5.2 materials include dibenzoyl peroxide, methyl ethyl ketone peroxide, and peroxyacetic acid.

B.2.7 Class 6 (Poisonous Materials).

B.2.7.1 Division 6.1. Division 6.1 (poisonous material) consists of materials, other than gases, that either are known to be so toxic to humans as to afford a hazard to health during transportation, or in the absence of adequate data on human toxicity, are presumed to be toxic to humans, including materials that cause irritation.

Examples of Division 6.1 materials include aniline, arsenic compounds, carbon tetrachloride, hydrocyanic acid, and tear gas.

Hazard zones associated with Class 6 materials are the following:

Hazard zone A — LC_{50} less than or equal to 200 ppm

Hazard zone B — LC_{50} greater than 200 ppm and less than or equal to 1,000 ppm

B.2.7.2 Division 6.2. Division 6.2 (infectious substance) consists of viable microorganisms, or their toxin, that cause or may cause disease in humans or animals. Infectious substance and etiologic agent are synonymous.

Examples of Division 6.2 materials include anthrax, botulism, rabies, and tetanus.

B.2.8 Class 7 (Radioactive Materials). Radioactive material is any material having a specific activity greater than 0.002 microcuries per gram (μCi/g).

Examples of Class 7 materials include cobalt, uranium hexafluoride, "yellow cake," radiography sources, and medical isotopes such as barium and technetium.

Radioactive isotopes retain the chemical properties and hazards of their nonradioactive forms.

B.2.9 Class 8 (Corrosive Materials). Corrosive material is a liquid or solid that causes visible destruction or irreversible alterations in human skin tissue at the site of contact, or a liquid that has a severe corrosion rate on steel or aluminum.

Examples of Class 8 materials include nitric acid, phosphorus trichloride, sodium hydroxide, and sulfuric acid.

B.2.10 Class 9 (Miscellaneous). Miscellaneous hazardous material is a material that presents a hazard during transport, but that is not included in another hazard class, including the following:

(1) Any material that has an anesthetic, noxious, or other similar property that could cause extreme annoyance or discomfort to a flight crew member so as to prevent the correct performance of assigned duties
(2) Any material that is not included in any other hazard class, but is subject to the DOT requirements (a hazardous substance or a hazardous waste)

Examples of Class 9 materials include adipic acid, hazardous substances [e.g., Polychlorinated Biphenyls (PCBs)], and molten sulfur.

B.2.11 ORM-D Material. ORM-D material is a material that presents a limited hazard during transportation due to its form, quantity, and packaging.

Examples of ORM-D materials include consumer commodities and small arms ammunition.

B.2.12 Forbidden. Forbidden is defined as prohibited from being offered or accepted for transportation. Prohibition does not apply if these materials are diluted, stabilized, or incorporated in devices.

Annex C Handling Hazardous Liquid Spills

This annex is not a part of the recommendations of this NFPA document but is included for informational purposes only.

C.1 General. One technique available for handling a spill of a hazardous liquid is the application of foams to suppress the vapor emanating from the liquid. This technique is ideally suited for liquid spills that are contained, i.e., diked. It can also be used where the spill is not confined. In all cases this technique should be undertaken only by personnel who have been trained in the use of foam concentrate for vapor suppression. Training in the use of foam as a fire extinguishing agent is not

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sufficient to qualify an individual for applying foam application as a vapor-suppressing agent.

C.2 Foam and Foam Concentrates. Vapor-suppressing foam concentrates vary in their effectiveness depending on a number of factors. These factors can include the type of foam, the 25 percent drainage time of the foam, the rate of application of the foam, and the depth of the foam blanket. These variables serve to emphasize the need for training of the person selecting this technique for applying foam as a vapor-suppressing medium.

Foams are produced by mechanically mixing a dilute solution of the foam concentrate and water with air, producing an expanded foam. Foams have been developed basically as fire extinguishing agents. Data have also been developed on their capability to suppress vapor release from water-immiscible flammable or combustible hydrocarbon liquids.

Foam and specific foam concentrates for each category, along with the definitions of appropriate terms, can be obtained by consulting NFPA 11, *Standard for Low-Expansion Foam;* NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems;* NFPA 16, *Standard for the Installation of Foam-Water Sprinklers and Foam-Water Spray Systems;* and ASTM Standard Guide F 1129, *Using Aqueous Foams to Control the Vapor Hazard from Immiscible Volatile Liquids.*

The use of fire-fighting foam as a vapor suppressant involves some considerations that are different from those required for fire-extinguishing agents. It should be noted that fire-fighting foams are predominantly restricted to use on water-immiscible hydrocarbon liquids or polar compounds. They are not usually effective on inorganic acids or bases, nor on liquefied gases, including the hydrocarbon gases such as methane and propane, in controlling vapor release. One of the obvious issues of concern is the stability of the foam blanket as a function of time. This can be approached by looking at what is referred to as the foam quality.

Foam quality is generally measured in terms of foam expansion ratio and foam 25 percent drainage time. Foam expansion ratio refers to the volume of foam solution. Aqueous film-forming foam (AFFF) is often used in nonaspirating equipment such as water fog nozzles. Nonaspirated AFFF solutions have significantly limited effectiveness in comparison with aspirated foam solutions in vapor suppression.

The 25 percent drainage time is the time that is required for 25 percent of the foam solution to drain from the foam. This is the property that is generally used to measure the stability of the foam. The slower the drainage of any expanded foam, regardless of expansion, the more effective and longer lasting is the foam blanket. This formula assumes weather conditions are ideal.

C.3 Vapor Pressure. An important factor is the vapor pressure of the liquid that is being suppressed. Liquid vapor pressures can vary widely. The higher the vapor pressure, the slower the control time. The key to effective use of foam as a vapor-suppressing agent is to have a continuous foam blanket on the fuel surface. Films from AFFF/FFFP are no guarantee of effective vapor control.

It is important to recognize that there are some limitations in the use of foam fire extinguishing agents in vapor suppression. As indicated, these materials are basically designed for flammable hydrocarbon liquids. They have severe shortcomings for inorganic acids or bases or liquefied gases. They should not be used for vapor suppression of these categories of volatile hazardous chemicals without consultation with the manufacturer of the specific foam agent being considered.

Most fire-fighting foam concentrates have a limited range of pH tolerance. The pH is a measure of the acidity or alkalinity of inorganic acids or bases. The pH tolerance is the level that the bubble wall of the foam can tolerate before collapsing catastrophically. A few surfactant foams and the polar compound-type foams have good pH tolerance. Most of the protein, fluoroprotein, AFFFs, and high-expansion foams are not suitable for inorganic acids or bases.

C.4 Foam Blankets. Liquefied gas spills may be controlled by the application of high-expansion foam blankets. Low-expansion foams are not effective for liquefied gas spill control. Because of the large temperature differential between the liquefied gas and the foam, the drainage from the foam initially exaggerates boiloff from the spill. The higher the expansion, the lesser the effect of the drainage. For liquefied gases and all water-reactive inorganic materials, the foam should exhibit the best chemical resistance and expansion ratios to ensure maximum water retention consistent with the condition of the spill site. Because each spilled material can have unique properties, the manufacturer of the foam concentrate should be consulted for directions.

The great differences in the chemistry of flammable hydrocarbon liquids and the water-reactive inorganic materials have resulted in the development of foam concentrates specifically applicable to the inorganic chemicals. Few fire-fighting foams have capabilities of vapor suppression of the inorganic acids and bases. For effective control, special foam concentrates should be employed.

C.5 Acids or Alkalis. Some special foam concentrates are specific for either acids or alkalis but not both. Further, they are not applicable to all inorganic materials, nor are they effective in fire suppression. In many cases, their effectiveness is limited, and intermittent foam make-up may be required to maintain the foam blanket. Others, usually containing a polymer modification, can cover a wide range of materials, both acids and bases, and may possess some degree of fire resistance. This is important for those inorganic materials that may also pose a fire hazard.

At present, there is no single foam concentrate that is truly effective against all categories of volatile hazardous chemicals. A few possess limited capabilities in most categories, but they are compromise materials, sacrificing in one category to provide some capability in other categories. These may, however, be the best choice for first responders where an overall capability is essential.

In all cases, however, the foam manufacturer or the manufacturer's literature should be consulted to provide specific guidance for the chemical to be treated.

Vapor suppression can also be considered a chemical method of mitigation.

Annex D Informational References

D.1 Referenced Publications. The following documents or portions thereof are referenced within this recommended practice for informational purposes only and are thus not part of the recommendations of this document unless also listed in Chapter 2.

D.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

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NFPA 11, *Standard for Low-Expansion Foam,* 1998 edition.

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, 1999 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 1999 edition.

NFPA 472, *Standard for Professional Competence of Responders to Hazardous Materials Incidents*, 2002 edition.

D.1.2 Other Publications.

D.1.2.1 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM F 716, *Method of Testing Sorbent Performance of Absorbents*, 1993.

ASTM F 726, *Method of Testing Sorbent Performance of Adsorbents*, 1999.

ASTM F 1129, *Using Aqueous Foams to Control the Vapor Hazard from Immiscible Volatile Liquids*, 1995.

D.1.2.2 U.S. Government Publications. U.S. Government Printing Office, Superintendent of Documents, Washington, DC 20402.

Title 29, *Code of Federal Regulations,* Parts 1910.120, 1910.134.

Title 40, *Code of Federal Regulations,* Parts 261.33, 300, 302, and 355.

Title 49, *Code of Federal Regulations,* Parts 170–179.

D.2 Informational References. The following documents or portions thereof are listed here as informational resources only. They are not a part of the recommendations of this document.

D.2.1 Industrial Hygiene (Air Sampling and Monitoring, Respiratory Protection, Toxicology).

Air Sampling Instruments for Evaluation of Atmospheric Contaminants, American Conference of Governmental Industrial Hygienists, Cincinnati, OH, 8th edition, 1995.

Fundamentals of Industrial Hygiene, National Safety Council, Chicago, IL, 4th edition, 1996.

Patty's Industrial Hygiene and Toxicology, John Wiley and Sons, Inc., New York, NY, 4th edition, 1995.

NIOSH Pocket Guide to Chemical Hazards, DHHS No. 85-114, National Institute for Occupational Safety and Health (NIOSH), Department of Health and Human Services, Cincinnati, OH, 1995.

Occupational Health Guidelines for Chemical Hazards, DHHS No. 81-123, NIOSH, Department of Health and Human Services, Cincinnati, OH, 1981.

Occupational Safety and Health Standards, Title 29, *Code of Federal Regulations,* Part 1910.120, "Hazardous Waste Operations and Emergency Response Final Rule," U.S. Government Printing Office, Washington, DC, 1997.

Documentation of Threshold Limit Values and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, Cincinnati, OH, 6th edition, 1991.

D.2.2 Chemical Data.

Chemical Hazard Response Information System (CHRIS), U.S. Coast Guard, Washington, DC, Commandant Instruction.

Hawley Condensed Chemical Dictionary, Van Nostrand Reinhold Co., New York, NY, 14th edition, 2001.

Dangerous Properties of Industrial Materials, N. Irving Sax, Van Nostrand Reinhold Co., New York, NY, 10th edition, 1999.

Farm Chemicals Handbook, Farm Chemicals Magazine, Willoughby, OH, Vol. 87, 2001.

Firefighter's Handbook of Hazardous Materials, Baker, Charles J., Maltese Enterprises, Indianapolis, IN, 5th edition, 1990.

Fire Protection Guide to Hazardous Materials, National Fire Protection Association, Quincy, MA, 11th edition, 1997.

The Merck Index, Merck, Whitehouse Station, NJ, 13th edition, 2001.

D.2.3 Safety and Personnel Protection.

Fire Protection Handbook, National Fire Protection Association, Quincy, MA, 18th edition, 1997.

Guidelines for Decontamination of Firefighters and Their Equipment Following Hazardous Materials Incidents, Canadian Association of Fire Chiefs, Ottawa, May 1987.

Hazardous Materials Emergencies Response and Control, John R. Cashman, Technomic Publishing Company, Lancaster, PA, October 1995.

Hazardous Materials for the First Responser, International Fire Service Training Association, Stillwater, OK, 1988.

Hazardous Materials: Managing the Incident, Gregory Noll, Michael Hildebrand, and James Yvorra, Fire Service Publications, Stillwater, OK, 1995.

National Safety Council Safety Sheets, National Safety Council, Chicago, IL.

Radiological Health — Preparedness and Response in Radiation Accidents, U.S. Department of Health and Human Services, Washington, DC.

D.2.4 Planning Guides.

Federal Motor Carrier Safety Regulations Pocketbook, Title 49, CFR, Part 390.

Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH/OSHA/USCG/EPA, U.S. Department of Health and Human Services, NIOSH, Washington, DC.

Hazardous Materials Emergency Planning Guide, National Response Team, 2001.

D.2.5 Agencies and Associations.

D.2.5.1 Agency for Toxic Substances Disease Registry
Centers for Disease Control
1600 Clifton Road, NE
Atlanta, GA 30333
(800) 447-4784

D.2.5.2 American Conference of Governmental Industrial Hygienists
1330 Kemper Meadow Drive
Cincinnati, OH 45240-1634
(513) 742-2020

D.2.5.3 American Industrial Hygiene Association
2700 Prosperity Avenue, Suite 250
Fairfax, VA 22031
(703) 849-8888

D.2.5.4 American National Standards Institute, Inc.
11 West 42nd Street, 13th Floor
New York, NY 10036
(212) 642-4900

D.2.5.5 American Petroleum Institute
1220 L Street N.W., 9th Floor
Washington, DC 20005
(202) 682-8100

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D.2.5.6 Association of American Railroads
50 F Street N.W.
Washington, DC 20001
(202) 639-2100

D.2.5.7 Chemical Manufacturers' Association
2501 M Street N.W.
Washington, DC 20037
(202) 877-1100

D.2.5.8 CHEMTREC
Washington, DC
(800) 424-9300

D.2.5.9 The Chlorine Institute
2001 L Street N.W.
Washington, DC 20036
(202) 775-2790

D.2.5.10 Compressed Gas Association
1725 Jefferson Davis Highway
Arlington, VA 22202
(703) 412-0900

D.2.5.11 The Fertilizer Institute (TFI)
501 2nd Street N.E.
Washington, DC 20002
(202) 675-8250

D.2.5.12 International Society of Fire Service Instructors
P.O. Box 2320
Stafford, VA 22555
(800) 435-0005

D.2.5.13 National Fire Protection Association
1 Batterymarch Park, P.O. Box 9101
Quincy, MA 02269-9101
(617) 770-3000

D.2.5.14 Spill Control Association of America
Suite 1900
400 Renaissance Center
Detroit, MI 48243
(313) 567-0500

D.2.5.15 U.S. Department of Transportation
Research and Special Programs Administrator
Washington, DC 20590
Information Center (800) 467-4922

D.2.5.16 U.S. Environmental Protection Agency Office of Research and Development
www.epa.gov/ORD/index.htm
Publications — CERI
Cincinnati, OH 45268
(513) 684-7562

D.2.5.17 U.S. EPA Office of Solid Waste (WH-562)
Superfund Hotline
401 M Street S.W.
Washington, DC 20460
(800) 424-9346

D.2.5.18 U.S. Mine Safety and Health Administration
Department of Labor
4015 Wilson Boulevard, Room 600
Arlington, VA 22203
(703) 235-1452

D.2.5.19 U.S. National Oceanic and Atmospheric Administration
Hazardous Materials Response Branch N/CMS 34
7600 Sand Point Way NE
Seattle, WA 98115

D.2.6 Computer Database Systems. Hazardous Materials Information Exchange (HMIX)
Federal Emergency Management Agency
State and Local Programs Support Directory
Technological Hazards Division
500 C Street S.W.
Washington, DC 20472

D.3 References for Extracts. The following documents are listed here to provide reference information, including title and edition, for extracts given throughout this recommended practice as indicated by a reference in brackets [] following a section or paragraph. These documents are not a part of the recommendations of this document unless also listed in Chapter 2 for other reasons.

NFPA 1, *Fire Prevention Code*, 2000 edition.

NFPA 295, *Standard for Wildfire Control*, 1998 edition.

NFPA 472, *Standard for Professional Competence of Responders to Hazardous Materials Incidents*, 2002 edition.

NFPA 1021, *Standard for Fire Officer Professional Qualifications*, 1997 edition.

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