NFPA 485 Standard for the Storage, Handling, Processing, and Use of Lithium Metal 1994 Edition

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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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NFPA 485

Standard for the

Storage, Handling, Processing, and Use of Lithium Metal

1994 Edition

This edition of NFPA 485, *Standard for the Storage, Handling, Processing, and Use of Lithium Metal*, was prepared by the Technical Committee on Combustible Metals and Metal Dusts and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 16-18, 1994, in San Francisco, CA. It was issued by the Standards Council on July 14, 1994, with an effective date of August 5, 1994.

The 1994 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 485

The Committee on Combustible Metals and Metal Dusts began its work on developing a proposed standard on lithium at a Committee meeting in December 1990. The Committee reviewed drafts of the proposed standard and continued to revise the draft standard at Committee meetings held in June 1991, October 1991, March 1992, November 1992, March 1993, and November 1993.

The standard was submitted and adopted at the 1994 Annual Meeting in San Francisco, CA, May 16-18, 1994. The 1994 edition is the first edition of this standard.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

NOTE: Membership on a Committee shall not in and of itself constitute an endorsement of the Association or any document developed by the Committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on safeguards against fire and explosion in the manufacturing, processing, handling, and storage of combustible metals, powders, and dusts.

Contents

NFPA 485

Standard for the

Storage, Handling, Processing, and Use of Lithium Metal

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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 and Appendix B.

Chapter 1 General

1-1 Scope.

1-1.1 This standard shall apply to the storage, handling, processing, and use of solid or molten lithium.

1-1.2* This standard shall also apply to finished parts and those materials, including scrap, that exhibit the burning characteristics of lithium as specified by the manufacturer.

1-1.3 This standard shall not apply to the primary production of lithium solid.

1-1.4 This standard shall not apply to the transportation of lithium.

1-1.5 This standard shall not apply to those laboratories handling hazardous chemicals as defined in NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals.*

1-1.6* This standard shall not apply to finely divided solid forms of dry lithium or finely divided lithium dispersed in a flammable liquid.

1-2 Applicability. Unless otherwise noted, it is not intended that the provisions of this document be applied to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of the document, except in those cases where it is determined by the authority having jurisdiction that the existing situation involves a distinct hazard to life or adjacent property.

1-3 Purpose. The purpose of this standard shall be to call attention to the fire and explosion hazard in the storage, handling, processing, and use of lithium; to emphasize the measures to be taken to reduce such hazards; and to minimize the frequency and severity of lithium-related fire and explosion incidents. The requirements of this standard are based on conclusions drawn from available reports and data on lithium fire tests and actual fire experience.

1-4 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard, provided technical documentation is made available to the authority having jurisdiction to demonstrate equivalency and the system, method, or device is approved for the intended purpose.

1-5 Definitions. For the purpose of this standard, the following terms shall have the meanings given below.

Approved.* Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

Handling. Any activity, including processing, that can expose the metal's surface to air or any other substance capable of reacting with the metal under the conditions of the exposure.

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Listed.* Equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

Lithium. Either pure metal or alloys having the generally recognized properties of lithium metal, including the burning characteristics of lithium.

Noncombustible. In the form used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. (Materials reported as noncombustible, where tested in accordance with ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, are considered noncombustible materials.)

Shall. Indicates a mandatory requirement.

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

Chapter 2 General Precautions

2-1* Special Considerations. Lithium shall be kept away from sources of moisture.

2-2* Handling, Processing, and Storage Areas for Lithium. Lithium shall be handled, processed, and stored only in areas specifically suitable for the special hazards of lithium.

2-3* Lithium Fire Residue.

2-3.1* Lithium fire residues shall be protected to prevent adverse reactions and to prevent the formation of reactive or unstable compounds.

2-3.2 Lithium fire residues shall be disposed of in accordance with federal, state, and local regulations.

2-4 Fire Inspection Frequency. Containers of lithium fire residue shall be inspected monthly by individuals who are familiar with lithium hazards and able to recognize potential problems associated with these containers.

Chapter 3 Building Construction

3-1 General.

3-1.1 This chapter applies to buildings or portions of buildings that are dedicated to the handling or storage of solid or molten lithium.

3-1.2 Buildings dedicated to the storage, handling, processing, or use of lithium shall be constructed of noncombustible materials.

Exception: Other construction types shall be permitted if equivalent protection can be demonstrated.

3-1.3 Buildings shall comply with applicable provisions of NFPA *101®, Life Safety Code®.*

3-1.4* Roof decks shall be watertight.

3-1.5 Walls and ceilings shall be constructed with noncombustible insulation tested in accordance with ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C.*

3-1.6* All floors or elevated platforms shall be sealed against the penetration of lithium. In areas where molten lithium is handled, wall-to-floor connections shall be constructed with the minimum number of joints.

3-1.7 Floor drains shall not be permitted.

3-1.8 Where molten lithium is handled, dispensed, or stored, the handling area shall be provided with a steel-lined containment. The containment shall provide for a volume of 110 percent of the maximum amount of material that is contained or could be spilled in the area. In areas where molten lithium is handled, wall-to-floor connections shall be sealed against the penetration of molten lithium.

3-1.9 All electrical equipment and wiring shall comply with NFPA 70, *National Electrical Code®.*

3-2 Separation from Water.

3-2.1 Water pipes or pipes that can contain water under normal use (e.g., domestic water, roof drains, waste pipes, etc.) shall not be permitted in areas containing lithium. Sprinkler piping shall not be permitted to pass through lithium areas for which sprinkler systems have been deemed inappropriate.

Exception: Sprinkler system piping as allowed by the Exception to 6-1.2 shall be permitted.

3-2.2 Portions of buildings shall be separated by watertight walls, ceilings, and door systems from adjacent areas not handling or storing lithium where water can be present. The floor shall be sloped away from the entrance to these areas, or other means shall be taken to prevent water from entering.

Chapter 4 Handling or Processing of Solid or Molten Lithium

4-1 General Precautions.

4-1.1 Lithium metal shall be handled only by trained personnel who are knowledgeable of the hazards associated with lithium.

4-1.2 The number of persons in lithium-handling areas during operations shall be limited to those necessary for the operation.

4-1.3 Access to lithium-handling areas by unauthorized personnel shall not be permitted.

4-1.4 Lithium shall not be handled in the presence of incompatible materials. (*See also A-5-1.3.*)

4-1.5 Primary storage of ordinary combustible materials and flammable and combustible liquids shall be prohibited in lithium-processing areas.

4-1.6 No open flames or electric or gas cutting, welding, or other spark-producing operations equipment shall be permitted in the section of the building where lithium is present unless approved hot work procedures are followed by qualified personnel. (See NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes.*)

4-1.7* Only lithium for immediate use shall be present in handling areas. Lithium handling or processing areas shall not be used for primary storage of lithium.

4-2 Solid Lithium Handling.

4-2.1 Solid lithium shall be protected from moisture during handling by water-free mineral oil or by the use of dry air, argon, helium, or other appropriate methods.

4-2.2* Only the amount of lithium needed for an individual task or procedure shall be removed from containers. Surplus lithium shall be returned to the shipping container and resealed as soon as possible.

4-3 Molten Lithium Handling.

4-3.1 Molten lithium shall be contained in closed systems that prevent its contact with air or reactive materials.

Exception: As required for the process.

4-3.2 Molten lithium piping systems shall be designed in conformance with ANSI B31.3, *Chemical Plant and Petroleum Refinery Piping.* All pump seals and flange gaskets shall be made of compatible materials.

4-3.3 Molten lithium systems shall overflow or relieve to secondary containments designed to handle 110 percent of the largest expected failure and shall be provided with the means to prevent contact with incompatible materials.

4-3.4 Molten lithium shall be handled in a detached building or in portions of a building separated from other exposures by barrier walls so any fire shall be permitted to be dealt with as a lithium fire.

Chapter 5 Storage of Solid or Molten Lithium

5-1 General Precautions.

5-1.1* Lithium shall be permitted to be stored in sealed Department of Transportation (DOT) or Hazardous Materials Regulations (HM 181) approved shipping containers or in clean, moisture-free, sealed metal containers dedicated for the storage of lithium.

5-1.2 Lithium shall not be stored in containers previously used for the storage of incompatible materials.

5-1.3* Lithium shall not be stored in an area with incompatible materials.

5-1.4 Lithium containers shall not be stored outside.

Exception: Lithium fire residues shall be permitted to be stored outside where placed in a double-steel, overpack drum and inspected daily.

5-2 Solid Lithium Storage.

5-2.1 Solid lithium shall be stored only on the ground floor. There shall be no basement or depression below the lithium storage area into which water or molten metal shall be permitted to flow or fall during a fire.

5-2.2 The solid lithium storage area shall be isolated from other areas so that water cannot enter by spray or drainage from automatic sprinkler systems or any other water source.

5-2.3 Container Storage Arrangement.

5-2.3.1 Containers shall be stored individually or on pallets in an arrangement that allows visual inspection for container integrity.

5-2.3.2 Containers on pallets shall be permitted to be stored in racks not more than 15 ft (4.5 m) high.

5-2.3.3 Containers on pallets not in racks shall not be stacked more than two high.

5-2.3.4 Aisle widths shall not be less than one-half the height of the piles.

5-2.3.5 Idle pallet storage shall not be permitted in solid lithium storage areas.

5-3 Molten Lithium Storage. Molten lithium storage shall be in closed systems and in separate buildings or portions of buildings designed by competent designers solely for that purpose.

Chapter 6 Fire Protection

6-1* General Precautions.

6-1.1 A fire protection plan shall be provided for all areas where lithium is processed, handled, used, and stored.

6-1.2* Buildings or portions of buildings dedicated to lithium storage or handling shall not be permitted to be equipped with automatic sprinkler protection.

Exception: Sprinkler systems installed in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems, shall be permitted in areas where combustibles other than lithium create a more severe fire hazard than the lithium and where acceptable to an authority having jurisdiction who is knowledgeable of the hazards associated with lithium.

6-1.3 As an alternative, a specially engineered fire protection system specifically designed to be compatible with the hazards present in the lithium operation area shall be permitted to be installed in areas where combustible loading is essential to the process operation.

NOTE: If dry chemical extinguishing systems are used, see NFPA 17, *Standard for Dry Chemical Extinguishing Systems.*

6-2 Extinguishing Agents and Application Techniques.

6-2.1* Only listed, Class D, extinguishing agents or those tested and shown to be effective for extinguishing lithium fires shall be permitted. A supply of extinguishing agent for manual application shall be kept within easy reach of personnel while working with lithium. The amount of extinguishing agent to be provided shall follow the listing agency's or manufacturer's recommendation.

6-2.2 Agents intended for manual application shall be kept in original labeled factory containers. Container lids shall be kept in place to prevent agent contamination and to keep agent moisture free. Where large quantities of agent are expected to be needed, a clean dry shovel shall be provided with the container. Where small amounts are needed, a hand scoop shall be provided with each container.

6-2.3* Portable or wheeled extinguishers listed for use on lithium fires shall be permitted and shall be distributed in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

6-2.4* The following agents shall not be used as extinguishing agents on a lithium fire because of adverse reaction.

(a) Water,
(b) Gaseous-based foams,
(c) Halon, and
(d) Carbon dioxide.

6-2.5* An ABC dry chemical and a B:C dry chemical extinguisher shall not be used as a lithium fire extinguishing agent, but shall be permitted to be used on other classes of fires in the area where lithium is present.

6-2.6* Fire extinguishing agent expellant gases shall be compatible with lithium.

6-3 Personal Protective Equipment for Fire Fighting.

6-3.1* Proper protective clothing, respiratory protection, and adequate eye protection shall be used by all responding fire-fighting personnel assigned to a lithium fire. (See NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program.*)

6-3.2* Additional eye protection shall be worn by personnel wearing SCBA protection to protect against the higher degree of emitted light during a lithium fire. Visual protection equivalent to a No. 6 welding lens shall be used.

6-4 Protective Equipment for Facility Personnel Performing Incipient Stage Lithium Fire Fighting.

6-4.1 If incipient lithium fires are to be fought, personal protective equipment shall be worn. Personal protective equipment shall include face shields, head protection, gloves, external clothing, and respiratory protection.

6-4.1.1* Personnel who attempt to fight a lithium fire in its incipient stage shall, as a minimum, wear full face shields.

6-4.1.2 Head protection shall consist of hard hats.

6-4.1.3 Gloves shall conform with 7-2.3.

6-4.1.4 If provided, external clothing shall conform with 7-2.5.

6-4.1.5 Respiratory protection suitable for the hazards of lithium shall be provided.

6-4.2 If incipient lithium fires are to be fought, personal protective equipment shall be readily accessible and maintained in good condition in all areas where lithium is handled.

6-4.3 A minimum of two sets of personal protective equipment shall be provided if incipient lithium fires are to be fought.

6-5 Lithium Fire-Fighting Procedures.

6-5.1* While fighting a lithium fire, every effort shall be made to avoid splattering the burning lithium.

6-5.2* Once the fire is extinguished and a crust is formed, the crust shall not be disturbed until the residues have cooled to room temperature.

Chapter 7 Personal Protective Equipment for Molten and Solid Handling Operations

7-1* Personal Protective Equipment for Solid Lithium Handling.

7-1.1 While handling solid lithium, eye protection shall be worn.

7-1.2 Gloves shall be worn while handling solid lithium. Gloves shall have tight-fitting cuffs and shall be made of a material suitable for protection from caustic hazards.

7-1.3 Clothing worn while handling solid lithium shall have no exposed pockets or cuffs that could trap and carry lithium residues.

7-2* Personal Protective Equipment for Handling Molten Lithium.

7-2.1 Personal protective equipment shall be worn and shall be compatible with the hazards of molten lithium.

7-2.2 While handling molten lithium, safety glasses and full-face protection shall be worn, i.e., face shields.

7-2.3 Gloves shall be worn and shall be loose-fitting, easily removable, and compatible with the hazards of molten lithium.

7-2.4 All clothing shall be loose-fitting, easily removable, flame-resistant, and compatible with the hazards of molten lithium.

7-2.5* An external clothing layer shall be worn for protection from splash. The external clothing layer shall be impervious to body moisture.

7-2.6 Protective footwear shall be appropriate for the hazards of molten lithium.

Chapter 8 Referenced Publications

8-1 The following documents or portions thereof are referenced within this document and shall be considered part of the requirements 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, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1994 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1994 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 1991 edition.

NFPA 70, *National Electrical Code*, 1993 edition.

NFPA *101*, *Life Safety Code*, 1994 edition.

8-1.2 ASTM Publication. American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103-1187.

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 1993-D.

8-1.3 ANSI Publication. American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

ANSI B31.3, *Chemical Plant and Petroleum Refinery Piping*, 1993 edition.

Appendix A Explanatory Material

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

A-1-1.2 Products or materials that have the characteristics of lithium should have a material safety data sheet (MSDS) that describes these burning characteristics. Refer to A-6-1, A-6-5.1, and A-6-5.2 for a general explanation of these characteristics, and consult with the manufacturer or technical personnel knowledgeable of the hazards associated with lithium.

A-1-1.6 Finely divided dry lithium and finely divided lithium dispersed in a flammable liquid can exhibit pyrophoric properties and, therefore, do not act as combustible metals, as covered by this standard.

A-1-5 Definitions.

Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or

evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

Authority Having Jurisdiction. 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, 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.

Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-2-1 Lithium reacts with moisture from any available source, such as concrete, the atmosphere, and human skin. The degree and speed of the reaction varies with conditions; therefore, the best approach is to take precautions to keep moisture away from lithium.

A-2-2 Small facilities isolated from other facilities under the same ownership are ideal for handling and processing lithium. In the event of an uncontrolled lithium emergency, property damage would be considerably less.

A-2-3 Lithium fire residue products can include metallic lithium, lithium nitride, lithium oxide, or lithium hydroxide, which can absorb moisture.

A-2-3.1 Once a lithium fire is extinguished, lithium is usually still present in sufficient quantity to create adverse reactions and exhibit the burning characteristics of lithium. Lithium fire residues can include other reactive components. These residues can react with each other and cause re-ignition. Containers of residues can be purged with argon gas or the residues can be coated with water-free mineral oil to reduce the potential for reaction.

A-3-1.4 The requirement for watertight roof decks is an effort to ensure that buildings are designed and maintained to minimize possible leaks from weather conditions. Special care should be given to maintain these roofs, especially in climates where heavy amounts of snow are expected.

A-3-1.6 Nonslip surfaces should be provided due to the potential presence of mineral oil on the floor. Gratings should be used only where containment provisions have been provided below the area or where access can be restricted below the area.

A-4-1.7 When evaluating the amounts needed for immediate use, the risks and fire exposures should be evaluated with other processing requirements.

A-4-2.2 Solid lithium is supplied in a variety of forms, e.g., ingots and ribbon, which are often individually protected in small cans or airtight foil pouches. If individual containers are not supplied and the containers are opened, lithium is exposed to surrounding air, causing slow reactions to take place. It is for this reason that once the container is opened, only that amount of lithium intended to be used should be removed.

A-5-1.1 Lithium is shipped from lithium manufacturers in DOT or HM 181-approved containers that should continue to act as storage containers. Containers should be sealed to remain airtight, with lithium coated with mineral oil or packed under an argon cover. Containers used to store lithium under mineral oil for long-term storage (over three months) should be inverted to redistribute the mineral oil covering the lithium. Containers packed under an argon cover should be regularly checked to verify the integrity of the container seal. When lithium is returned to any shipping container, the protective method used by the manufacturer should be duplicated.

A-5-1.3 Lithium is known to be incompatible with the following materials: inorganic and organic acids; Halon 1211; Halon 2402; carbon tetrachloride; 1,1,1 trichloroethane; oxidizers such as nitric acid, chromic acid, phosphoric acid, or hypochlorous acid; and reducing acids such as sulfuric, hydrochloric, and sulfamic acid. Oxalic acid, phenol and organic acid mixtures, or compounds such as paint strippers or metal cleaners are also reactive and should not be stored in the vicinity of lithium. Refer to NFPA 491M, *Manual of Hazardous Chemical Reactions*.

A-6-1 Lithium fires, being quite unique in nature, require a comprehensive fire protection plan where lithium is processed, handled, used, or stored. This plan should include specific actions in the event of a lithium fire and should be coordinated with the local facility management, responding fire fighters, and medical personnel.

This plan should pay special attention to the extreme hazards associated with lithium-water reactions that might occur with sprinkler water. Specific attention should be paid to an evacuation plan for personnel in the event of any release of water.

The particulate fumes given off by burning lithium are very corrosive; therefore, nonessential personnel in the vicinity should be evacuated to a safe distance, with special attention given to shifting winds. Where frequent lithium fires can affect local environmental quality conditions, an exhaust treatment system should be provided.

Properly trained personnel who work with lithium know its hazards. Such personnel will have the greatest chance to extinguish a lithium fire in its incipient stage. Training should include sufficient information to determine if extinguishment can be safely and effectively accomplished.

Lithium at room temperature in the presence of incompatible materials can reach the melting point and reach the autoignition temperature.

The degree of reaction and the amount of time to produce these effects vary with conditions surrounding the fire; temperature of the exposed lithium being the major factor. At low temperatures or temperatures within a few degrees of lithium's melting point, the reaction is slower with reduced intensity. At higher temperatures, the reaction is accelerated and more intense.

When fighting a lithium fire, it is very important that fire fighters be aware of the dangers of burning lithium. When molten lithium reacts with materials such as water or flammable or combustible liquids or gases, molten lithium can be ejected for a considerable distance. The severity of lithium reactions varies with a multitude of conditions.

Lithium in contact with moisture and air forms lithium hydroxide and lithium oxide, which will cause caustic burns without adequate personal protective equipment.

A-6-1.2 The reaction of lithium, especially burning lithium, with water is extremely hazardous. Where combustible loading in areas used for lithium processing is determined by the authority having jurisdiction to require sprinkler protection, consideration should be given to the installation of preaction sprinkler systems to reduce the opportunity for accidental discharge.

A-6-2.1 Several agents, e.g., graphite-based agents and lith-x, have been successfully tested on lithium fires and found to be successful with varying results. These agents all form a crust of varying durability over the fuel, but due to molten lithium's fluid properties, lithium tends to seek any weak spot in this crust and develop "burn-throughs." Copper powder formed the most durable crust of all these effective fire-fighting agents.

Low density agents were found to be difficult to apply in windy conditions, resulting in decreased extinguisher effective range, reduced visibility, and larger amounts of agent needed.

Testing indicates that the amount of agent needed depends on several factors. Small-scale lithium fires require the use of an acceptable ratio of extinguishing agents. Larger fires can require dramatically larger ratios. The acceptable ratio varies, depending on the agent selected.

Lithium, with its low density, will float on solid or liquid. Extinguishing agents will tend to sink in molten lithium; therefore, as depth of fuel increases, the amount of agent needed will increase. Extended testing and evaluation of lithium fires indicates the amount of agent needed is not based on weight of agent per weight of fuel, but should be based on depth and surface area of involved fuel per weight of agent.

The lower the temperature of the lithium, the less heat will be required to be drawn from the lithium to reduce reactions, therefore reducing the amount of agent needed.

A-6-2.3 In cases where the weight of the lithium hazard is small and well defined, portable or wheeled extinguishers should be distributed so that at least one is located within 75 ft (22.7 m) of the hazard and additional extinguishers can be readily available.

The reasoning for recommending wheeled extinguishers where large amounts of lithium are found is based on the following:

(a) One or two individuals can deliver large amounts of agent in a relatively short period of time.

(b) Being highly mobile, wheeled extinguishers can be situated to provide a more complete coverage of any facility.

(c) Wheeled units protecting other areas that might not be affected in the emergency can be brought to the scene.

A-6-2.4 The following extinguishing agents should not be used as lithium fire extinguishing agents:

(a) The application of water in any form on lithium releases considerable amounts of hydrogen gas, steam, and heat and is not recommended on lithium.

Tests have demonstrated that the effect of water on lithium fires is the formation of hydrogen gas. In some cases, hydrogen will burn and intensify the fire; in other cases, hydrogen results in rapid heat rise with an explosive-like effect.

The amount of hydrogen gas present in the vicinity of any lithium reaction is directly proportional to the degree of further reaction. If the environment surrounding the fire is such that the hydrogen gas is driven off or its concentration is reduced to a level below its lower explosive limit, the reaction is less in intensity.

(b) Past testing of the application of aqueous film-forming foam (AFFF) on burning lithium resulted in extreme reactions.

(c) Halon should not be used as a lithium fire extinguishing agent.

Halon, when applied to a lithium fire, exhibits an immediate reaction. One effect is that the reaction will track the agent stream putting the fire fighter in increased danger.

(d) The application of CO_2 produces minimal reactions, yet the force of this agent can greatly spread burning lithium. Therefore, CO_2 is not recommended as a lithium fire extinguishing agent.

A-6-2.5 Dry chemical agents should not be used on a lithium fire. Testing indicated that a B:C dry chemical was not an effective lithium fire-fighting agent although it exhibited the least amount of adverse reaction with lithium.

A-6-2.6 Many common extinguishing agents and extinguisher expelling gases, when exposed to burning lithium, exhibit high reactivity. The degree of reactivity depends on a wide range of variables, e.g., temperature of the fire and other chemical compounds reacting with the lithium. For example, nitrogen commonly used to expel dry powder agent does not exhibit a high degree of reactivity until the temperature of the fire increases.

Testing has indicated that carbon dioxide and nitrogen, commonly used as extinguisher expellant gases, are reactive to lithium at higher temperatures. Argon gas, being nonreactive to lithium, can be used successfully as a substitute.

If lithium is involved in a multiclass fire and agents that are reactive to lithium, e.g., water, AFFF, and halon, are used, expect and prepare for the effects of the reaction. Use unmanned delivery techniques and use whatever physical protection is available.

A-6-3.1 Burning lithium will burn through material used in the construction of most fire fighter protective clothing. Some features (e.g., heavy quilted lining and aluminized outer shell) can reduce this risk. It is recognized that SCBA face piece eye protection worn by fire fighters is adequate protection with the exception of the intense light given off by burning lithium.

A-6-3.2 Specific testing has indicated that white light levels emitted from burning lithium exceed recommended levels. Extended lithium fire experience has shown that this intense light can cause serious damage to unprotected eyes.

A clip-on adapter over an SCBA face piece with a shaded glass lens equivalent to a No. 6 welding lens has been used very successfully to reduce such hazards. A darker lens tends to obstruct fire fighters view to an unacceptable degree.

A-6-4.1.1 Full face shields, preferably shaded shields, should be made readily available in areas where lithium fires are likely to occur. These shields will provide adequate protection against small incipient-stage lithium fires.

A-6-5.1 One of the greatest dangers to fire fighters is the splattering effect of burning lithium. Molten lithium is very fluid and easily spread; therefore, extreme care needs to be taken when applying fire-fighting agent. The force used to deliver agent from an extinguisher can easily spread lithium particles; therefore, delivery technique is very important. Should direct agent application become hazardous, indirect application techniques should be used. Deflecting agent off another object or directing the agent stream above the hazard and letting the agent fall by gravity can be effective.

A-6-5.2 Forming a crust over burning lithium reduces the available oxygen and eliminates exothermic reactions. Extinguishing agent should first be applied to the white-hot burning areas, then evenly applied to the mass, controlling the flow to form an oxygen-depleting crust. Since lithium tends to flow easily through any weak spots, agents should be applied evenly to construct a continuous crust. If lithium surfaces, additional agent should be applied to strengthen the crust.

Actual crust formation is created by the ability of some powdered agents to absorb heat from the lithium. In the case of copper powder, a lithium-copper alloy is formed as heat is absorbed from the lithium. Once the crust is formed, the temperature of the lithium decreases and exothermic reactions are reduced. Extreme care should be taken to ensure the crust is not disturbed or broken until the temperature of the lithium is decreased to the point where resolidification occurs.

A-7-1 Lithium in contact with moisture forms lithium hydroxide and lithium oxide, which will cause caustic burns. Lithium in contact with human skin will react with body moisture and cause thermal and caustic burns.

A-7-2 Hazards involved with handling molten lithium are significantly greater than those of handling solid lithium due to enhanced reactivity, heat of reaction, and elevated temperatures.

A-7-2.5 Fire risk is significantly reduced when the outer clothing layer is kept dry.

Appendix B Referenced Publications

B-1 The following documents or portions thereof are referenced within this standard for informational purposes only and thus are not considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

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

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 1994 edition.

NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*, 1994 edition.

NFPA 491M, *Manual of Hazardous Chemical Reactions*, 1991 edition.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, 1992 edition.

B-1.2 Other Publications.

B-1.2.1 ASTM Publication. American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103-1187.

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 1993-D.

B-1.2.2 New Mexico Engineering Research Institute, University of New Mexico, Albuquerque, NM 87131-1376.

Moore, T. A., Stepetic, T. J., and Tapscott, R.E., Preliminary Environmental and Safety Evaluation of Large Scale Lithium Metal Fires, Naval Undersea Warfare Engineering Station, Keyport, Washington, March 1989.

Lee, M. E., Stepetic, T. J., Watson, J. D., and Moore, T. A., Lithium Fire Suppression Study, Phase 3 (Medium-Scale), Naval Undersea Warfare Engineering Station, Keyport, Washington, November 1989. (NMERI OC 90/10).

B-1.2.3 U.S. Government Publication. U.S. Government Printing Office, Superintendent of Documents, Washington, DC 20402.

49 CFR Part 1200 (DOT and HM-181) and Parts 100-199.

B-1.2.4 National Safety Council, 1121 Spring Lake Dr., Itasca, IL, 60143-3201.

National Safety Council, Data Sheet 1-66, Lithium.

Index

The NFPA Codes and Standards Development Process

Since 1896, one of the primary purposes of the NFPA has been to develop and update the standards covering all areas of fire safety.

Calls for Proposals
The code adoption process takes place twice each year and begins with a call for proposals from the public to amend existing codes and standards or to develop the content of new fire safety documents.

Report on Proposals
Upon receipt of public proposals, the technical committee members meet to review, consider, and act on the proposals. The public proposals – together with the committee action on each proposal and committee-generated proposals – are published in the NFPA's Report on Proposals (ROP). The ROP is then subject to public review and comment.

Report on Comments
These public comments are considered and acted upon by the appropriate technical committees. All public comments – together with the committee action on each comment – are published as the Committee's supplementary report in the NFPA's Report on Comments (ROC).

The committee's report and supplementary report are then presented for adoption and open debate at either of NFPA's semi-annual meetings held throughout the United States and Canada.

Association Action
The Association meeting may, subject to review and issuance by the NFPA Standards Council, (a) adopt a report as published, (b) adopt a report as amended, contingent upon subsequent approval by the committee, (c) return a report to committee for further study, and (d) return a portion of a report to committee.

Standards Council Action
The Standards Council will make a judgement on whether or not to issue an NFPA document based upon the entire record before the Council, including the vote taken at the Association meeting on the technical committee's report.

Voting Procedures
Voting at an NFPA Annual or Fall Meeting is restricted to members of record for 180 days prior to the opening of the first general session of the meeting, except that individuals who join the Association at an Annual or Fall Meeting are entitled to vote at the next Fall or Annual Meeting.

"Members" are defined by Article 3.2 of the Bylaws as individuals, firms, corporations, trade or professional associations, institutes, fire departments, fire brigades, and other public or private agencies desiring to advance the purposes of the Association. Each member shall have one vote in the affairs of the Association. Under Article 4.5 of the Bylaws, the vote of such a member shall be cast by that member individually or by an employee designated in writing by the member of record who has registered for the meeting. Such a designated person shall not be eligible to represent more than one voting privilege on each issue, nor cast more than one vote on each issue.

Any member who wishes to designate an employee to cast that member's vote at an Association meeting in place of that member must provide that employee with written authorization to represent the member at the meeting. The authorization must be on company letterhead signed by the member of record, with the membership number indicated, and the authorization must be recorded with the President of NFPA or his designee before the start of the opening general session of the Meeting. That employee, irrespective of his or her own personal membership status, shall be privileged to cast only one vote on each issue before the Association.

Sequence of Events Leading to Publication of an NFPA Committee Document

Call for proposals to amend existing document or for recommendations on new document.

▼

Committee meets to act on proposals, to develop its own proposals, and to prepare its report.

▼

Committee votes on proposals by letter ballot. If two-thirds approve, report goes forward. Lacking two-thirds approval, report returns to committee.

▼

Report is published for public review and comment. (Report on Proposals - ROP)

▼

Committee meets to act on each public comment received.

▼

Committee votes on comments by letter ballot. If two-thirds approve, supplementary report goes forward. Lacking two-thirds approval, supplementary report returns to committee.

▼

Supplementary report is published for public review. (Report on Comments - ROC).

▼

NFPA membership meets (Annual or Fall Meeting) and acts on committee report (ROP and ROC).

▼

Committee votes on any amendments to report approved at NFPA Annual or Fall Meeting.

▼

Complaints to Standards Council on Association action must be filed within 20 days of the NFPA Annual or Fall Meeting.

▼

Standards Council decides, based on all evidence, whether or not to issue standard or to take other action, including hearing any complaints.

▼

Appeals to Board of Directors on Standards Council action must be filed within 20 days of Council action.

FORM FOR PROPOSALS ON NFPA TECHNICAL COMMITTEE DOCUMENTS

Mail to: Secretary, Standards Council
National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269-9101
Fax No. 617-770-3500

Note: All proposals must be received by 5:00 p.m. EST/EDST on the published proposal-closing date.

If you need further information on the standards-making process, please contact the Standards Administration Department at 617-984-7249.

Date 9/18/93 **Name** John B. Smith **Tel. No.** 617-555-1212

Company _____

Street Address 9 Seattle St., Seattle, WA 02255

Please Indicate Organization Represented (if any) Fire Marshals Assn. of North America

1. a) NFPA Document Title National Fire Alarm Code **NFPA No. & Year** NFPA 72, 1993 ed.

b) Section/Paragraph 1-5.8.1 (Exception No.1)

FOR OFFICE USE ONLY
Log # _____
Date Rec'd _____

2. Proposal recommends: (Check one)
- ❑ **new text**
- ❑ **revised text**
- ☒ **deleted text**

3. Proposal (include proposed new or revised wording, or identification of wording to be deleted):

Delete exception.

4. Statement of Problem and Substantiation for Proposal: (Note: State the problem that will be resolved by your recommendation; give the specific reason for your proposal including copies of tests, research papers, fire experience, etc. If more than 200 words, it may be abstracted for publication.)

A properly installed and maintained system should be free of ground faults. The occurrence of one or more ground faults should be required to cause a "trouble" signal because it indicates a condition that could contribute to future malfunction of the system. Ground fault protection has been widely available on these systems for years and its cost is negligible. Requiring it on all systems will promote better installations, maintenance and reliability.

5. ☒ This Proposal is original material. (Note: Original material is considered to be the submitter's own idea based on or as a result of his/her own experience, thought, or research and, to the best of his/her knowledge, is not copied from another source.)

❑ **This Proposal is not original material; its source (if known) is as follows:** _____

Note 1: Type or print legibly in black ink.
Note 2: 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.

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John B. Smith
Signature (Required)

PLEASE USE SEPARATE FORM FOR EACH PROPOSAL

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Date _____ **Name** _____ **Tel. No.** _____

Company _____

Street Address _____

Please Indicate Organization Represented (if any) _____

1. a) NFPA Document Title _____ **NFPA No. & Year** _____

b) Section/Paragraph _____

2. Proposal Recommends: (Check one)
- ❑ **new text**
- ❑ **revised text**
- ❑ **deleted text**

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Log # _____

Date Rec'd _____

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