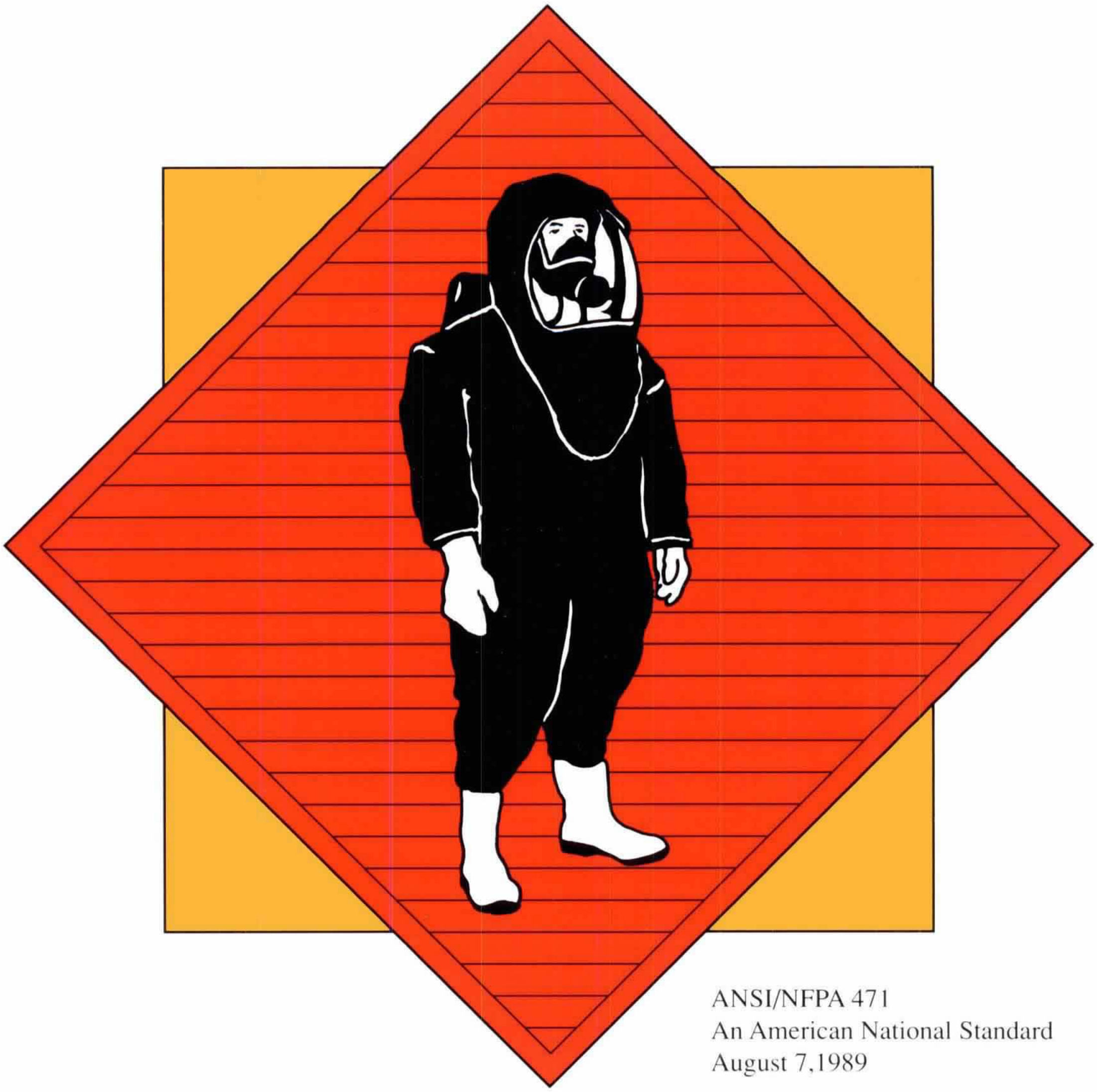
NFPA

471

1989 Edition

Recommended Practice for Responding to Hazardous Materials Incidents



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National Fire Protection Association

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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NATIONAL FIRE PROTECTION ASSOCIATION

NFPA 471

Recommended Practice for

Responding to Hazardous Materials Incidents

1989 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 the National Fire Protection Association, Inc. at its Annual Meeting held May 15-18, 1989 in Washington, DC. It was issued by the Standards Council on July 14, 1989, with an effective date of August 7, 1989, and supersedes all previous editions.

The 1989 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 471

In 1984, two separate requests to NFPA expressed a perceived need for documents relating to response to hazardous materials incidents. One came from the International Society of Fire Service Instructors, the other from the International Fire Service Training Association. NFPA sought public support for the idea and received many letters indicating agreement with the requests.

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."

When establishment of the Committee was formally announced, many requests for membership were received, and similar requests continued to arrive during the first year of its existence. The first meeting of the Committee took place in October 1986 at the Fairfax County Fire and Rescue Training Center. Since that opening session, five additional meetings were held to complete work on this document.

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

The Committee decided at the very first meeting that one document should concern itself with professional competencies of the responder (NFPA 472) and that another should recommend some basic operating procedures that would be applicable to most incidents. That latter document became this recommended practice. The principal operating procedures are covered, including decontamination, safety, personal protective equipment, and mitigation. The recommended practice is intended to serve as a guide for responders. It is anticipated that future editions might well become more comprehensive.

The gratitude of the Committee is extended to all who participated in the development process, and especially to the non-committee members who helped so much.

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

Information on referenced publications can be found in Chapter 8.

Chapter 1 Administration

1-1* Scope. This practice applies to all organizations that have responsibilities when responding to hazardous materials incidents and recommends standard operating guidelines for responding to such incidents. It specifically covers planning procedures, policies, and application of procedures for incident levels, personal protective equipment, decontamination, safety, and communications.

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.

1-4 Definitions.

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: The phrase "authority having jurisdiction" 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, 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 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."

Confinement. Those procedures taken to keep a material in a defined or local area.

Containment. Those procedures taken to keep a material in its container.

Contaminant/Contamination. A substance or process that poses a threat to life, health, or the environment.

Control. The procedures, techniques, and methods used in the mitigation of a hazardous materials incident, including containment, extinguishment, and confinement.

Control Zones. The designation of areas at a hazardous materials incident based upon safety and the degree of hazard. Many terms are used to describe the zones involved in a hazardous materials incident. For purposes of this standard, these zones shall be defined as the hot, warm, and cold zones.

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.

Degradation. A chemical action involving the molecular breakdown of a protective clothing material due to contact with a chemical. The term degradation may also refer to the molecular breakdown of the spilled or released material to render it less hazardous.

Emergency. A sudden and unexpected event calling for immediate action.

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

Hazard/Hazardous. Capable of posing an unreasonable risk to health and safety (Department of Transportation). Capable of doing harm.

Hazard Sector. That sector of an overall incident command system that deals with the actual mitigation of an incident. It is directed by a sector officer and principally deals with the technical aspects of the incident.

Hazard Sector Officer. The person responsible for the management of the hazard sector.

Hazardous Material.* A substance (gas, liquid, or solid) capable of creating harm to people, property, and the environment. See specific regulatory definitions in Appendix A.

Class. The general grouping of hazardous materials into nine categories identified by the United Nations Hazard Class Number System, including:

Explosives
Gases (compressed, liquefied, dissolved)
Flammable Liquids
Flammable Solids
Oxidizers
Poisonous Materials
Radioactive Materials
Corrosive Materials
Other Regulated Materials

Classification. The individual divisions of hazardous materials called "hazard classes" in the United States and "divisions" in the United Nations system, including:

Explosives A
Explosives B
Explosives C
Blasting Agents
Nonflammable Gases
Flammable Gases
Flammable Liquids
Combustible Liquids
Flammable Solids
Oxidizers
Organic Peroxides
Poison Gases
Poison B
Irritating Materials
Etiologic Agents
Radioactive Materials
Corrosive Materials
ORM A
ORM B
ORM C
ORM D
ORM E

Incident. The release or potential release of a hazardous material into the environment.

Incident Command System. An organized system of roles, responsibilities, and standard operating procedures used to manage and direct emergency operations.

Incident Commander. The person responsible for all decisions relating to the management of the incident. The incident commander is in charge at the incident.

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

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

National Contingency Plan.* Policies and procedures of the federal agency members of the National Oil and Hazardous Materials Response Team. This document provides guidance for responses, remedial action, enforcement, and funding mechanisms for hazardous materials incident responses.

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.

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

Protective Clothing. See Chapter 5 for definitions.

Response. That portion of incident management in which personnel are involved in controlling a hazardous materials incident.

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

Stabilization. The period of an incident where the adverse behavior of the hazardous material is controlled.

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

Chapter 2 Incident Response Planning

2-1 Planning is an essential part of emergency preparedness. The development of both facility response plans and community emergency plans is required by numerous state and federal laws, including SARA, Title III, "The Emergency Planning and Community Right to Know Act of 1986." Planning guides and reference materials are listed in Appendix B-2.4.

2-2 A planning team is necessary to develop 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.

2-3 A planning team is necessary to develop the hazardous material emergency plan.

2-4 As a minimum, an annual review and update of the hazardous material emergency plan is necessary.

2-5 As a minimum, a training exercise should be conducted annually to determine the adequacy and effectiveness of the hazardous material emergency plan.

Chapter 3 Response Levels

3-1* Table 3-1 is a planning guide intended to provide the user with assistance in determining incident levels for response and training. Potential applications to a jurisdiction's response activities may 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 3-1 Planning Guide for Determining Incident Levels, Response, and Training

Incident Level	One	Two	Three
Incident Conditions			
Product Identifications	Placard not required, NFPA 0 or 1 all categories, all ORM A, B, C, and D.	DOT placarded, NFPA 2 for any categories, PCBs without fire, EPA regulated waste.	Poison A (gas), explosives A/B, 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 one-ton, packages, bags).	Medium (e.g., one-ton cylinder, 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.

Chapter 4 Site Safety

4-1 Emergency Incident Operations.

4-1.1 Emergency incident operations should be conducted in compliance with Chapter 6 of NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, or 29 CFR 1910.120 or EPA.

4-1.2 An incident command system should be implemented at all hazardous materials incidents. Operations should be directed by a designated incident commander and follow established written standard operation procedures.

NOTE: Though in the following text 29 CFR 1910.120 is cited, 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.

4-1.3 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.

4-2 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.

4-3 Safety Officer.

4-3.1 A safety officer should be designated by and report to the incident commander.

NOTE: Under this section the safety officer is given specific responsibilities. It should be understood that even though these duties are to be carried out by the safety officer, the incident commander still has overall responsibility for the implementation of these tasks.

4-3.2 The safety officer should provide the incident commander with recommendations on the establishment of the control zones at each emergency incident, based on the identification and evaluation of the hazards.

4-3.3 The safety officer should maintain control and security of entry and exit of all personnel between the various zones.

4-3.4 The safety officer is responsible for implementing the safety plan.

4-3.5 The safety officer should make the final decision on entry/no entry, corrective actions, respiratory and personal protective clothing, monitoring and sampling methods, and when personnel should be withdrawn or evacuated.

4-3.6 The safety officer should ensure that the proper decontamination procedures are in place before entry.

4-3.7 The safety officer should monitor and maintain communications between the entry personnel and him/herself, and with the incident commander.

4-3.8 The safety officer should ensure that a backup team wearing the appropriate level of personal protective equipment is ready at all times during entry team operations.

4-3.9 The safety officer should ensure that all other elements of safety are in place and that emergency medical services with transport capabilities are available.

4-3.10 The safety officer should ensure that all pertinent information is gathered and recorded. Pertinent documents, manifests, and reports should be collected and safeguarded.

4-3.10.1 Incident Site Log. A record of the incident should be maintained for future reference, and as a minimum should contain the following:

(a) Location

(b) Date

(c) Name, description, source, quantity, and cause of release

(d) Weather information

(e) Names and job assignments for all personnel involved

(f) Injuries to personnel and public

(g) Corrective action taken

(h) Chronological recording of events

(i) Entry and exit times of the entry personnel

(j) Method of recording exposure of personnel to hazardous materials

(k) Resource personnel data.

4-4 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 4-4.

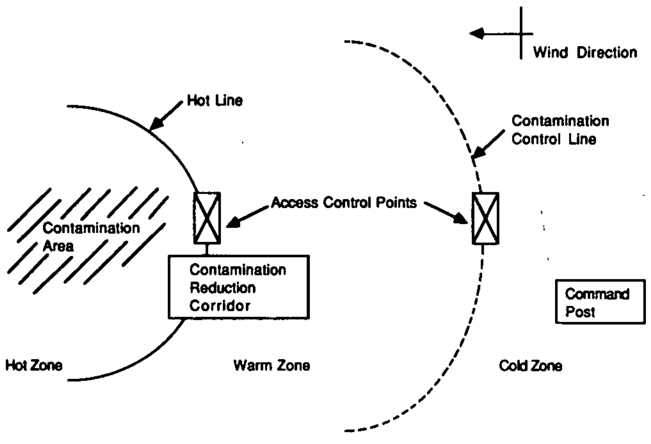

Figure 4-4 Diagram of control zones.

4-4.1 Hot Zone. Area immediately surrounding a hazardous materials incident, which extends 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.

NOTE: 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.

4-4.2 Warm Zone. The area where personnel and equipment decontamination and hot zone support takes place. It includes control points for the access corridor and thus assists in reducing the spread of contamination. This is also referred to as the decontamination, contamination reduction, or limited access zone in other documents.

4-4.3 Cold Zone. This area contains the command post and such other support functions as are deemed necessary to control the incident. This is also referred to as the clean zone or support zone in other documents.

4-5 Communications.

4-5.1 When personal protective clothing or remote operations inhibit communications, an effective means of communications, such as radios, should be established.

4-5.2 The frequencies employed in these radios should be "dedicated" and not used or shared with other local agencies.

4-5.3 Communication should be supplemented by a prearranged set of hand signals and hand-light signals to be used when primary communication methods fail. Handlights employed for this purpose should be in accordance with NFPA 70, *National Electrical Code*®, for use in hazardous environments.

4-6 Monitoring Equipment.

4-6.1 Monitoring equipment operates on several different principles and measures different aspects of hazardous materials releases. Examples of this equipment are:

(a) Oxygen meters

(b) Combustible gas indicator (explosimeter)

(c) Carbon monoxide meter

(d) pH meter

(e) Radiation detection instruments

(f) Colorimetric detector tubes

(g) Organic vapor analyzer

(h) Photoionization meter

(i) Air sampling devices

(j) Other meters to measure specific products such as chlorine, hydrogen sulfide, or ethylene oxide

(k) pH paper or strips

(l) Organic vapor badge or film strip

(m) Mercury badge

(n) Formaldehyde badge or strip.

4-6.2 All monitoring equipment should be operationally checked prior to use and periodically calibrated as per manufacturer's specifications.

Chapter 5 Personal Protective Equipment

5-1 General. It is essential that personal protective equipment meeting appropriate NFPA and OSHA standards be provided, maintained, and used. Protection against physical, chemical, and thermal hazards must be considered when selecting personal protective equipment.

5-1.1 A written personal protective equipment program should be established in accordance with 29 CFR Part 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/or conditions present and appropriate for the hazards encountered.

5-1.2 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.

5-2 Respiratory Protective Equipment.

5-2.1 Self-contained breathing apparatus (SCBA) should meet the requirements of NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters*.

5-2.2 Personal alert safety systems should meet the requirements of NFPA 1982, *Standard on Personal Alert Safety Systems (PASS) for Fire Fighters*.

5-2.3 Air Purifying Respirators. These devices are worn to filter particulates and contaminants from the air. They should only be worn in atmospheres where the type and quantity of the contaminants are known and sufficient oxygen is known to be present.

5-3 Chemical-Protective Clothing.

5-3.1 Chemical-protective clothing (CPC) is made from special materials and is designed to prevent the contact of chemicals with the body. Chemical-protective clothing is of two types: totally encapsulating and nonencapsulating.

5-3.2 A variety of materials are used to make the fabric from which clothing is manufactured. Each material will provide protection against certain specified chemicals or mixtures of chemicals. It may 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 must be compatible with the chemical substances involved, consistent with manufacturers' instructions.

5-3.3 Performance requirements must be considered in selecting the appropriate chemical-protective material. These would include chemical resistance, permeation, penetration, flexibility, abrasion, temperature resistance, shelf life, and sizing criteria.

5-3.3.1 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, discolor, become brittle, sticky, or soft, or to deteriorate. These changes permit chemicals to get through the suit more rapidly or to increase the probability of permeation.

5-3.3.2 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. Manufacturer's data and reference sources should be consulted. Generally if a material degrades rapidly, permeation will occur rapidly.

5-3.3.3 Penetration. 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.

5-4 Thermal Protection.

5-4.1 Proximity Suits. These suits provide short duration and close proximity protection at radiant heat temperatures as high as 2000 °F and may withstand some exposure to water and steam. Respiratory protection must be provided with proximity suits.

5-4.2 Fire Entry Suits. This type of suit provides protection for brief entry into total flame environment at temperatures as high as 2000 °F. This suit is not effective or meant to be used for rescue operations. Respiratory protection must be provided with fire entry suits.

5-4.3 Overprotection Garments. These garments are worn in conjunction with chemical-protective encapsulating suits.

5-4.3.1 Flash Cover Protective Suit. Flash cover suits are neither proximity nor fire entry suits. They provide limited overprotection against flash-back only. They are worn outside of other protective suits and are used only when the risks require them.

5-4.3.2 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 risk requires them.

5-5 Levels of Protection. Personal protective equipment is divided into four categories based on the degree of protection afforded.

NOTE: An asterisk (*) after the description indicates optional, as applicable.

5-5.1 Level A. To be selected when the greatest level of skin, respiratory, and eye protection is required. The following constitute Level A equipment; it may be used as appropriate.

5-5.1.1 Pressure-demand, full facepiece, self-contained breathing apparatus (SCBA), or pressure-demand supplied air respirator with escape SCBA, approved by the National Institute of Occupational Safety and Health (NIOSH).

5-5.1.2 Totally encapsulating chemical-protective suit.

Totally encapsulating chemical-protective suit (TECP suit) means a full body garment that is constructed of protective clothing materials; covers the wearer's torso, head, arms, and legs; has boots and gloves that may be an integral part of the suit, or separate and tightly attached; and completely encloses the wearer by itself or in combination with the wearer's respiratory equipment, gloves, and boots. All components of a TECP suit, such as relief valves, seams, and closure assemblies, should provide equivalent chemical resistance protection.

5-5.1.3 Coveralls.*

5-5.1.4 Long underwear.*

5-5.1.5 Gloves, outer, chemical-resistant.

5-5.1.6 Gloves, inner, chemical-resistant.

5-5.1.7 Boots, chemical-resistant, steel toe and shank.

5-5.1.8 Hard hat (under suit).*

5-5.1.9 Disposable protective suit, gloves, and boots (depending on suit construction, may be worn over totally encapsulating suit).*

5-5.1.10 Two-way radios (worn inside encapsulating suit).

5-5.2 Level B. The highest level of respiratory protection is necessary but a lesser level of skin protection is needed. The following constitutes Level B equipment; it may be used as appropriate.

5-5.2.1 Pressure-demand, full facepiece, self-contained breathing apparatus (SCBA), or pressure-demand supplied air respirator with escape SCBA, NIOSH approved.

5-5.2.2 Hooded chemical-resistant clothing (overalls and long-sleeved jacket, coveralls, one or two-piece chemical-splash suit, disposable chemical-resistant overalls).

5-5.2.3 Coveralls.*

5-5.2.4 Gloves, outer, chemical-resistant.

5-5.2.5 Gloves, inner, chemical-resistant.

5-5.2.6 Boots, outer, chemical-resistant, steel toe and shank.

5-5.2.7 Boot-covers, outer, chemical-resistant (disposable).*

5-5.2.8 Hard hat.

5-5.2.9 Two-way radios (worn inside encapsulating suit).

5-5.2.10 Face shield.*

5-5.3* Level C. 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; it may be used as appropriate.

5-5.3.1 Full-face or half-mask, air purifying respirators (NIOSH approved).

5-5.3.2 Hooded chemical-resistant clothing (overalls, two-piece chemical-splash suit, disposable chemical-resistant overalls).

5-5.3.3 Coveralls.*

5-5.3.4 Gloves, outer, chemical-resistant.

5-5.3.5 Gloves, inner, chemical-resistant.

5-5.3.6 Boots, outer, chemical-resistant, steel toe and shank.

5-5.3.7 Boot-covers, outer, chemical-resistant (disposable).*

5-5.3.8 Hard hat.

5-5.3.9 Escape mask.*

5-5.3.10 Two-way radios (worn under outside protective clothing).

5-5.3.11 Face shield.*

5-5.4 Level D. A work uniform affording minimal protection, used for nuisance contamination only. The following constitute Level D equipment; it may be used as appropriate.

5-5.4.1 Coveralls.

5-5.4.2 Gloves.*

5-5.4.3 Boots/shoes, chemical-resistant steel toe and shank.

5-5.4.4 Boots, outer, chemical-resistant (disposable).*

5-5.4.5 Safety glasses or chemical-splash goggles.

5-5.4.6 Hard hat.

5-5.4.7 Escape mask.*

5-5.4.8 Face shield.*

5-6 The types of hazards for which levels A, B, C, and D protection are appropriate are described below.

5-6.1 Level A protection should be used when:

5-6.1.1 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;

5-6.1.2 Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible; or

5-6.1.3 Operations must be conducted in confined, poorly ventilated areas, and the absence of conditions requiring Level A have not yet been determined.

5-6.2 Level B protection should be used when:

5-6.2.1 The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection, but less skin protection;

NOTE: This 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.

5-6.2.2 The atmosphere contains less than 19.5 percent oxygen; or

5-6.2.3 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.

5-6.2.4 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.

5-6.3 Level C protection should be used when:

5-6.3.1 The atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect or be absorbed through any exposed skin;

5-6.3.2 The types of air contaminants have been identified, concentrations measured, and an air-purifying respirator is available that can remove the contaminants; and

5-6.3.3 All criteria for the use of air-purifying respirators are met.

5-6.3.4* Atmospheric concentration of chemicals must not exceed IDLH levels. The atmosphere must contain at least 19.5 percent oxygen.

5-6.4 Level D protection should be used when:

5-6.4.1 The atmosphere contains no known hazard; and

5-6.4.2 Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

NOTE: 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.

Chapter 6 Incident Mitigation

6-1 Control.

6-1.1 This chapter will address those actions necessary to assure confinement and containment (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.

6-2 Types of Hazardous Materials.

6-2.1 **Chemical Materials.** Those materials that pose a hazard based upon their chemical and physical properties.

6-2.2 **Biological Materials.** Those organisms that have a pathogenic effect to life and the environment and can exist in normal ambient environments.

6-2.3 **Radioactive Materials.** Those materials that emit ionizing radiation.

6-3 **Physical States of Hazardous Materials.** Hazardous materials may 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 may be affected by the environment in which the incident occurs. The emergency responder must take into account conditions such as heat, cold, rain, or wind, which can have a significant effect on the methods used to accomplish a safe operation.

6-4 **Methods of Mitigation.** There are two basic methods for mitigation of hazardous materials incidents, physical and chemical. Table 6-4.1 lists many physical methods and Table 6-4.2 lists many chemical methods that may be acceptable for mitigation of hazardous materials incidents. Recommended practices should be implemented only by personnel appropriately prepared by training, education, or experience.

Table 6-4.1 Physical Methods of Mitigation[5]

Method	Chemical				Biological				Radiological			
	Gases		Liq.	Sol.	Gases		Liq.	Sol.	Gases		Liq.	Sol.
	LVP*	HVP**			LVP	HVP			LVP	HVP		
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, & Retention	yes	yes[6]	yes	yes	no	no	yes	yes	no	no	yes	yes
Dilution	yes	yes	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
Venting[1]	yes	yes	yes	no	yes	no	no	no	yes[2]	no	no	no

* 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 certified health physicist.
3. Covering should be done only after consultation with appropriate experts.
4. Absorption of liquids containing bacteria is permitted where the absorption bacteria or environment is hostile to the bacteria.
5. For substances involving more than one type, the most restrictive control measure should be used.
6. Water dispersion on certain vapors and gases only.

6-4.1 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 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. Refer to Table 6-4.1.

NOTE: Procedures described in 6-4.1.1 through 6-4.1.8 should be completed only by personnel trained in those procedures.

6-4.1.1 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 they are, therefore, considered to be hazardous materials and must be treated and disposed of accordingly.

6-4.1.2 Covering. Refers to 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 appropriate experts.

6-4.1.3 Dilution. Refers to the application of water to water miscible hazardous materials. The goal is to reduce the hazard to safe levels.

6-4.1.4 Dikes, Dams, Diversions, and Retention. These 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 the 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 using a water spray.

6-4.1.5 Vapor Dispersion. Vapors from certain materials can be dispersed or moved using a water spray. With other products, such as liquefied petroleum gas (LPG), the gas concentration can 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.

6-4.1.6 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 must be used. (The spilled materials still should be treated or properly disposed of.)

6-4.1.7 Plug and Patch. Plugging and patching refers to 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 may not be reused without proper inspection and certification.

6-4.1.8 Transfer. Transfer refers to the process of moving a liquid, gas, or some forms of solids, either manually, by pump, or pressure transfer, from a leaking or damaged container or tank. Care must be taken to ensure the pump, transfer hoses and fittings, and container selected are compatible with the hazardous material. When flammable liquids are transferred, proper concern for electrical continuity (such as bonding/grounding) must be observed.

6-4.1.9* Vapor Suppression (Blanketing). Vapor suppression refers to the reduction or elimination of vapors emanating from a spilled or released material through the most efficient method or application of specially designed agents. The recommended vapor suppression agent is a polar solvent aqueous film forming foam, proportioned at the same concentration regardless of the nature of the spill.

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

6-4.1.10 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.

6-4.2 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. 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 appropriate for the hazards encountered. Refer to Table 6-4.2.

NOTE: The procedures described in 6-4.2.1 through 6-4.2.10 should only be used by personnel trained in those procedures.

6-4.2.1 Adsorption. Adsorption is the process in which a sorbate (hazardous liquid) interacts with a solid sorbent surface. The principal characteristics of this interaction are:

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, i.e., activated carbon, alumina, etc.

NOTE: Spontaneous ignition can occur through the heat of adsorption of flammable materials, and caution should be exercised.

6-4.2.2 Controlled Burning. For purposes of this practice, controlled combustion is considered a chemical method of control. However, it should only be used 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 advised that consultation be made with the appropriate environmental authorities when this method is used.

6-4.2.3 Dispersion, 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 to acceptable levels. Use of this method may require the prior approval of the appropriate environmental authority.

6-4.2.4 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.

6-4.2.5 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 must be disposed of properly.

6-4.2.6 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

Table 6-4.2 Chemical Methods of Mitigation

Method	Chemical				Biological				Radiological			
	Gases		Liq.	Sol.	Gases		Liq.	Sol.	Gases		Liq.	Sol.
	LVP*	HVP**			LVP	HVP			LVP	HVP		
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
Gelation	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.

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 may occur. One of the advantages of neutralization is that a hazardous material may be rendered nonhazardous.

6-4.2.7 Polymerization. A process in which a hazardous material is reacted in the presence of a catalyst, of heat or light, or with itself or another material to form a polymeric system.

6-4.2.8 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.

6-4.2.9 Vapor Suppression. The use of solid activated materials to treat hazardous materials so as to effect suppression of the vapor off gassing 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.

6-4.2.10 Venting and Burning. This involves the use of shaped charges to vent the high vapor pressure at the top of the container and then with additional charges to release and burn the remaining liquid in the container in a controlled fashion.

Chapter 7 Decontamination

7-1 Decontamination Plan. At every incident involving hazardous materials there is a possibility that response personnel and their equipment will become contaminated. The contaminant poses a threat, not only to the persons contaminated, but to other personnel who may subsequently have contact with them or the equipment.

7-1.1 Incident responders should have an established procedure to minimize contamination or contact, to limit migration of contaminants, and to properly dispose of contaminated materials. Decontamination procedures should begin upon arrival at the scene, should provide for an adequate number of decontamination personnel, and should continue until the incident commander determines that decontamination procedures are no longer required. Decontamination of victims may be required.

7-2 Personal Protective Equipment. Before personal protective equipment is removed it should be decontaminated. During doffing of personal protective equipment, the clothing should be removed in a manner such that the outside surfaces do not touch or make contact with the wearer. A log of personal protective equipment used during the incident should be maintained. Personnel wearing disposable protective equipment should go through the decontamination process and the disposable protective equipment should be disposed of in accordance with established procedures.

7-3 Decontamination. Decontamination consists of removing the contaminants by chemical or physical processes. The conservative action is always to assume contamination has occurred and to implement a thorough, technically sound decontamination procedure until it is determined or judged to be unnecessary.

7-3.1 Procedures for all phases of decontamination must be developed and implemented to reduce the possibility of contamination to personnel and equipment. Reference guides for the development of decontamination procedures can be found in Appendix B-2.4(d) and B-2.4(f). Assuming protective equipment is grossly contaminated, use appropriate decontamination methods for the chemicals encountered.

7-3.2 Outer clothing should be decontaminated prior to removal. The outer articles of clothing, after removal, should be placed in plastic bags for later additional decontamination, cleaning, and/or inspection. In some cases, they may have to be overpacked into containers for proper disposal. Water or other solutions used for washing or rinsing may have to be contained, collected, containerized, and analyzed prior to disposal.

7-3.2.1 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.

7-3.3 Decontaminating Solutions. Using solutions containing chemicals to alter or change contaminants to less hazardous materials should only be done after consultation with persons experienced and familiar with the hazards involved. The use of detergent-water washing solutions is more prevalent, but its effectiveness against certain contaminants may be low. It is less risky however than using chemical solutions.

7-3.4 Decontamination of Equipment. Many types of equipment are very difficult to decontaminate and may have to be discarded as hazardous wastes. Whenever possible, other pieces of small equipment should be disposable or made of nonporous material. Monitoring instruments and some types of sampling equipment can be placed in plastic bags (with only the detecting element exposed) to minimize potential contamination problems.

7-3.5 Large items of equipment, such as vehicles and trucks, should be subjected to decontamination by high pressure water washes, steam, or special solutions. Water or other solutions used for washing or rinsing may have to be contained, collected, containerized, and analyzed prior to disposal. Consultation with appropriate sources should be utilized to determine proper decontamination procedures.

7-3.6 Decontamination Team. Personnel assigned to the decontamination team should wear an appropriate level of personal protective equipment and may require decontamination themselves.

Chapter 8 Referenced Publications

8-1 The following documents or portions thereof are referenced within this recommended practice and should be considered part of the recommendations of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

8-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 70-1990, *National Electrical Code*

NFPA 472-1989, *Standard for Professional Competence of Responders to Hazardous Materials Incidents*

NFPA 1500-1987, *Standard on Fire Department Occupational Safety and Health Program*

NFPA 1981-1987, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters*

NFPA 1982-1988, *Standard on Personal Alert Safety Systems (PASS) for Fire Fighters.*

8-1.2 US Government Publication. US Government Printing Office, Superintendent of Documents, Washington, DC 20402.

Title 29 CFR Part 1910.120.

Appendix A

This Appendix is not a part of the recommendations of this NFPA document, but is included for information purposes only.

A-1-1 Many of the recommendations in this document are based on United States 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-1-4 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 United States 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.

(a) *Hazardous Materials.* The United States Department of Transportation (DOT) uses the term *hazardous materials*, which covers eight hazard classes, some of which have subcategories called classifications, and a ninth class covering other regulated materials (ORM). DOT includes in its regulations hazardous substances and hazardous wastes as an ORM-E, both of which are regulated by the Environmental Protection Agency (EPA), if their inherent properties would not otherwise be covered.

(b) *Hazardous Substances.* EPA uses the term *hazardous substance* for the chemicals which, 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 40 CFR Part 302, Table 302.4.

(c) *Extremely Hazardous Substances.* EPA uses the term *extremely hazardous substance* for the chemicals which 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 Superfund Amendments and Reauthorization Act (SARA) of 1986 (40 CFR Part 355).

(d) *Toxic Chemicals.* EPA uses the term *toxic chemical* 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.

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

(f) *Hazardous Chemicals.* The United States Occupational Safety and Health Administration (OSHA) uses the term *hazardous chemical* to denote any chemical that would be a risk to employees if exposed in the work place. Hazardous chemicals cover a broader group of chemicals than the other chemical lists.

(g) *Hazardous Substances.* OSHA uses the term *hazardous substance* in 29 CFR Part 1910.120, which resulted from Title I of SARA and covers emergency response. OSHA uses the term differently than EPA. Hazardous substances, as used by OSHA, cover every chemical regulated by both DOT and EPA.

A-1-4 National Contingency Plan. See Code of Federal Regulations: 40 CFR, Part 300, Subchapters A through J.

A-3-1 These incidents can be considered as requiring either offensive operations 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. This includes: 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. This includes: elimination of ignition sources, vapor suppression, and diking or diverting to keep a release in a confined area. It requires 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, first responder operational level may equate to incident level one, the technician level may equate to incident level two, and the specialist may equate to incident level three.

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

A-5-5.3 Refer to OSHA 29 CFR 1910.134.

A-5-6.3.4 Refer to OSHA 29 CFR 1910.134.

A-6-4.1.9 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 only be undertaken by personnel who have been trained in the use of foam agents for vapor suppression. Training in the use of foam as a fire extinguishing agent is not sufficient to qualify an individual for foam application as a vapor suppressing agent.

Vapor suppressing foam agents vary in their effectiveness depending on a number of factors. These factors can include the type of foam, the expansion ratio of the foam, the 25 percent drainage time of the foam, the rate of application of the foam, and the application (gpm/sq ft) density (gallons/sq ft) of the foam. These variables serve to emphasize the need for training of the person selecting this technique for applying foam as a vapor suppressing medium.

There are two general categories of foam agents used as fire extinguishing agents, namely chemical foam and mechanical foam. Chemical foam is produced by a chemical reaction between salts of weak acids and weak bases. It is becoming obsolete in the United States and has never been tested as a vapor suppressing foam agent. Mechanical foam agents are produced by mechanically mixing a dilute solution of the foam concentrate and water with air, producing an expanded foam. Mechanical foam agents have been tested both as fire extinguishing agents and as vapor suppressing agents.

Several types of mechanical foam will be briefly described. For more detailed information, consult NFPA 11, *Standard for Low Expansion Foam and Combined Agent Systems*, or the foam agent or equipment manufacturer's literature.

Mechanical foam agents can be broken down into two broad categories that reflect the chemical composition of the surfactants used to produce the foam concentrate. Protein foam agents are derived from a hydrolyzed protein substance such as hoof and horn meal or feather meal. These are naturally occurring substances. The second category of mechanical foam agents are synthetically derived. The two subdivisions within the synthetic foam area reflect the surfactant composition. Synthetic foams may contain surfactants of the hydrocarbon surfactant type, i.e. detergents; or more commonly, they may contain surfactants that are fluorinated and are known generically as AFFF. AFFF is an acronym for the terminology Aqueous Film Forming Foam, indicating that these foam agents form an aqueous film on a hydrocarbon liquid surface in spite of the fact that the hydrocarbon is less dense than water.

A more practical way of differentiating synthetic foams is based on their expansion ratios. Most synthetic foams that are composed strictly of hydrocarbon surfactants are used either as medium expansion or high expansion foam agents. Low expansion agents are those foam agents that when mechanically mixed with air will produce expansion ratios of 20 to 1 or less. Medium expansion refers to expansion ratios between 200 to 1 and 20 to 1. High expansion foam agents refer to expansion ratios in excess of 200 to 1 and typically are in the vicinity of 750 to 1. Synthetic foam agents derived from hydrocarbon surfactants can be used as low expansion foams but they generally are not used in that fashion.

Within the two types of mechanical foams, several variations exist. Low expansion foams consist of six categories that are differentiated by chemical composition. The first and oldest of the low expansion foam agents are those derived from hydrolyzed proteins, to which are added stabilizers, freezing point depressants, and fungicide agents. Protein foams are characterized by a consistent mass of foam bubbles that have relatively poor mobility but good burnback resistance and good vapor suppression characteristics when used on fuels of moderate volatility.

A second type of low expansion foam agent is derived from protein foam to which a fluorochemical surfactant has been added. They are called fluoroprotein foams and have improved mobility on fuel surfaces, slightly improved burnback resistance, and the same vapor suppressing characteristics as the protein foams.

A third type of low expansion foams are the synthetic hydrocarbon type surfactants or detergent foams used in the expansion ratio categories of medium and high expansion. They have, however, been used as low expansion foams. Their mobility on a fuel surface and their vapor suppressing characteristics are not as good as the other foam agents in this category.

A fourth category of low expansion foams are those referred to as AFFF. AFFF are foams that are formulated from synthetic fluorochemical and hydrocarbon surfactants in conjunction with solvents. They provide an aqueous film from the draining foam bubbles whose surface characteristics allow it to spread on a hydrocarbon fuel surface in spite of the lower density of a hydrocarbon fuel such as gasoline. The mobility of the AFFF on a hydrocarbon fuel surface is superior to that of the other low expansion foam concentrates. However, the burnback resistance of this foam is not as good as that of the protein or fluoroprotein foams. Its vapor suppressing characteristics would be as good as most of the other foam agents due to the aqueous film.

A fifth category involves a modification of the fluoroprotein foam. This type of low expansion foam is referred to by the acronym FFFP, standing for Film Forming Fluoroprotein Foam agent. These agents are simply fluoroprotein foam agents to which enough fluorochemical surfactant has been added to provide the ability to form the aqueous film that gives mobility comparable to the AFFF products. However, adding this fluorochemical weakens the burnback characteristics to the point that they are comparable to the AFFF agent. They are also comparable to the AFFF products as vapor suppressing agents.

The sixth and final type of low expansion foam has an ability to extinguish not only hydrocarbon fires but those fires involving certain types of hydrocarbons that are referred to as polar solvents. These are materials that have appreciable water miscibility or solubility and are typified by materials such as alcohols, ketones, and ethers. Some common examples of these types of materials would be methanol, ethanol, isopropanol, acetone, methyl ethyl ketone, dimethyl ether, diethyl ether, isopropyl ether, etc. The five low expansion foam agents previously discussed are effective only on the hydrocarbon type fuels such as gasoline. If those products are applied to a fire involving a fuel such as methanol, the foam will dissolve and the fuel is said to be foam destructive. It should be clearly understood that the five previous compositions for low expansion foams are effective only on water insoluble fuels such as gasoline.

There are two basic compositions that allow for the use of a low expansion foam extinguishing agent on a polar solvent. The most widely used composition is based on a conventional AFFF type low expansion foam to which a material known as a polysaccharide has been added. The polysaccharide forms an insoluble membrane when it comes in contact with a water miscible fuel such as methanol or ethanol. This membrane acts in much the same way that the aqueous film acts when that same product is used on a conventional hydrocarbon fuel such as gasoline. Until recently, this type of product was available in a configuration that required that it be proportioned as a 3 percent product, i.e. 3 parts of concentrate to 97 parts of water, when used on hydrocarbon fuels such as gasoline; and as a 6 percent product, i.e. 6 parts of concentrate to 94 parts of water, when used on a polar solvent such as ethanol. This problem has been resolved and there are now products available that will proportion at 3 percent on either type of fuel substance. The polysaccharide also stabilizes the AFFF product so the burnback resistance is equivalent to protein and fluoroprotein foam. On this basis, the agent to use as a vapor suppressant would be a product that is capable of being used regardless of the type of fuel substrate, that can be proportioned at the same concentration regardless of the fuel substrate, and that has excellent mobility as well as burnback resistance, thereby providing vapor suppressing characteristics.

A second composition of this type has been derived from the film forming fluoroprotein products that allows them to be used on a polar solvent fuel as well as on a normal hydrocarbon fuel. They have to be proportioned at two different concentrations and therefore are not as attractive, although they will perform adequately in a vapor suppressing application.

The use of fire fighting foam as a vapor suppressant involves some considerations that are different than those required for fire extinguishing agents. One of the obvious issues that is of concern is the stability of the foam blanket as a function of time. This can be generally approached by looking at what is referred to as the foam quality. Foam quality is generally measured in terms of three parameters: foam expansion ratio, foam 25 percent drainage time, and foam viscosity. Foam expansion ratio refers to the volume of foam obtained from a unit volume of foam liquid dilute solution. The expansion ratio for low expansion foams is less than 20 to 1. Typical values for expansion ratio for some of the low expansion foam agents are in the range of 6 to 1 and 12 to 1 when used in aspirating equipment. AFFF, however, can be used in nonaspirating equipment such as water fog nozzles, and the expansion ratios obtained there can be as low as 3 to 1 or 2 to 1.

The 25 percent drainage time is the time that is required for 25 percent of the foam liquid to drain from the foam. This is the property that is generally used to measure the stability of the foam, and it, in combination with the expansion ratio, will determine how the thickness of the foam blanket will vary with time. For example, a typical application of foam could involve an expansion ratio of 10 to 1 with a 25 percent drain time of 10 minutes. This means that whatever thickness is attained on the fuel surface with a 10 to 1 expanded foam, 25 percent of it or 2.5 units of it will disappear within 10 minutes. For purposes of simplicity, we can assume that foam drainage is a linear function and that in the course of draining, approximately 40 minutes will be required to deplete the foam from the fuel surface. This makes several assumptions regarding the environmental conditions such as wind velocity, wind direction, ambient temperature, etc.

An important factor is the vapor pressure of the fuel that is being used as the substrate by the vapor suppressant. Fuel vapor pressure can vary widely depending on the type of fuel. For example, the vapor pressure of unleaded regular gasoline is certainly considerably higher than the vapor pressure associated with a fuel oil. The key to using foam as a vapor suppressing agent is to have a good thick foam blanket continuously on the fuel surface. This requires that common sense, good judgement, and the use of manufacturer's recommendations for the foam agent be followed at all times.

There is another category of foam agents that are used as vapor suppressants. These particular foam agents are not fire extinguishing agents and should never be used for that purpose. They are specifically formulated to be used as vapor suppressants in spills involving materials that are acidic or caustic. These materials are generally synthetic in nature and are designed to be used in a certain way. At present, there exists no standard that addresses materials of this type nor are there any approval or testing procedures. These products should be used in the equipment specified by the manufacturer and with the application conditions that are specified by the manufacturer.

It is important to recognize that there are some limitations in the use of foam fire extinguishing agents and of foam vapor suppressing agents that must be observed. In the case of the former, the foam blanket must be maintained in such a fashion that there are no openings for vaporization to occur that could result in fire or in exposure to human life. There are a number of low expansion foam agents that can be used for vapor suppression. There are disadvantages and advantages associated with all of them. Recognize that both medium expansion and high expansion foams can be used for vapor suppression but both are technique dependent, less mobile on the fuel surface, and in general result in foams that are more impaired by climatic conditions such as wind velocity, wind direction, precipitation, etc. Foam agents that are designed specifically to be used as vapor suppressants for spills involving acidic or caustic materials are not fire extinguishing agents. They can never be used when a fire is involved with the acidic or basic material. They are vapor suppressants and the manufacturer's recommendations and specifications regarding how they are used, and in what type of equipment, must be followed.

Appendix B Suggested Reading List

This Appendix is not a part of the recommendations of this NFPA document, but is included for information purposes only.

B-1 Introduction.

This list provides the titles of references and organizations that may be of value to those responding to hazardous materials incidents. This list can be expanded based on personal preferences and requirements.

The references are categorized by subject. The title, author, publisher, and place of publication are given for each. The year of publication is not always given because many are revised annually. The user should attempt to obtain the most recent edition.

The last section lists sources of these references as well as other information that might be useful. Usually, these agencies or associations will provide a catalog on request. Where available, phone numbers are also listed.

B-2 References.

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

(a) *Air Sampling Instruments for Evaluation of Atmospheric Contaminants*, American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

(b) *Direct Reading Colorimetric Indicator Tubes Manual*, American Industrial Hygiene Association, Akron, OH.

(c) *Fundamentals of Industrial Hygiene*, National Safety Council, Chicago, IL.

(d) *Industrial Hygiene and Toxicology*, Frank A. Patty, John Wiley and Sons, Inc., New York, NY.

(e) *Manual of Recommended Practice for Combustible Gas Indicators and Portable, Direct Reading Hydrocarbon Detectors*, American Industrial Hygiene Association, Akron, OH.

(f) *NIOSH/OSHA Pocket Guide to Chemical Hazards*, DHHS No. 85-114, NIOSH, Department of Health and Human Services, Cincinnati, OH.

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

(h) *Occupational Safety and Health Standards*, Title 29, Code of Federal Regulations, Part 1910.120. "Hazardous Waste Operations and Emergency Response Final Rule."

(i) *TLVs Threshold Limit Values and Biological Exposure Indices (Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment)*, American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

B-2.2 Chemical Data.

(a) *Chemical Hazard Response Information System (CHRIS)*, U.S. Coast Guard, Washington, DC, Commandant Instruction M.16565.12A.

(b) *CHRIS—A Condensed Guide to Chemical Hazards*, U.S. Coast Guard, Commandant Instruction M16565.11a.

(c) *The Condensed Chemical Dictionary*, G. Hawley, Van Nostrand Reinhold Co., New York, NY.

(d) *CRC Handbook of Chemistry and Physics*, CRC Press, Boca Raton, FL.

(e) *Dangerous Properties of Industrial Materials*, N. Irving Sax, Van Nostrand Reinhold Co., New York, NY.

(f) *Effects of Exposure to Toxic Gases*, Matheson.

(g) *Emergency Handling of Hazardous Materials in Surface Transportation*, Association of American Railroads.

(h) *Farm Chemicals Handbook*, Farm Chemicals Magazine, Willoughby, OH.

(i) *Firefighter's Handbook of Hazardous Materials*, Baker, Charles J., Maltese Enterprises, Indianapolis, IN.

(j) *Fire Protection Guide to Hazardous Materials*, National Fire Protection Association, Quincy, MA.

(k) *Hazardous Materials Handbook*, Meidl, J.H., Glencoe Press.

(l) *The Merck Index*, Merck and Co., Inc., Rahway, NJ.

(m) *Emergency Action Guides*, Association of American Railroads.

B-2.3 Safety and Personnel Protection.

(a) *A Guide to the Safe Handling of Hazardous Materials Accidents*, ASTM STP 825. American Society for Testing and Materials, Philadelphia, PA.

(b) *Fire Protection Handbook*, National Fire Protection Association, Quincy, MA.

(c) *Guidelines for Decontamination of Firefighters and their Equipment Following Hazardous Materials Incidents*, Canadian Association of Fire Chiefs (May 1987).

(d) *Guidelines for the Selection of Chemical Protective Clothing.* Volume 1: Field Guide, A.D. Schwope, P.P. Costas, J. O. Jackson, D. J. Weitzman. Arthur D. Little, Inc., Cambridge, MA (March 1983).

(e) *Guidelines for the Selection of Chemical Protective Clothing.* Volume 2: Technical and Reference Manual, A.D. Schwope, P.P. Costas, J.O. Jackson, D.J. Weitzman, J.O. Stull; Arthur D. Little, Inc., Cambridge, MA. 3rd Edition (February 1987).

(f) *Hazardous Materials*, Warren Isman and Gene Carlson, Glencoe Press, 1981.

(g) *Hazardous Materials Emergencies Response and Control*, John R. Cashman, Technomic Publishing Company, Lancaster, PA (June 1983).

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

(i) *Hazardous Materials: Managing the Incident*, Gregory Noll, Michael Hildebrand, and James Yvorra, Fire Service Publications, Stillwater, OK (1988).

(j) *Handling Radiation Emergencies*, Purington and Patterson, NFPA, Batterymarch Park, Quincy, MA.

(k) *Hazardous Materials Injuries, A Handbook for Pre-Hospital Care*, Douglas R. Stutz, Robert C. Ricks, Michael F. Olsen, Bradford Communications Corp., Greenbelt, MD.

(l) *National Safety Council Safety Sheets*, National Safety Council, Chicago, IL.

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

(n) *SCBA—A Fire Service Guide to the Selection, Use, Care, and Maintenance of Self-Contained Breathing Apparatus*, NFPA, Batterymarch Park, Quincy, MA.

(o) *Standard First Aid and Personal Safety*, American Red Cross.

B-2.4 Planning Guides.

(a) *A Fire Department's Guide to Implementing Title III and the OSHA Hazardous Materials Standard* (August 1987), William H. Stringfield, International Society of Fire Service Instructors, Ashland, MA.

(b) *Federal Motor Carrier Safety Regulations Pocketbook*, U.S. Department of Transportation, J. J. Keller and Associates, Inc.

(c) *Hazardous Chemical Spill Cleanup*, Noyes Data Corporation, Ridge Park, New Jersey.

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

(e) *Hazardous Materials Emergency Planning Guide* (March 1987), National Response Team.

(f) *Standard Operating Safety Guides*, Environmental Response Branch, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency.

(g) *1987 Emergency Response Guidebook—Guidebook for Hazardous Materials Incidents*, DO P 5800.3 USDOT, Materials Transportation Bureau, Attn: DHM 51 RS PA, Washington, DC 20590.

B-3 Agencies and Associations.

Agency for Toxic Substances Disease Registry
Shamlee 28 S., Room 9
Centers for Disease Control
Atlanta, GA 30333
404/452-4100

American Conference of Governmental
Industrial Hygienists
6500 Glenway Avenue—Building D-5
Cincinnati, OH 45211
513/661-7881

American Industrial Hygiene Association
475 Wolf Ledges Parkway
Akron, OH 44311-1087
216/762-7294

American National Standards Institute, Inc.
1430 Broadway
New York, NY 10018
212/354-3300

American Petroleum Institute (API)
1220 L St. N.W. 9th Floor
Washington, DC 20005
202/682-8000

Association of American Railroads
50 F St. N.W.
Washington, DC 20001
202/639-2100

Chemical Manufacturer's Association
2501 M St. N.W.
Washington, DC 20037
202/877-1100

CHEMTREC
800/424-9300

The Chlorine Institute
2001 L. Street N.W.
Washington, DC 20001
202/639-2100

Compressed Gas Association
1235 Jefferson Davis Highway
Arlington, VA 22202
703/979-0900

The Fertilizer Institute (TFI)
1015 18th St. N.W.
Washington, DC 20036
202/861-4900

International Society of
Fire Service Instructors
30 Main Street
Ashland, MA 01721
617/881-5800

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269
617/770-3000

Spill Control Association of America
Suite 1575
100 Renaissance Center
Detroit, MI 48243-1075

U.S. Department of Transportation
Materials Transportation Bureau
DHM 51 RS PA
Washington, DC 20590
202/366-4555

U.S. EPA Office of Research & Development
Publications—CERI
Cincinnati, OH 45268
513/684-7562

U.S. EPA Office of Solid Waste (WH-562)
Superfund Hotline
401 M St. S.W.

Washington, DC 20460
800/424-9346

U.S. Mine Safety and Health Administration
Department of Labor
4015 Wilson Blvd, Room 600
Arlington, VA 22203
703/235-1452

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

B-4 Computer Data Base 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

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SUBMITTING PROPOSALS ON NFPA TECHNICAL COMMITTEE DOCUMENTS

Contact NFPA Standards Administration for final date for receipt of proposals on a specific document.

INSTRUCTIONS

Please use the forms which follow for submitting proposed amendments.
Use a separate form for each proposal.

1. For each document on which you are proposing amendment indicate:
   (a) The number and title of the document
   (b) The specific section or paragraph.

2. Check the box indicating whether or not this proposal recommends new text, revised text, or to delete text.

3. In the space identified as "Proposal" include the wording you propose as new or revised text, or indicate if you wish to delete text.

4. In the space titled "Statement of Problem and Substantiation for Proposal" state the problem which will be resolved by your recommendation and give the specific reason for your proposal including copies of tests, research papers, fire experience, etc. If a statement is more than 200 words in length, the technical committee is authorized to abstract it for the Technical Committee Report.

5. Check the box indicating whether or not this proposal is original material, and if it is not, indicate source.

6. If supplementary material (photographs, diagrams, reports, etc.) is included, you may be required to submit sufficient copies for all members and alternates of the technical committee.

NOTE: The NFPA Regulations Governing Committee Projects in Paragraph 10-10 state: Each proposal shall be submitted to the Council Secretary and shall include:

(a) identification of the submitter and his affiliation (Committee, organization, company) where appropriate, and

(b) identification of the document, paragraph of the document to which the proposal is directed, and

(c) a statement of the problem and substantiation for the proposal, and

(d) proposed text of proposal, including the wording to be added, revised (and how revised), or deleted.