

NFPA® 484

Standard for Combustible Metals

2015 Edition



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An International Codes and Standards Organization

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NFPA® 484

Standard for Combustible Metals

2015 Edition

This edition of NFPA 484, *Standard for Combustible Metals*, was prepared by the Technical Committee on Combustible Metals and Metal Dusts and released by the Correlating Committee on Combustible Dusts. It was issued by the Standards Council on April 29, 2014, with an effective date of May 19, 2014, and supersedes all previous editions.

This edition of NFPA 484 was approved as an American National Standard on May 19, 2014.

Origin and Development of NFPA 484

The 2002 edition of NFPA 484, then titled *Standard for Combustible Metals, Metal Powders, and Metal Dusts*, was a comprehensive combustible-metal fire safety document. It was created by taking the requirements of the metals standards NFPA 480, *Standard for the Storage, Handling, and Processing of Magnesium Solids and Powders*; NFPA 481, *Standard for the Production, Processing, Handling, and Storage of Titanium*; NFPA 482, *Standard for the Production, Processing, Handling, and Storage of Zirconium*; NFPA 485, *Standard for the Storage, Handling, Processing, and Use of Lithium Metal*; NFPA 65, *Standard for the Processing and Finishing of Aluminum*; and NFPA 651, *Standard for the Machining and Finishing of Aluminum and the Production and Handling of Aluminum Powders*, and making them into individual chapters in NFPA 484. Chapter 10 was written to address combustible metals not covered by one of the metal-specific chapters. Additionally, a metal-specific chapter was written for tantalum because of its increased use. Thus, NFPA 484 provided safety requirement, including processing, storage, handling, dust collection, housekeeping, and fire protection, for all combustible metals.

The 2006 edition of NFPA 484, *Standard for Combustible Metals*, contained several major changes, including a new title. A new chapter, Chapter 4, gave test requirements for classifying a material as a combustible metal. Other new chapters were Chapter 5, which addressed alkali metals; Chapter 8, which addressed niobium; and Chapter 13, which consolidated the fire protection requirements given in Chapters 5 through 12.

The 2009 edition of NFPA 484 contained the following changes:

- (1) Addition of a new Chapter 14, Combustible Metal Recycling Facilities
- (2) Addition of thresholds in Table 1.1.9, for applicability of the document; prior to this change the standard applied to any amount of a combustible metal
- (3) Updates to the recommended suppression materials in Table A.13.3.3.

The 2012 edition of NFPA 484 contained the following changes:

- (1) A unified format was applied for chapter-to-chapter consistency for the individual combustible metals in the document.
- (2) New definitions were added for dust explosion and dust flash-fire hazard area and a number of particular forms, including metal dust, fines, superfines, ultrafines, flakes, paste, and ribbon. A definition for screening test was also added. The Committee clarified when the standard would apply rather than when the standard would not apply. New information was included in Chapter 16 to clarify the testing and classification of potentially combustible metals.
- (3) Management of change requirements was added to chapters where it was not previously identified as a requirement.
- (4) New information was included on wet dust collection systems. Additional information was added addressing housekeeping, an important issue for the prevention of fires and explosions. Personal protective equipment (PPE) requirements were identified.
- (5) Chapter 15, Fire Prevention, Fire Protection, and Emergency Response, remained retroactive for all of the specific metal chapters and for the general metal chapter.



Documents

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- (6) Chapter 16, Combustible Metal Recycling Facilities, was retroactive. Additional information was added to address emergency response requirements.
- (7) Hazard analysis requirements were applicable to all metal chapters.
- (8) A new chapter on performance-based design was added.

The 2015 edition of NFPA 484 revises a provision in Chapter 1 that establishes a framework for the protection of mixtures of metals and other combustible dusts and includes revised definitions in Chapter 3. Chapter 4 includes revised procedures for material characterization and determining combustibility and explosibility for metal dusts. As part of those requirements, test data or historical data are permitted to be used. Chapter 5 now includes requirements for management systems elements, such as management of change, hazard analysis, and personal protective equipment. As part of an effort to consolidate fundamental requirements within dedicated chapters, ignition control sources such as hot work and static electricity are moved from Chapter 6 to Chapter 8, now titled Control of Ignition Sources. Chapter 6 includes new requirements on emergency response and preparedness. In Chapter 7, the Committee established a threshold for fugitive dust accumulations, which is used to trigger specific requirements related to dust hazard control. Chapter 9 has been modified to include new requirements for pneumatic conveying. The Committee also modified Chapters 11 through 18 by moving requirements common for all the metal types (such as PPE, management of change, dust collection, ignition sources, and hazard analysis) to one of the fundamental chapters (Chapters 4 through 9). The Committee added acceptance criteria to Chapter 19 for metal recycling.



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Committee Scope: This Committee shall have primary responsibility for documents on the hazard identification, prevention, control, and extinguishment of fires and explosions in the design, construction, installation, operation, and maintenance of facilities and systems used in manufacturing, processing, recycling, handling, conveying, or storing combustible particulate solids, combustible metals, or hybrid mixtures.

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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.



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

Chapter 1 Administration

1.1* Scope. This standard shall apply to the production, processing, finishing, handling, recycling, storage, and use of all metals and alloys that are in a form that is capable of combustion or explosion.

1.1.1* The procedures in Chapter 4 shall be used to determine whether a metal is in a noncombustible form.

1.1.2 Combustible Metal Powder or Dust.

1.1.2.1 This standard also shall apply to operations where metal or metal alloys are subjected to processing or finishing operations that produce combustible powder or dust.

1.1.2.2 Operations where metal or metal alloys are subjected to processing or finishing operations that produce combustible powder or dust shall include, but shall not be limited to, machining, sawing, grinding, buffing, and polishing.

1.1.3* Metals, metal alloy parts, and those materials, including scrap and mixtures, shall be subject to the requirements of the metal whose combustion characteristics they most closely match.

1.1.4 Metals, metal alloy parts, and those materials and mixtures, including scrap, not covered by a specific metal chapter, are subject to the requirements of Chapter 18.

1.1.5 Materials submitted for recycling or waste disposal shall be subject to the requirements of Chapter 19.

1.1.6* This standard shall apply to mixtures that contain metals exhibiting combustion characteristics of metals covered by this standard.

1.1.6.1 Metal only mixtures shall be subject to the requirements of this standard.

1.1.6.2* Metal-containing mixtures shall be permitted to be excluded from this standard and protected according to NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, or other NFPA industry- or commodity-specific standard, if by testing it is established that the mixture meets all of the following criteria:

- (1) It has been demonstrated that mixture fires can be controlled safely and effectively with Class ABC fire-extinguishing agents.
- (2) It has been demonstrated that mixture fires can be controlled safely and effectively with water.
- (3) The material is not a UN Class 4.3 solid as tested using UN 4.3 water reactivity test methods.
- (4) It has been demonstrated that the volume resistivity is greater than 1 M ohm-m.
- (5) It is not a metal/metal-oxide mixture (e.g., thermite).

1.1.7* This standard shall not apply to the transportation of metals in any form on public highways and waterways or by air or rail.

1.1.8 This standard shall not apply to the primary production of aluminum, magnesium, and lithium.

1.1.9 This standard shall apply to laboratories that handle, use, or store more than 0.23 kg (½ lb) of alkali metals or 0.907 kg (2 lb) aggregate of other combustible metals, excluding alkali metals.

1.1.10 All alkali metals and metals that are in a form that is water reactive shall be subject to this standard.

1.1.11* If the quantity of a combustible metal listed in Table 1.1.11 is exceeded in an occupancy, the requirements of this document shall apply.

Table 1.1.11 Applicability Thresholds by Occupancy

Occupancy Class (as defined in NFPA 5000)	Threshold Quantity (kg)	Threshold Quantity (lb)
Assembly	0.454	1
Educational	0.23 kg of alkali metals or 0.907 aggregate of other combustible metals, excluding alkali metals	½ lb of alkali metals or 2 aggregate of other combustible metals, excluding alkali metals
Day care	Not permitted	Not permitted
Health care	0.907	2
Ambulatory health care	0.907	2
Detention and correctional	Not permitted	Not permitted
Residential	0.907	2
Residential board and care	Not permitted	Not permitted
Mercantile	0.907	2
Business	4.535	10 for storage; 0 for use and handling
Industrial	2.268	5
Storage	22.675	50



1.2 Purpose. The objective of this standard shall be to minimize the occurrence of, and resulting damage from, fire or explosion in areas where combustible metals or metal dusts are produced, processed, finished, handled, stored, and used.

1.3 Application.

1.3.1 The provisions of this standard shall be applied in accordance with Figure 1.3.1.

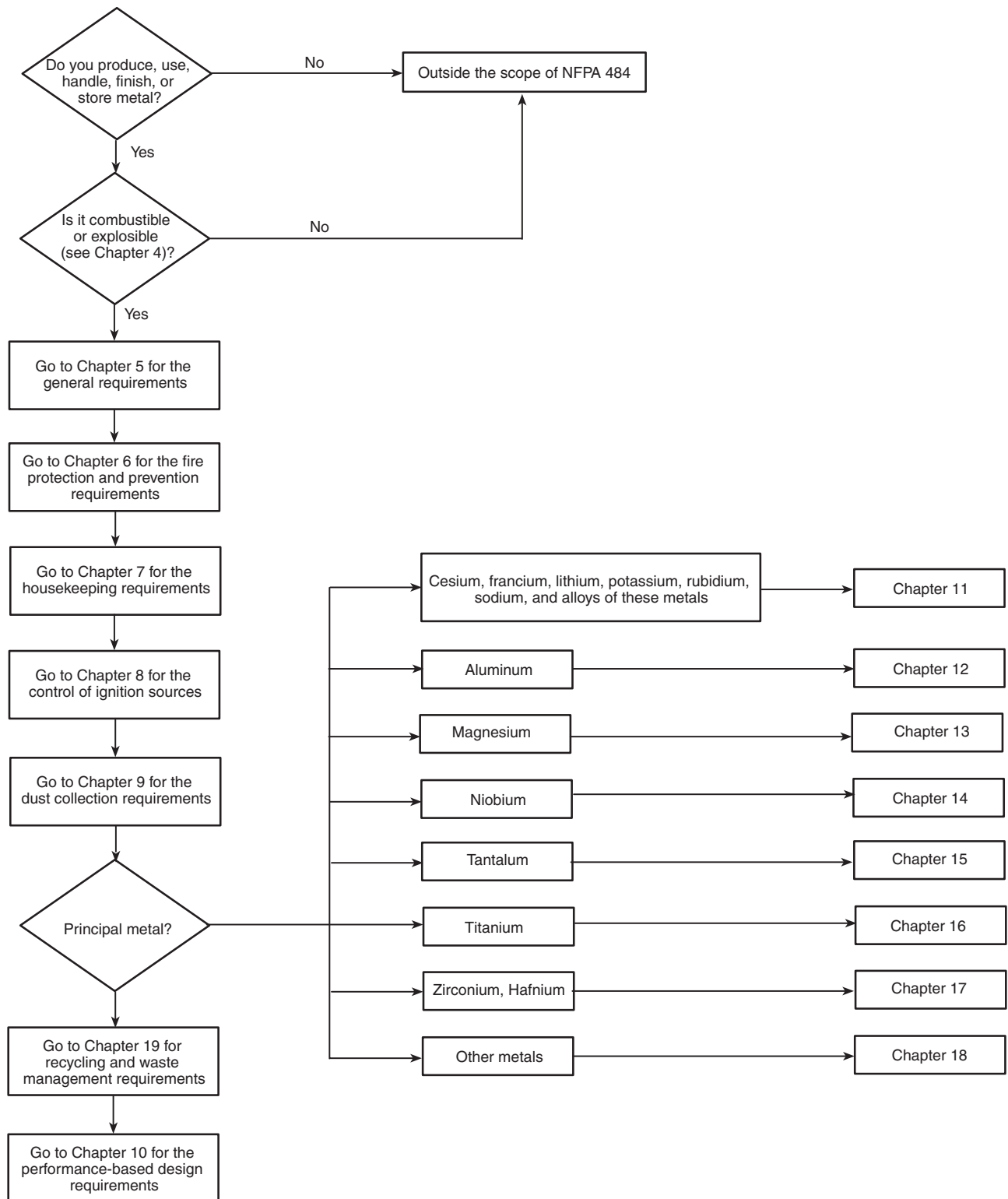


FIGURE 1.3.1 Navigation Flow Diagram.

1.3.2 The provisions of this document shall be considered necessary to provide a reasonable level of protection from loss of life and property from fire and explosion.

1.3.3 The provisions of this document shall reflect situations and the state of the art prevalent at the time the standard was issued.

1.3.4 A hazard assessment shall be performed to resolve any conflicts between the requirements of this standard and any other NFPA code or standard.

1.4 Retroactivity. The provisions of this standard shall reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.4.1 Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard.

1.4.2* Where specified, the provisions of this standard shall be retroactive.

1.4.2.1 Chapters 6 and 19 shall be retroactive.

1.4.3 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate.

1.4.4 The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction, and only where it is clearly evident that a reasonable degree of safety is provided.

1.5 Equivalency. Nothing in this standard shall be 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.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code*, 2015 edition.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2013 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2013 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2015 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, 2011 edition.

NFPA 34, *Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*, 2011 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2014 edition.

NFPA 54, *National Fuel Gas Code*, 2015 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2013 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2014 edition.

NFPA 70®, *National Electrical Code®*, 2014 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2013 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2015 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*, 2010 edition.

NFPA 101®, *Life Safety Code®*, 2015 edition.

NFPA 220, *Standard on Types of Building Construction*, 2015 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2015 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 2013 edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*, 2013 edition.

NFPA 600, *Standard on Industrial Fire Brigades*, 2010 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2013 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2012 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2014 edition.

NFPA 1081, *Standard for Industrial Fire Brigade Member Professional Qualifications*, 2012 edition.

NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, 2012 edition.

NFPA 2113, *Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire*, 2015 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2015 edition.

2.3 Other Publications.

2.3.1 ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI/ASME B31.3, *Process Piping Design*, 2010.

ANSI/ISA 84.00.01 *Functional Safety: Safety Instrumental Systems for the Process Industry Sector—Part 2*, 2004.

2.3.2 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM E 11, *Standard Specification for Wire Cloth and Sieves for Testing Purposes*, 2009.

ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 2012.

ASTM E 176, *Standard Terminology of Fire Standards*, 2010.

ASTM E 1226, *Standard Test Method for Explosibility of Dust Clouds*, 2012.

ASTM E 1515, *Standard Test Method for Minimum Explosible Concentration of Combustible Dust*, 2007.

ASTM E 2019, *Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air*, 2007.

ASTM E 2931, *Standard Test Method for Limiting Oxygen (Oxidant) Concentration of Combustible Dust Clouds*, 2013.



ASTM F 1002, *Standard Performance Specifications for Protective Clothing for Use by Workers Exposed to Specific Molten Substances and Related Thermal Hazards*, 2006.

2.3.3 UN Publications. United Nations Publications, Room DC2-853, 2 UN Plaza, New York, NY 10017.

UN Recommendations on the Transport of Dangerous Goods: Manual of Tests and Criteria, 5th edition, 2009.

2.3.4 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

Eckoff, Rolf K., *Dust Explosions in the Process Industries*, third edition, 2003. Butterworth-Heinemann Ltd., Oxford, UK.

Explosibility of Metal Powders, Report of Investigations (RI) 6516, 1964, BuMines, U.S. Department of the Interior, Washington DC, 1965.

GESTIS-DUST-EX, Combustion and Explosion Characteristics of Dusts (database), —Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung, Germany (IFA).

2.4 References for Extracts in Mandatory Sections.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2013 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2014 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*, 2010 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2013 edition.

NFPA 921, *Guide for Fire and Explosion Investigations*, 2014 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2015 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 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.

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

3.2.5 Shall. Indicates a mandatory requirement.

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

3.2.7 Standard. A document, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the *Manual of Style for NFPA Technical Committee Documents*.

3.3 General Definitions.

3.3.1 Alkali Metals. See 3.3.26.1.

3.3.2 Aluminum Paste. Aluminum flake pigment homogeneously incorporated in a solid or liquid carrier in such a way so as to have a nonflowing product without a free-flowing liquid.

3.3.3 Aluminum Powder. See 3.3.32.3.

3.3.4 Castings. An object or finished shape obtained by solidification of a substance in a mold.

3.3.4.1* Heavy Casting. Castings greater than 11.3 kg (25 lb) with walls of large cross-sectional dimensions [at least 6.4 mm (¼ in.)].

3.3.5* Chips. Particles produced from a cutting or machining operation that are not oxidized and that are not diluted by noncombustible materials.

3.3.6 Combustible Metal. See 3.3.26.2.

3.3.6.1* Combustible Metal Dust. A combustible particulate metal that presents a fire or explosion hazard when suspended in air or the process specific oxidizing medium over a range of concentrations, regardless of particle size or shape.

3.3.6.2 Combustible Metal Particulate. See Combustible Metal Dust 3.3.6.1.

3.3.6.3* Metal Dust. Particulate metal resulting from a solid state secondary processing operation.

3.3.7* Critical Process. A process that has the potential to cause harm to personnel, equipment, structures, or product in the event of an uncontrolled failure.

3.3.8 Deflagration. Propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium. [68, 2013]

3.3.9 Deflagration Hazard Area.

3.3.9.1 Dust Explosion Hazard Area. A room or building volume where an unvented deflagration of the entrainable dust mass can result in a pressure exceeding the strength of the weakest structural element not intended to fail.

3.3.9.2 Dust Flash-Fire Hazard Area. An area where combustible dust accumulation on exposed or concealed surfaces, outside of equipment or containers, can result in personnel injury from thermal dose during a dust deflagration, as well as any areas where dust clouds of a hazardous concentration exist during normal operation. A propagating deflagration yield a flash-fire through the hazard area.

3.3.10 Dryer. A piece of processing equipment using temperature or pressure change to reduce the moisture or volatile content of the material being handled. [654, 2013]

3.3.11 Duct. Pipes, tubes, or other enclosures used for the purpose of pneumatically conveying materials. [91, 2010]

3.3.12 Dust. See Combustible Metal Dust, 3.3.6.1.

3.3.13 Eutectic Reaction. (Reserved)

3.3.14 Explosion. The bursting or rupture of an enclosure or a container due to the development of internal pressure from a deflagration. [69, 2014]

3.3.15 Fines. The portion of a powder composed of particles that are smaller than 45 microns (U.S. Standard Sieve No. 325); also known as the subsieve size fraction.

3.3.15.1 Superfines. Particles smaller than 10 microns (μm).

3.3.15.2 Ultrafines. Particles with size generally less than 1 micron (μm).

3.3.16* Fire-Resistive. Meeting the requirements for Type I or Type II construction.

3.3.17 Flake. A flat or scale-like particulate material that is relatively thin with a large aspect ratio.

3.3.18 Fugitive Material. See 3.3.23.1.

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

3.3.20 Hazard Analysis. A documented assessment performed by personnel knowledgeable of the specific hazards of the material and that is acceptable to the AHJ.

3.3.21 Hot Work. Any work involving burning, spark-producing, welding, or similar operations that is capable of initiating fires or explosions.

3.3.22* Incipient-Stage Fire. A fire that is in the initial or beginning stage and that can be controlled or extinguished by portable extinguishers or small amounts of dry extinguishing agents, without the need for protective clothing or breathing apparatus.

3.3.23 Material.

3.3.23.1 Fugitive Material. Any particle, regardless of size, that is lost from manufacturing or other processes.

3.3.23.2* Pyrophoric Material. A chemical with an auto-ignition temperature in air at or below 54.4°C (130°F). [5000, 2015]

3.3.23.3* Spark-Resistant Material. A material that is not prone to generate impact sparks under conditions of use.

3.3.24 Media Collector. A bag house or a filter-type cartridge collector used for collecting dust.

3.3.25* Mesh Size. The dimensions of a mesh that are specified in ASTM E 11, *Standard Specification for Wire Cloth and Sieves for Testing Purposes*.

3.3.26* Metal. Pure metal or alloys having the generally recognized properties of the metal, including the fire or explosion characteristics of the metal in its various forms.

3.3.26.1 Alkali Metals. Cesium, francium, lithium, potassium, rubidium, sodium, and alloys of these metals, such as NaK.

3.3.26.2* Combustible Metal. Any metal composed of distinct particles or pieces, regardless of size, shape, or chemical composition, that will burn.

3.3.26.3 Metal Alloy. A multiphase solid that is formed by mixing in the molten state, in which the primary component or matrix phase is a metal and the original composition is retained during size reduction.

3.3.26.4* Metal-Containing Mixture. A physical combination of one or more metals or metal alloys with one or more solid, liquid, or semi-solid chemical elements or compounds.

3.3.27* Minimum Explosible Concentration (MEC). The minimum concentration of a combustible dust suspended in air, measured in mass per unit volume, that will support a deflagration. [654, 2013]

3.3.28 Mixtures. (Reserved)

3.3.29* 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.

3.3.30 Passivation. A controlled process by which a barrier coating is placed on the surface of the metal to inhibit reaction.

3.3.30.1 Oxygen Passivation. A controlled process that exposes the metal powder to oxygen with the goal of forming an oxide of the metal on the particle surface.

3.3.31 Paste. A mixture consisting of a liquid and suspended particles or flakes.

3.3.31.1 Aluminum Paste. Aluminum flake pigment homogeneously incorporated in a solid or liquid carrier in such a way so as to have a nonflowing product without a free-flowing liquid.

3.3.32 Powder. Particles of matter intentionally manufactured to a specific size and shape. Typically, powders are less than 1 millimeter and can be elemental or alloy in composition and regular, irregular, spherical, sponge, granular, dendritic, or nodular in shape.

3.3.32.1* Aluminum Flake Powder. See 3.3.32.3.

3.3.32.2 Aluminum Granular Powder. See 3.3.32.3.

3.3.32.3* Aluminum Powder. Aluminum powder is divided into three broad classifications: atomized, flake, and granules.

3.3.32.4* Combustible Metal Powder. A combustible particulate metal, regardless of particle size or shape, that is an intentional product and will burn as determined by testing conducted in accordance with Chapter 4.



3.3.32.5 Tantalum Powder. Nodular or flake-like tantalum particles that will pass through a 20 mesh screen [850 μm (microns)] as discrete particles or as agglomerates of discrete particles.

3.3.32.5.1 Unrefined Tantalum Powder. Any tantalum powder that contains impurities, such that further refinement is required to produce a tantalum product suitable for commercial use.

3.3.33* Powder Production Plant. Facilities or buildings in which the primary product is powder.

3.3.34 Pyrophoric Material. See 3.3.23.2.

3.3.35* Recycling. Processing, reprocessing, resizing, sorting, sifting, or staging of scrap materials formerly in the process stream or in use, that no longer serve their original and/or intended purpose, but continue to have resale value.

3.3.36 Replacement-in-Kind. A replacement that satisfies the design specifications.

3.3.37 Ribbon. A manufactured product or a continuous chip resulting from secondary processing (e.g., boring, grinding, milling, turning, etc.), of a ductile material.

3.3.37.1* Magnesium Ribbon. Magnesium metal that is less than 3.2 mm ($\frac{1}{8}$ in.) in two dimensions or less than 1.3 mm ($\frac{1}{16}$ in.) in single dimension, also considered a powder for the purposed of this standard.

3.3.38 Screening Test. For the purposes of this standard, a test performed to determine whether a material, product, or assembly, (a) exhibits any usual fire or explosion related characteristics, (b) has certain expected fire or explosion related characteristics, or (c) is capable of being categorized according to the fire or explosion characteristic in question. [ASTM E176, 2010 Modified]

3.3.39 Spark-Resistant Material. See 3.3.23.3.

3.3.40* Sponge. Metal after it has been won from the ore but before it is melted.

3.3.41 Spontaneous Heating. Process whereby a material increases in temperature without drawing heat from its surroundings. [921, 2014]

3.3.42 Swarf. Particles produced from a cutting, machining, or grinding operation that causes partial oxidation of the parent material or dilution by other inert materials.

3.3.43 Tantalum Powder. See 3.3.32.5.

3.3.44 Tantalum Ultrafines. (Reserved)

3.3.45* Thermite Reaction. The exothermic reaction between a metal and any metal oxide lower in the electromotive series.

3.3.46 Threshold Dust Accumulation. An established value of dust accumulation, determined as part of the hazard analysis for a particular enclosure of facility and specific metal, for taking an appropriate action.

3.3.47 Titanium Fines. (Reserved)

3.3.48 Zirconium Fines. (Reserved)

Chapter 4 Determination of the Combustibility or Explosibility of a Metal, Metal Powder, or Metal Dust

4.1* Overview. The screening test in Section 4.3 and in Section 4.4 shall be conducted to determine if a metal is in combustible or explosible form.

4.1.1 If either of the tests produces a positive result, the material shall be considered a combustible metal.

4.1.2 Test results shall be documented, the AHJ shall be notified, and the test results shall be provided when requested.

4.1.3 Documentation of noncombustibility proven through analytical testing of combustibility and explosibility of the specific forms of these materials, as described in this chapter and acceptable to the AHJ, is required to eliminate application of this standard.

4.1.4 Application of This Document.

4.1.4.1 Only those specific forms of combustible metals, powders, dusts, and alloys of those materials that can be documented through accepted testing, and shown in that form not to satisfy the conditions and definitions of combustibility and explosibility, shall qualify for exclusion from the requirements of this document.

4.1.4.2 Wherever combustibility can be shown to exist in these materials, the full scope and requirements of this document shall apply.

4.1.4.3 Wherever the documentation necessary for compliance with 4.1.2 and 4.1.3 is lacking, the requirements of this document shall apply.

4.1.5* Test samples for the preliminary screening tests shall be tested in forms that reflect actual process conditions. Variations in process and material conditions shall be assessed and documented in the selection of test sample materials.

4.1.5.1 Representative samples shall be collected from the process and preserved in suitable inert gas or vacuum packaging until tested.

4.1.6 Forms of combustible metal dust (CMD) that have been evaluated as noncombustible shall be required to be re-evaluated whenever a change in manufacture, processing, handling, or storage conditions creates a modified form that might exhibit the characteristic of combustibility.

4.2* Basic Material Characterization.

4.2.1* Representative samples and components of metal-containing mixtures shall be collected and identified.

4.2.2* Collected samples, including metal-containing mixtures, shall be subject to basic materials characterization to include at a minimum composition, form, particle size and distribution, and moisture content.

4.3 Determination of Combustibility.

4.3.1* Combustibility shall be determined for metals, metal powders, and metal dusts by the preliminary screening test set forth in the UN Recommendations on the Transport of Dangerous Goods: *Model Regulations — Manual of Tests and Criteria*, Part III, Subsection 33.2.1.

4.3.1.1 Representative samples shall be maintained in suitable inert gas or vacuum packaging until tested.

4.3.2 For purposes of determining the combustibility of metal powders, pastes, finely divided materials, and metal dusts, the results of the screening test shall be categorized as one of the following three categories:

- (1) No reaction
- (2) Glowing but no propagation along the powder train
- (3) Propagation along the powder train past the heated zone

4.3.3 If the results of the screening test provide either no reaction or glowing but no propagation along the powder train past the heated zone by burning with flame or smoldering, the test material shall be considered to be in a noncombustible form.

4.3.4* If the material, in the form tested, ignites and propagates combustion, or ejects sparks from the heated zone after the heat source is removed, the material shall be considered combustible and the standard shall be applicable.

4.3.5* For materials other than dusts, powders, pastes, or other finely divided material, the flame from a 1000°C (1832°F) torch shall be applied for 10 minutes.

4.3.5.1* If the material does not sustain combustion, it shall be considered to be a metal in a noncombustible form.

4.3.5.2 Safety measures shall be taken based on the assumption that the test will result in combustion.

4.4 Determination of Explosibility.

4.4.1* The explosibility of metals, metal powders, metal dusts, and alloys of these materials shall be determined by using the flow chart in Figure 4.4.1.

4.4.1.1 If the material is determined to be explosible, some or all of the standard test methods in Figure 4.4.1 shall be performed as needed by the hazard analysis as described in Section 5.2.

4.4.1.2 Additional tests chosen shall be those relevant to hazard analysis of the intended explosion protection techniques and flash-fire hazards anticipated for the process.

4.4.2* The explosibility classification screening test shall serve as the basis to determine whether a metal, metal powder, metal dust, or alloy of these materials is capable of initiating or sustaining an explosion when suspended as a dust cloud.

4.4.3* Test samples for the explosibility classification screening tests shall be tested in forms that reflect actual process conditions and the normal composition of the material with respect to particle size distribution, moisture content, and chemical composition. Variations in process and material conditions shall be assessed and documented in the selection of test sample materials.

4.4.3.1 Representative samples shall be maintained in suitable inert gas or vacuum packaging until tested.

4.4.4* The explosibility classification screening tests shall be conducted in accordance with ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*.

4.5 Use of Test Data for Hazard Analysis.

4.5.1* The hazard analysis shall be based on data from tests of collected samples or historical data.

4.5.2* If historical data are used, an assessment of the composition, form, and particle size distribution, at a minimum, shall be compared to ensure the historical data are representative of the current material.

4.6* Determination of Flash Fire Potential. (Reserved)

4.7 Risk Evaluation. Where a risk evaluation (*see Annex I*) is required by the AHJ, material property data and material handling and processing conditions shall be reviewed to determine the likelihood and consequences of a metal powder or

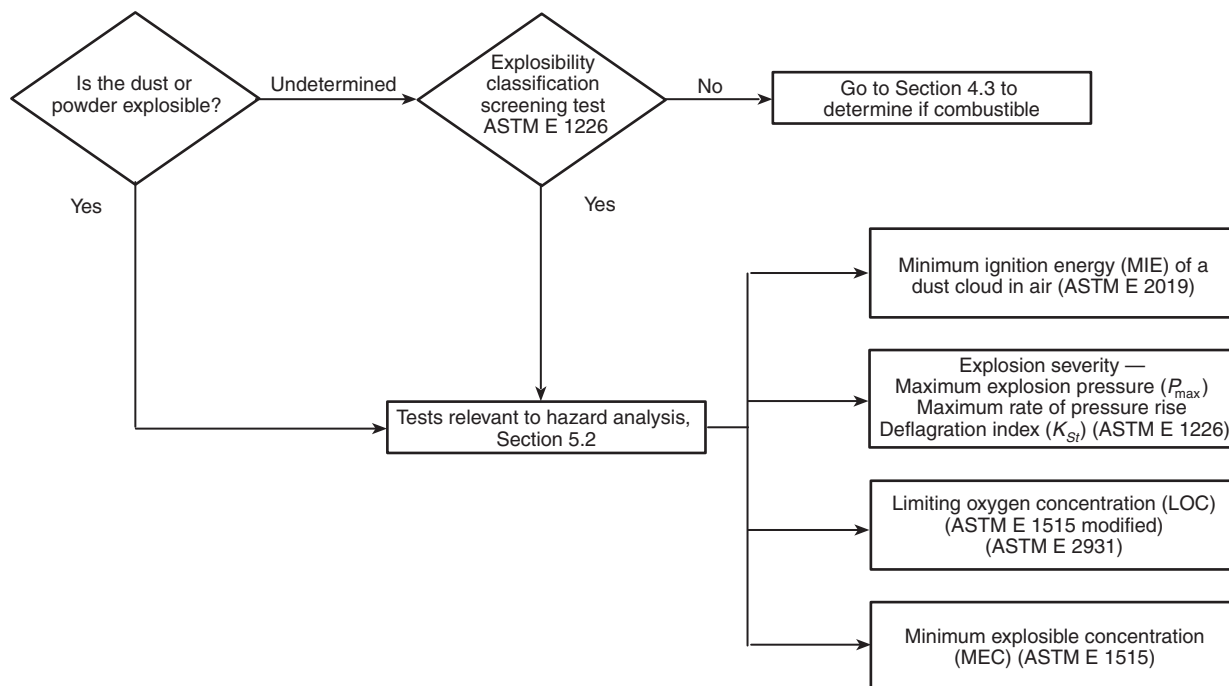


FIGURE 4.4.1 Determination of Explosibility.

dust ignition. It shall be permitted to make qualitative determinations of likelihood and consequences, providing at least some of the following property data are included in the determinations:

- (1) Minimum ignition energy (MIE)
- (2) Maximum pressure ($P_{\max}$)
- (3) Maximum rate of pressure rise ($dP/dt_{\max}$)
- (4) Deflagration index (K_{St})
- (5) Limiting oxygen concentration (LOC)
- (6) Minimum explosible concentration (MEC)
- (7) Thermal stability
- (8) Electrostatic risk
- (9) Reactivity

4.8 Compliance Options. If the material has been determined to be either explosible or combustible by this chapter, compliance shall be achieved by either of the following methods:

- (1) The prescriptive provisions in accordance with Chapters 5 through 9 and Chapter 19 of this standard, as well as the applicable specific metal chapter from Chapters 11 through 18
- (2) The performance-based provisions in accordance with Chapter 5 through 8 and Chapter 10 of this standard

Chapter 5 General

5.1* Management of Change.

5.1.1 The requirements of 5.1.2 through 5.1.5 shall apply to new and existing facilities and processes.

5.1.2 Written procedures shall be established and implemented to manage proposed changes to process materials, technology, equipment, procedures, and facilities.

5.1.3 The procedures shall ensure that the following are addressed prior to any change:

- (1) The technical basis for the proposed change
- (2) Safety and health implications, including hazard analysis
- (3) Whether the change is permanent or temporary
- (4) Modifications to operating and maintenance procedures
- (5) Employee training requirements
- (6) Authorization requirements for the proposed change
- (7) Results of characterization tests used to assess the hazard, if conducted

5.1.4 Implementation of the management of change procedure shall not be required for replacements-in-kind.

5.1.5 Design documentation shall be updated to incorporate the change.

5.2 Hazard Analysis.

5.2.1* The design of the fire and explosion safety provisions shall be based on a hazard analysis of the facility, the process, and the associated fire and explosion hazards.

5.2.2 The results of the hazard analysis shall be documented and maintained for the life of the process.

5.2.3 The hazard analysis shall be reviewed and updated at least every 5 years.

5.2.4 New and/or altered operations, equipment, and/or facilities shall be reviewed prior to operation for potential hazards.

5.2.5 Written records shall be maintained of all hazard analyses conducted.

5.2.6 Hazard analyses shall be signed off, prior to operation, by a cognizant authority at the facility.

5.2.7 Appropriate safeguards shall be put in place with regard to findings of the hazard analysis.

5.2.8 Corrective actions as a result of the hazard analysis shall be tracked and completed to ensure that all identified hazards have been abated or that the level of risk has been reduced to a tolerable level by a knowledgeable authority.

5.3* Personal Protective Equipment (PPE).

5.3.1 PPE Hazard Analysis.

5.3.1.1 Requirements for PPE shall be based on a documented analysis of the potential for facility personnel to be exposed to hazards from combustible and molten metals during facility operations and maintenance activities.

5.3.1.2* The PPE hazard analysis shall determine which operations and activities warrant use of primary PPE for molten metals, primary PPE for dust flash fires, and secondary PPE for general work and maintenance in facilities with combustible metals.

5.3.2 Primary PPE for Molten Metals.

5.3.2.1 Primary PPE for molten metals shall include all of the items described in paragraphs 5.3.2.2 to 5.3.2.5.

5.3.2.2 Face shields, neck protection, and safety glasses shall be used as part of the primary PPE for molten metal exposures.

5.3.2.3* External clothing, including but not limited to shirts, trousers, and coveralls, shall meet the performance requirements for primary protective clothing in ASTM F1002, *Standard Performance Specification for Protective Clothing for Use by Workers Exposed to Specific Molten Substances and Related Thermal Hazards*.

5.3.2.4 Gloves or mittens shall be worn and shall be loose fitting, easily removable, and compatible with the hazards of the pertinent molten metals.

5.3.2.5 Protective footwear shall be high-top leather safety shoes, at least 150 mm (6 in.) high, and appropriate for the hazards of molten metals used in the areas where personnel are working.

5.3.3 Primary PPE for Dust Flash Fires.

5.3.3.1* Primary PPE for dust flash fires shall include flame-resistant garments in accordance with the workplace hazard assessment required by NFPA 2113, *Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire*.

5.3.3.2* Personnel wearing PPE for dust flash fires shall be informed about the limited protection provided by NFPA 2112-compliant garments against the higher-temperature flames and heat fluxes associated with combustible metal dust flash fires.

5.3.3.3 Primary PPE for dust flash fires shall be designed to prevent potential accumulations of combustible metal dust in places such as, but not limited to, pant cuffs, sleeve cuffs, and open pockets, and shall have a smooth outer surface that allows dust to be readily brushed off.

5.3.3.4 Primary PPE for dust flash fires shall include shirts, trousers, or coveralls.

5.3.3.4.1 Trousers or coveralls shall cover the tops of footwear.

5.3.3.5 Primary PPE for dust flash fires shall include safety shoes without exposed metal.

5.3.3.6* Primary PPE for dust flash fires shall include gloves made of heat-resistant fabrics.

5.3.3.7* When worn in areas containing dusts with minimum ignition energies less than 100 mJ, primary PPE for dust flash fires shall be made of static-dissipative materials.

5.3.4 Secondary PPE for General Work Areas Near or Containing Combustible Metals.

5.3.4.1 Safety glasses with side shields and hard hats shall be required as part of the secondary PPE.

5.3.4.2 Outer garments worn as secondary PPE shall be designed to prevent potential accumulations of combustible metal dust by not having exposed pockets or cuffs, and shall have a smooth outer surface that allows dust to be readily brushed off.

5.3.4.3 Secondary PPE shall have some measure of flame resistance determined as part of the PPE hazard analysis.

5.3.4.4* When worn in areas containing dusts with minimum ignition energies less than 100 mJ, secondary PPE shall be made of static-dissipative materials.

5.3.4.5 Secondary PPE worn in areas containing alkali metals shall have an external clothing layer that is impervious to body moisture.

5.3.4.5.1* Proper protective clothing, respiratory protection, and adequate eye protection shall be used by all responding fire-fighting personnel assigned to a combustible metal fire equipped to the requirements of NFPA 600, *Standard on Industrial Fire Brigades*, or NFPA 1081, *Standard for Industrial Fire Brigade Member Professional Qualifications*.

5.4 Dust Explosion and Flash-Fire Hazard Areas.

5.4.1 Those portions of the process and facility where deflagration venting is not currently required and a dust explosion hazard or flash-fire hazard exists shall be evaluated to determine appropriate protection levels from the effects of these hazards in accordance with this section and the fire protection and building construction sections in each metal chapter — Chapter 11 through 18 — and Chapter 6.

5.4.2 Dust explosion hazard areas and dust flash-fire hazard areas shall be deemed to exist in all operating areas of facilities processing or handling combustible metal dusts unless a hazard analysis determines otherwise.

5.5 Segregation, Separation, or Detachment to Limit Dust Hazard Areas.

5.5.1 It shall be permitted to use segregation, separation, or detachment to limit the extent of a dust explosion hazard area or a dust flash-fire hazard area.

5.5.2 Use of Segregation.

5.5.2.1 Physical barriers that are erected to segregate dust flash-fire hazard areas, including seals at all penetrations of floors, walls, ceilings, or partitions shall have a 1-hour fire resistance rating.

5.5.2.2 Physical barriers that are erected to segregate dust explosion hazard areas shall be designed to preclude failure of those barriers during a dust explosion in accordance with NFPA 68, *Standard on Explosion Protection by Deflagration Venting*.

5.5.2.3 Doors and openings shall not be permitted in physical barriers unless they are normally closed and have at least the strength and fire resistance rating required of the physical barrier.

5.5.3 Use of Separation.

5.5.3.1* Where separation is used to limit the dust flash-fire hazard area, the required separation distance between the flash-fire hazard area and surrounding exposures shall be determined by the following:

- (1) Engineering evaluation that addresses the properties of the materials
- (2) Type of operation
- (3) Amount of material likely to be present outside the process equipment
- (4) Building design
- (5) Nature of surrounding exposures

5.5.3.2 Where separation is used to limit the dust flash-fire hazard area, in no case shall the required separation distance determined in 5.5.3.1 be less than 11 m (35 ft).

5.5.3.3 Where separation is used, housekeeping fixed-dust collection systems employed at points of release, and compartmentation shall be permitted to be used to limit the extent of the dust flash-fire hazard area.

5.5.3.4* Where separation is used to limit a dust flash-fire hazard area, the hazard analysis shall be applied to this limited area.

5.5.3.5 Where a limited area is both a dust flash-fire hazard area and a dust explosion hazard area, separation shall not be permitted to be used to reduce the dust flash-fire hazard area.

Chapter 6 Fire Prevention, Fire Protection, and Emergency Response

6.1 Applicability.

6.1.1 The requirements of this chapter shall apply to new and existing facilities where combustible and alkali metals, metal powders, and metal dusts are used, processed, recycled, stored, or handled.

6.2 Fire Prevention.

6.2.1 Inspection and Maintenance.

6.2.1.1 An inspection, testing, and maintenance program shall be implemented that ensures that process controls and equipment perform as designed and that a change in process equipment does not increase the hazard.

6.2.1.2 The inspection, testing, and maintenance program shall include the following:

- (1) Fire and explosion protection and prevention equipment in accordance with the applicable NFPA codes and standards
- (2) Dust control equipment
- (3) Housekeeping
- (4) Potential ignition sources
- (5) Electrical, process, and mechanical equipment, including process interlocks



- (6) Process changes
- (7) Continuity check on grounding and bonding systems
- (8) Resistivity testing of static-dissipative footwear and conductive floors where required
- (9) Piping systems that carry or transport combustible/flammable gases, liquids, and/or hazardous chemicals, or materials that can interact and present a hazard should a release occur, (i.e., water lines in the vicinity of molten metal).

6.2.1.3 A thorough inspection of the operating area shall take place on an as-needed basis to help ensure that the equipment is in good condition and that proper work practices are being followed.

6.2.1.3.1 The inspection shall be conducted at least quarterly.

6.2.1.3.2 The inspection shall be conducted by a person(s) knowledgeable in the proper practices who shall record the findings and recommendations.

6.2.1.4 Operating and maintenance procedures shall be reviewed annually and as required by process changes.

6.2.2 Control of Combustible Materials.

6.2.2.1 Areas in which flammable and combustible liquids are used shall be in accordance with the requirements of NFPA 30, *Flammable and Combustible Liquids Code*.

6.2.2.1.1 Forge presses, heavy grinders, and other milling equipment operated by hydraulic systems of 189 L (50 gal) or greater shall use a less hazardous hydraulic fluid with a flash point greater than 93°C (200°F).

6.2.2.1.2 Dipping and coating applications of flammable or combustible liquids shall be done in accordance with NFPA 34, *Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*.

6.2.2.1.3 Spray application of flammable or combustible liquids shall be done in accordance with NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*.

6.2.2.2 Ordinary Combustible Storage.

6.2.2.2.1 Ordinary combustible materials, such as paper, wood, cartons, and packing material, shall not be stored or allowed to accumulate in processing areas unless necessary for the process, and then only in designated areas.

6.2.2.2.2 Ordinary combustible materials shall not be discarded in containers used for the collection of combustible metal waste.

6.2.2.3 Removal of Combustible Metal Chips, Fines, Swarf, Paste, Powder, Dust, and Sweepings.

6.2.2.3.1 All combustible metal chips, lathe turnings, and swarf shall be collected in closed-top metal containers and removed daily, as a minimum, to a safe storage or disposal area.

6.2.2.3.2 Open storage of sponge, chips, fines, and dust that are readily ignitable shall be isolated and segregated from other combustible materials and metal scrap to prevent propagation of a fire.

6.2.3* Molten Metal.

6.2.3.1 All containers used to receive molten metal, molten titanium, molten titanium chloride, or liquid alkali metals shall be cleaned and dried thoroughly before use.

6.2.3.2 All pieces of metal shall be clean and dry when charged to reactors.

6.3 Fire Protection.

6.3.1 Automatic Sprinkler Protection for Combustible Metals Other Than Alkali Metals.

6.3.1.1* Automatic sprinkler protection shall not be permitted in areas where combustible metals are produced or handled unless allowed by 6.3.1.2, 6.3.1.3, and 6.3.1.4.

6.3.1.2* Sprinkler systems installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, shall be permitted in areas where combustibles other than combustible metals in molten form or in a state that could cause an immediate explosive reaction with water create a more severe hazard, as determined by a hazards analysis, than the metals and where acceptable to an authority having jurisdiction knowledgeable of the hazards associated with combustible metals.

6.3.1.3 The hazards analysis shall consider the possibility of fires and explosions involving both combustible metals and the other combustibles.

6.3.1.4 The special hazards associated with metals in a combustible form and in contact with water shall be considered in the selection, design, and installation of automatic sprinkler systems.

6.3.1.5 Employee training and organizational planning shall be provided to ensure safe evacuation of the areas that contain combustible metal hazards in case of fire in accordance with 6.3.4.

6.3.1.6* Light casting storage areas shall be protected by automatic sprinklers in any of the following situations:

- (1) Where storage in quantities greater than 28 m³ (989 ft³) is contained in a building of combustible construction
- (2) Where magnesium products are packed in combustible crates or cartons
- (3) Where other combustible storage is within 9 m (30 ft) of the magnesium

6.3.2 Sprinkler Protection for Alkali Metals.

6.3.2.1* Buildings or portions of buildings in which the only combustible hazard present is alkali metals shall not be permitted to be equipped with sprinkler protection.

6.3.2.2 Buildings or portions of buildings that have combustible hazards in addition to alkali metals shall be evaluated for fire protection requirements with a hazards analysis that is acceptable to the authority having jurisdiction.

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

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

6.3.2.5 Fire-extinguishing agents compatible for the hazards present shall be readily available in combustible metals-scrap storage areas.

6.3.2.6* Fire-extinguishing agents compatible for the hazards present shall be readily available in combustible-metals-powder storage areas.

6.3.3* Extinguishing Agents and Application Techniques.

6.3.3.1* Class D extinguishing agents or those agents shown to be effective for controlling combustible-metal fires shall be provided in areas where metals in a combustible form are present.

6.3.3.1.1 The effectiveness of the fire suppressing agent for controlling, suppressing, or extinguishing a fire involving a specific combustible metal shall be demonstrated to the AHJ or supported by third-party testing.

6.3.3.1.2 Any agent that when applied at the recommended rate results in an increase in fire intensity shall be prohibited.

6.3.3.2 A supply of extinguishing agent for manual application shall be kept within easy reach of personnel working with combustible metal powder.

6.3.3.3 Container lids shall be kept in place to prevent agent contamination and to keep agents moisture free.

6.3.3.4 Portable or wheeled extinguishers listed for use on combustible-metal fires shall be provided and shall be distributed in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

6.3.3.5 The following agents shall not be used as extinguishing agents on a combustible-metal fires because of adverse reactions or ineffectiveness unless they are compatible with the metal and are an effective extinguishing agent (*see 6.3.3*):

- (1) Water
- (2) Foams
- (3) Halon
- (4) Carbon dioxide
- (5)*Nitrogen (IG-100)
- (6) Halocarbon Clean Agents

6.3.3.6 A:B:C dry-chemical and B:C dry-chemical extinguishers shall not be used as an extinguishing agent on a combustible-metal fire but shall be permitted to be used on other classes of fires in the area where combustible metals are present.

6.3.3.7 Fire-extinguishing agent expellant gases shall be compatible with the combustible metal.

6.3.3.8 Where Class A, Class B, or Class C fire hazards are in the combustible-metal area, extinguishers suitable for use on such fires shall be permitted, provided they are marked "Not for Use on Combustible-Metal Fires."

6.3.3.9* Solvent-Wetted Powders. Incipient fires in solvent-wetted powders shall be handled according to 6.3.3.9.1 or 6.3.3.9.2.

6.3.3.9.1 An incipient fire occurring while the metal powder is in slurry form shall be permitted to be fought using listed Class B extinguishing agents, except that halogenated extinguishing agents shall not be used.

6.3.3.9.2 An incipient fire occurring in semi-wet material or filter cake shall be fought using a listed Class B extinguishing agent.

6.3.3.9.2.1* Where Class B extinguishing agents are used to extinguish fires involving solvent-wetted aluminum, the residual material shall be immediately covered with dry sand, with dry inert granular material, or with another listed Class D

extinguishing agent, and the entire mass shall be allowed to cool until it reaches ambient temperature.

6.3.3.9.2.2* When the material has cooled and it has been determined that there are no hot spots, the covered material shall be carefully removed for disposal.

6.3.3.9.2.3 The material shall be handled in covered containers.

6.3.3.10 Applications of Extinguishing Agents. Applications of extinguishing agents shall be handled according to 6.3.3.10.1 through 6.3.3.10.4.

6.3.3.10.1* An incipient fire shall be ringed with a dam of dry sand, with dry material that will not react with the metal being extinguished, or with a listed or approved Class D extinguishing powder in accordance with the manufacturer's instructions.

6.3.3.10.2 Application of dry extinguishing agent shall be conducted in such a manner as to avoid any disturbance of the combustible-metal dust, which could cause a dust cloud.

6.3.3.10.3* The use of pressurized extinguishing agents shall not be permitted on a combustible-metal powder fire or chip fire, unless applied carefully so as not to disturb or spread the combustible-metal powder or chip fire.

6.3.3.10.4 Only listed or approved Class D extinguishing agents or those tested and shown to be effective for extinguishing combustible-metal fires shall be permitted in combustible metal processing locations at risk for combustible metal fires.

6.3.3.11 Fire-extinguishing agents compatible for the hazards present shall be available in metal-scrap storage areas.

6.3.3.12 Fire-extinguishing agents compatible for the hazards present shall be available in metal-powder storage areas.

6.3.4 Fire-Fighting Activities.

6.3.4.1* Trained employees shall be permitted to fight incipient-stage fires, provided the fire can be controlled with portable extinguishers or other dry extinguishing agent.

6.3.4.2 In case of fire in the chips, turnings, or powder compact, the pan or tray shall not be disturbed or moved, except by an individual knowledgeable in the fire aspects of combustible metals, until the fire has been extinguished and the material has cooled to ambient temperature.

6.3.4.3 Combustible-metal fires beyond the incipient stage shall be fought by professional fire fighters, specially trained fire brigade personnel, or both.

6.3.4.4 Once the fire is extinguished and a crust is formed, the crust shall not be disturbed until the residue has cooled to room temperature.

6.3.4.5 Fire residues shall be protected to prevent adverse reactions and to prevent the formation of reactive or unstable compounds.

6.3.4.6 Fire residues shall be disposed of in accordance with federal, state, and local regulations.

6.3.4.7 When drums or tote bins of burning materials can be moved safely, they shall be moved away from processing equipment and out of buildings as rapidly as possible.

6.3.4.8 Processing Equipment.

6.3.4.8.1* When a fire occurs in processing equipment, material feed to the equipment shall be stopped.

6.3.4.8.2 The equipment shall be kept in operation, unless continued operation will spread the fire.

6.3.4.9 Alkali Metals Fire-Fighting Procedures.

6.3.4.9.1* While an alkali-metal fire is being fought, every effort shall be made to avoid splattering the burning alkali metals.

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

6.3.5 Fire-Fighting Organization.

6.3.5.1 Only trained personnel shall be permitted to engage in fire control activity.

6.3.5.1.1 Personnel other than trained personnel shall be evacuated from the area.

6.3.5.1.2 Training shall emphasize the different types of fires anticipated and the appropriate agents and techniques to be used.

6.3.5.2 Fire-fighting personnel shall be given training in the extinguishment of test fires set in a safe location away from manufacturing buildings.

6.3.5.2.1 Training shall include all possible contingencies.

6.3.5.2.2* If professional or volunteer fire fighters are admitted onto the property in the event of a fire emergency, their activity shall be directed by a unified incident command that includes knowledgeable plant personnel.

6.4* Emergency Response.

6.4.1 The following information shall be provided to the emergency responders for the safe handling of combustible metal fires:

- (1)*Perform a size-up, evaluation, and identification of metals involved in the fire.
- (2) Ensure control of utilities (water, gases, power, etc.) to affected areas.
- (3) Review safety data sheets (SDSs) for the involved products, and if available, contact those familiar with the product and hazards.
- (4) Evaluate whether the fire can be isolated safely and allowed to burn out.
- (5) Determine whether uninvolved product and exposures (other than alkali metals) can be protected by hose streams, after an adequate review has been completed to ensure any runoff from hose streams does not come into contact with burning or molten combustible metal.
- (6) Water shall not be applied to alkali metals in either a fire or non-fire situation.
- (7) Use an inert blanket (such as argon, helium, or nitrogen) if the fire is burning in a closed container, such as a dust collection system, to control the fire where an adequate delivery system is available and personnel safety is considered.
- (8) Evaluate the potential for explosion.
- (9) Use extreme caution with fires involving combustible-metal powders, dusts, and fines because of the possibility of explosions, especially if the product becomes airborne and there is an available ignition source.
- (10) Evaluate the control and shutdown of both domestic and fire protection water systems to prevent unintended contact of water with burning or molten combustible metal.

- (11) Use extinguishing agents that are compatible with the hazards present. (*See 6.3.3.*)
- (12) Use extinguishing agents for containment of small and incipient fires. (*See 6.3.3.*)
- (13)*Use extreme caution with fires involving large quantities of product within structures.
- (14) Most fires involving combustible metals cannot be extinguished in a manner other than by providing an inert atmosphere of argon or helium (and nitrogen for alkali metals or iron) if the product is dry.
- (15) Most fires can be controlled by application of argon or helium (or nitrogen for alkali metals or iron) or by the development of an oxide crust.
- (16) The temperature of the metals involved in the fire can remain extremely high and the fire can flare up again if the product is disturbed prior to complete oxidation of the product or self-extinguishment.
- (17) Water in contact with molten combustible metals will result in violent steam explosions, and can cause hydrogen explosions and reactions.
- (18) Isolate the metal as much as possible; large fires might be impossible to extinguish.
- (19) Evaluate whether there is adequate drainage to prevent the contact of water with burning metal that is not compatible for protecting exposures.
- (20) Evaluate the fire to determine whether the fire can burn itself out naturally to minimize hazards to personnel and losses to exposures.

6.5 Emergency Preparedness.

6.5.1 Local emergency response agency notification shall be required for any operation storing or processing 2.27 kg (5 lb) or more of powder, dusts, fines, or alkali metal in any form or 227 kg (500 lb) or more of chips or turnings.

6.5.2* Because of the unique nature of combustible-metal fires, a comprehensive emergency preparedness plan shall be prepared and maintained by the facility owner or operator where combustible metals are processed, handled, used, or stored.

6.5.2.1 This plan shall be available on site to emergency responders.

6.5.2.2 The plan shall include specific actions in the event of a combustible metal fire and shall be coordinated with the facility management and emergency responders.

6.5.2.3 The plan shall address locations for remote shutoff of supply systems when any of the following are present:

- (1) Water (water from all types of sources)
- (2) Electrical materials
- (3) Flammable gases
- (4) Flammable liquids
- (5) Toxic materials
- (6) Other hazardous materials

6.5.2.4 The following information on the safe handling of combustible metal fires shall be provided for emergency preparedness planning:

- (1) Water, when applied to most burning combustible metals, results in an increase in burning intensity and possible explosion.
- (2) Water applied to alkali metals not involved in the fire will result in hazardous decomposition, ignition, or explosion.

- (3) Application of carbon dioxide on combustible-metal fire adds to the intensity of the burning. Most combustible metals ignite and burn in 100 percent carbon dioxide atmospheres. (See 6.3.3.)
- (4) Dry chemical extinguishers react with alkali metals and intensify the fire.
- (5) Dry chemical extinguishers utilized on non-alkali metal fires are ineffective in controlling the metal fire but might be effective where flammable or combustible liquids are used and the metal is not yet involved in the fire. (See 6.3.3.)
- (6) Halogenated extinguishing agents used on alkali metals can result in an explosion.
- (7) Halogenated extinguishing agents will have a detrimental effect on other combustible metal fires, with the decomposition producing hazardous by-products.
- (8) A primary metal fire displays intense orange-to-white flame and can be associated with a heavy or large production of white or gray smoke.
- (9) When water is applied to non-alkali combustible metal, it can disassociate to the basic compounds, oxygen and hydrogen. Similar results occur with carbon dioxide.
- (10) When water is applied to alkali metals, hydroxides and hydrogen are generated immediately.
- (11) Fires involving combustible metals that contain moisture exhibit more intense burning characteristics than dry product.
- (12) Extreme heat can be produced. For example, burning titanium and zirconium have the potential to produce temperatures in excess of 3857°C (7000°F) and 4690°C (8500°F), respectively.
- (13) Dusts, fines, and powders of combustible metals present an explosion hazard, especially in confined spaces.
- (14) Dusts, fines, and powders of titanium and zirconium present extreme hazards; zirconium powders have ignition temperatures as low as 20°C (68°F). Static electric charges can ignite some dusts and powders of titanium and zirconium.
- (15) Zirconium and titanium powder can exhibit pyrophoric characteristics.
- (16) Turnings and chips of combustible metals can ignite and burn with intensity, especially if coated with a petroleum-based oil, with some spontaneous combustion having been observed.
- (17) With the exception of alkali metals, the larger the product, the smaller the likelihood of ignition. Bars, ingots, heavy castings, and thick plates and sheets are virtually impossible to ignite and, in most cases, self-extinguish when the heat source is removed.
- (18) The sponge product of most combustible metals burns at a slower rate but still produces tremendous heat.
- (19) Burning combustible metals can extract moisture from concrete and similar products that can intensify burning and cause spalling and explosion of the products and spewing of chunks of concrete.
- (20) Burning metal destroys asphalt and extracts moisture from rock.
- (21) Most fires involving non-alkali combustible metals usually cannot be extinguished, and unless they are placed in an inert atmosphere of argon or helium, they can only be controlled.
- (22) Fires involving large quantities of metals should be allowed to cool for at least 24 hours prior to being disturbed to prevent re-ignition.

- (23) Fires will oxidize most metals and provide a protective covering limiting open burning.
- (24) Alkali metal fires can be extinguished with the suitable extinguishing agents correctly applied. (See 6.3.3.)
- (25) Combustible metal fines and powders that are stored and contain moisture can produce hydrogen gas.
- (26) Combustible metal fines and dusts that are reduced (not oxidized) and that come into contact with other metal oxides can result in thermite reactions.

6.5.3 Emergency procedures to be followed in case of fire or explosion shall be established.

6.5.4* All employees in areas handling metals in a combustible form shall be trained initially and annually in the following procedures:

- (1) All employees shall be carefully and thoroughly instructed by their supervisors regarding the hazards of their working environment and their behavior and procedures in case of fire or explosion.
- (2) All employees shall be trained in the means of safe and proper evacuation of work areas.
- (3) All employees shall be shown the location of electrical switches and alarms, first-aid equipment, safety equipment, and fire-extinguishing equipment.
- (4) Employees expected to utilize fire-extinguishing equipment on incipient fires shall receive training on proper utilization of equipment.
- (5) All employees shall be taught the permissible methods for fighting incipient fires and for isolating fires and initiating an emergency notification.
- (6) The hazards involved in causing dust clouds and the danger of applying liquids onto an incipient fire shall be reviewed and explained.
- (7) Equipment operation, start-up and shutdown, and response to upset conditions shall be reviewed and explained.
- (8) The necessity and functioning of fire and explosion protection systems shall be reviewed and explained.
- (9) Emergency response plans shall be reviewed and explained.
- (10) The importance of housekeeping in minimizing fire and explosion hazards shall be reviewed with and explained to employees.
- (11) The appropriate cleaning and dust removal methods for the metal(s) present shall be reviewed with and explained to employees.

6.5.5 Prior to the arrival of alkali metals on site, the local fire department shall be notified of the presence of water-reactive materials on site and shall be notified of the hazards of using water on alkali-metal fires.

6.5.6 Where combustible metal is collected or stored in containers, material-handling equipment with sufficient capability to remove any container from the immediate area in the case of an emergency shall be readily available.

6.5.7* Clothing Fires.

6.5.7.1 Emergency procedures for handling clothing fires shall be established.

6.5.7.2 If deluge showers are installed, they shall be located away from dry metal powder-processing and metal powder-handling areas.



Chapter 7 Housekeeping

7.1 Retroactivity. The requirements this chapter shall apply to new and existing facilities.

7.2* Housekeeping Plan.

7.2.1 A documented housekeeping program shall be established.

7.2.2 Corrective actions shall be tracked for identified issues from the housekeeping program to ensure completion.

7.2.3 Procedures for unscheduled housekeeping of unplanned or accidental spillage of combustible metal dusts in operating areas shall be established as a part of a housekeeping plan.

7.3 Cleanup Procedures for Fugitive Dust Accumulations.

7.3.1* Fugitive dust shall not be allowed to accumulate to a level that obscures the color of the surface beneath it.

7.3.2* It shall be permissible to establish, in a building or room, an alternate housekeeping dust accumulation threshold based on a documented hazard assessment acceptable to the AHJ.

7.3.3 Periodic cleanup of fugitive dusts shall be accomplished by using one of the following:

- (1) Conductive, nonsparking scoops and soft brooms
- (2) Brushes that have natural fiber bristles
- (3) Dedicated vacuum cleaning systems designed for handling combustible metal powders in accordance with Section 7.5

7.3.4 Special attention shall be paid to areas utilizing powder for accumulations in crevices and joints between walls, ceilings, and floors.

7.3.5 Systematic cleaning of areas containing dust-producing equipment, including roof members, pipes, conduits, and other components, shall be conducted as frequently as conditions warrant.

7.3.5.1 The cleaning shall include machinery.

7.3.5.2 Cleaning methods shall be limited to those methods that minimize the probability of fire or explosion, as determined by a person knowledgeable in the properties of combustible-metal dusts.

7.3.5.3 Chips or powder sweepings shall be removed to a designated storage or disposal area.

7.3.5.4 Potential ignition sources associated with the operation of equipment during the cleaning operation shall be reviewed, and appropriate actions to isolate, eliminate, or minimize the potential hazards shall be taken.

7.3.5.5 Collected dust and fines shall be removed to a safe storage or disposal area.

7.4* Cleanup of Spilled Dust, Fine or Powder.

7.4.1 Preliminary cleanup of the bulk of the spilled powder shall be accomplished by using conductive, nonsparking scoops and soft brooms as well as brushes that have natural fiber bristles.

7.4.2 Vacuum cleaners shall be permitted to be used only for residual amounts of material remaining after preliminary cleanup.

7.4.3 Compressed-air blowdown shall be permitted as a method for cleaning only when done in accordance with Section 7.6.

7.5* Vacuum Cleaning.

7.5.1 Vacuum cleaning systems shall be used only for removal of dust accumulations too small, too dispersed, or too inaccessible to be thoroughly removed by hand brushing.

7.5.2* Vacuum cleaning systems shall be effectively bonded and grounded to minimize the accumulation of static electric charge.

7.5.3* Due to the inherent hazards associated with the use of fixed and portable vacuum cleaning systems for finely divided combustible metal dust, special engineering consideration shall be given to the design, installation, maintenance, and use of such systems. (*See Section 9.2.*)

7.5.4* When being used for combustible metal powder, portable vacuum cleaners shall be used only if listed for the material being vacuumed with the following conditions:

- (1) They shall be permitted only for small amounts of residual material remaining after preliminary cleanup
- (2) They shall be emptied at the end of each operational period or shift
- (3) They shall not be used as primary dust collectors

7.5.5* When a vacuum cleaner is used for other materials, the equipment shall be thoroughly cleaned prior to use and identified accordingly.

7.5.6 Vacuum cleaner hose shall be conductive, and nozzles or fittings shall be made of conductive, nonsparking material.

7.5.7 Assembled components shall be conductive and bonded where necessary.

7.5.8 Periodic tests for continuity shall be performed.

7.5.9 Combustible metal dust picked up by a fixed vacuum cleaning system shall be discharged into a container or collector located outside the building.

7.5.10 Sludge from dust collectors and vacuum cleaning system precipitators shall be removed weekly as a minimum and when equipment is shut down after use.

7.6 Compressed Air Cleaning Requirements.

7.6.1 Compressed air blowdown shall be permitted in areas that are otherwise impossible to clean by vacuuming or other means and shall be performed under carefully controlled conditions with all potential ignition sources prohibited in or near the area and with all equipment shut down.

7.6.1.1 Vigorous sweeping or blowing down with compressed air produces dust clouds and shall be permitted only where the following requirements are met:

- (1) Electrical equipment not suitable for Class II, Group E locations and other sources of ignition shall be shut down or removed from the area.
- (2) Compressed air shall not exceed a gauge pressure of 206 kPa (30 psi), unless otherwise determined to be safe by a documented hazard analysis.

7.6.2 To prevent potential explosions caused by the inadvertent use of high-pressure compressed air in place of low-pressure inert gas, fittings used on outlets of compressed-air and inert-gas lines shall not be interchangeable.

7.7 Water-Cleaning Requirements.

7.7.1 The use of water for cleaning shall not be permitted in manufacturing areas unless the following requirements are met:

- (1) Competent technical personnel have determined that the use of water will be the safest method of cleaning in the shortest exposure time.
- (2) Operating management has full knowledge of and has granted approval of its use.
- (3) Ventilation, either natural or forced, is available to maintain the hydrogen concentration safely below the lower flammable limit (LFL)
- (4) Complete drainage of all water effluent to a safe, contained area is available

7.7.2 Water-cleaning shall not be permitted in areas that have exposed alkali or water reactive materials.

7.7.3 Hose used for cleaning and wash down purposes shall be pressurized only while in active use for cleaning and wash down purposes.

7.8 Cleaning Frequency.

7.8.1* The accumulation of excessive dust on any portions of buildings or machinery not regularly cleaned in daily operations shall be minimized.

7.8.2 Regular, periodic cleaning of combustible metal dust and fines from buildings and machinery including roof members, pipes, conduits, and so on, shall be carried out as frequently as conditions warrant, based on visual inspections.

7.8.3* The housekeeping frequency shall be established to ensure that the accumulated dust levels on walls, floors, and horizontal surfaces, such as equipment, ducts, pipes, conduits, hoods, ledges, beams, roof members, and above suspended ceilings and other concealed areas, such as the interior of electrical enclosures, does not exceed the threshold accumulation.

7.8.4 Collected fugitive metal dust shall be removed to a designated storage or disposal area.

7.9 General Precautions.

7.9.1 Supplies of production materials in processing areas shall be limited to the amounts necessary for normal operations.

7.9.2 Ordinary combustible materials, such as paper, wood, cartons, and packing material, shall not be stored or allowed to accumulate in combustible metals processing areas unless necessary for the process and then only in designated areas.

7.9.3 Oil spills shall be cleaned up promptly.

7.9.4 Supplies shall be stored in an orderly manner with properly maintained aisles to allow routine inspection and segregation of incompatible materials.

7.9.5 Except for alkali metals, floor sweepings from combustible-metal-dust operations shall be permitted to contain small amounts of ordinary combustible materials.

7.9.6 The review of the hazards associated with cleaning operations shall include isolation, minimization, and elimination of the hazards.

7.9.7 In aluminum powder-handling or manufacturing buildings and in the operation of powder-conveying systems, precautions shall be taken to avoid the production of sparks from static electricity; electrical faults; impact, such as iron or steel articles on each other, on stones, or on concrete; frictional heating; or other energy sources.

Chapter 8 Control of Ignition Sources

8.1* Retroactivity. Unless otherwise specified, the requirements of this chapter shall be applied retroactively.

8.2* Hot Work.

8.2.1 Hot work operations in facilities covered by this standard shall comply with the requirements of NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, and this section.

8.2.2 Hot work permits shall be required in any areas that contain metals in a combustible form.

8.2.3 Open flames, cutting or welding operations, propellant-actuated tools, and spark-producing operations shall not be permitted in areas where combustible metals are produced, stored, handled, or processed, including disposal areas, unless hot work procedures approved by qualified personnel are followed.

8.2.4 All hot work areas that require a permit shall be thoroughly cleaned of exposed metals in a combustible form before hot work is performed.

8.2.5 All internal sections of grinding equipment, ducts, and dust collectors shall be completely free of moist or dry metals in a combustible form and shall be purged before hot work is performed.

8.2.6 Hot work that is an integral step in a manufacturing process, is routine in nature, and has been reviewed as part of the hazard analysis shall not require a hot work permit.

8.3 Smoking.

8.3.1* Smoking shall not be permitted in areas where metals in a combustible form are present.

8.3.2 Smoking materials, matches, and lighters shall not be carried or used by employees or visitors in areas where metals in a combustible form are present.

8.3.3 Smoking shall be permitted only in designated areas.

8.3.4 No-smoking areas shall be posted with "No Smoking" signs.

8.3.5 Where smoking is prohibited throughout an entire plant, the use of signage shall be at the discretion of the facility management.

8.4 Spark-Resistant Tools.

8.4.1* Where tools and utensils are used in areas handling metals in a combustible form with minimum ignition energy less than 30 mJ or in a hybrid mixture, consideration shall be given to the risks associated with generating impact sparks and static electricity.

8.4.2* Tools including but not limited to scoops, shovels, and scrapers, used in the handling of metals in a combustible form shall be electrically conductive, bonded, and grounded, and shall be made of spark-resistant materials.

8.4.3 Spark-resistant tools shall be used when repairs or adjustments are made on or around any machinery or apparatus where metals in a combustible form are present and cannot be removed.

8.5* Static Electricity.

8.5.1* All permanently installed process equipment and all building structural steel shall be grounded by permanent ground wires to prevent accumulation of static electricity.

8.5.2* Movable or mobile process equipment or tools of metal construction shall be bonded and/or grounded prior to use.

8.5.3* A monitoring and testing schedule shall be established based on the hazard assessment to ensure that the effectiveness of grounding and bonding of fixed and mobile equipment has not failed or deteriorated over time and use.

8.5.4 Static dissipative belts shall be used on belt-driven equipment.

8.5.5 All machinery where nonconductive components present a discontinuity in the grounding path shall be bonded between adjacent conductive components.

8.5.6 Ductwork for Pneumatic Conveying Systems. Bonding and grounding for dust collection and pneumatic conveying shall be in accordance with Chapter 9.

8.5.7* Grounding of Personnel.

8.5.7.1 Personnel involved in manually filling or emptying containers or vessels, or handling open containers of metals in a combustible form, shall be grounded during such operations.

8.5.7.2 Personnel grounding shall not be required where both of the following conditions are met:

- (1)*Flammable gases, vapors, and hybrid mixtures are not present.
- (2)*The minimum ignition energy (MIE) of the dust cloud is greater than 30 mJ.

8.6 Control of Friction Hazards. All machinery shall be installed and maintained in such a manner that the possibility of friction sparks is minimized.

8.6.1 Bearings.

8.6.1.1 Ball or roller bearings shall be sealed against dust.

8.6.1.2 Where exposed bearings are used, the bearings shall be protected to prevent ingress of combustible metal dust and shall have a lubrication program.

8.6.1.3 Clearances between moving surfaces that are exposed to paste, powder, or dust shall be maintained to prevent rubbing or jamming.

8.6.1.4 Localized frictional heating of bearings in any machine shall be minimized.

8.6.1.5 Grounded and bonded bearings shall be used.

8.6.1.6 Bearings of wet mills shall be grounded across the lubricating film by use of current collector brushes, a conductive lubricant, or other applicable means.

8.6.2 Fan and Blower Construction.

8.6.2.1 This section shall not be required to be applied retroactively.

8.6.2.2* Fans and blowers used to move air or inert gas in conveying ducts shall be of spark-resistant design and compatible with the material to be conveyed.

8.6.2.3 The design of the fan or blower shall not allow the transported combustible metal powder to pass through the

fan before entering the final collector, unless the combustible metal powder-conveying system is inerted.

8.6.2.4* Fans or blowers shall be equipped with ball or roller bearings.

8.6.2.4.1 Bearings shall be equipped with temperature indicating devices.

8.6.2.4.2 Bearings shall be arranged to sound an alarm in case of overheating.

8.6.2.5 Fans and blowers shall be electrically interlocked with powder-producing machinery so that the machines can operate only if the fans are operating.

8.6.3* Grinding Wheels.

8.6.3.1 Wheels used for grinding combustible metal castings shall be relocated for dressing.

8.6.3.2 If it is not feasible to move the grinding wheels to a safer location for dressing, the hoods shall be thoroughly cleaned or removed entirely before dressing operations are started, and all deposits of dust on and around the wheel shall be removed before, during, and after dressing.

8.7 Electrical Power and Control.

8.7.1 All electrical equipment and wiring shall be installed in accordance with *NFPA 70, National Electrical Code*.

8.7.2 All process equipment and all building steel shall be bonded and grounded in accordance with *NFPA 70, National Electrical Code*.

8.7.3 All manufacturing buildings shall be provided with emergency lighting systems in accordance with *NFPA 101, Life Safety Code*.

8.7.4 Control equipment, control rooms, and offices meeting the requirements of NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, shall be permitted.

8.7.5 Preventive maintenance for electrical equipment shall be established commensurate with the environment and conditions.

8.7.6 One or more remotely located control stations shall be provided to allow the safe and selective shutdown of process equipment in an emergency.

8.7.7 Where process equipment presents a deflagration hazard to a normally unoccupied room or building, an interlock shall prevent process operation unless associated room doors are fully closed.

8.7.8 Where process equipment presents an internal deflagration hazard, an interlock shall prevent equipment operation unless associated access panels are fully closed.

8.8 Electrical Area Classification.

8.8.1* In local areas of a plant where combustible or flammable liquids are present, or where combustible metal dust accumulates or is present in suspension in the air, the area shall be classified, and all electrical equipment and installations in those local areas shall comply with Article 500 of *NFPA 70, National Electrical Code*.

8.8.2 All hazardous (classified) areas identified in accordance with 8.8.1 shall be documented, and such documentation shall be maintained on file for the life of the facility.

8.8.3* Electrical equipment and components installed in unclassified locations, where combustible metal dusts are processed or handled, shall be inspected both internally and externally and cleaned at least annually, or more frequently if warranted.

8.8.4 Flashlights and other portable electrical equipment shall be identified for the locations where they are used.

8.9 Powered Industrial Trucks.

8.9.1 Where used, powered industrial trucks shall be selected and maintained in accordance with NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*.

8.9.2* Where industrial trucks, in accordance with NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*, are not commercially available, a documented risk assessment acceptable to the authority having jurisdiction shall be permitted to be used to specify the fire and explosion prevention features for the equipment used.

8.10 Propellant-Actuated Tools.

8.10.1* Propellant-actuated tools shall not be used in areas where a dust explosion can occur unless all machinery in the area is shut down and the area and machinery are properly cleaned.

8.10.2 Propellant-actuated tools shall be used in accordance with Section 8.2.

Chapter 9 Dust Collection

9.1 General.

9.1.1 Dust collection systems, vacuum cleaning, and pneumatic conveying of a powder or dust for metals in a combustible form shall comply with the requirements of this chapter.

9.1.2 Dust collection for combustible metal powder production operations shall follow the requirements of Section 9.3.

9.1.3 Dust collection for machining, fabrication, finishing, and other dust-generating operations shall follow the requirements of Section 9.4.

9.2 Pneumatic Conveying of Powder.

9.2.1 Ductwork for Pneumatic Conveying Systems.

9.2.1.1 Conveyor ducts shall be fabricated of spark-resistant metals that are compatible with the metal being transported.

9.2.1.2 Plastics or other nonconductive ducts or duct liners shall not be used.

9.2.1.3* Ducts shall be electrically bonded and grounded to minimize accumulation of static electric charge.

9.2.1.4* Where the conveying duct is exposed to weather or moisture, it shall be moisture-tight.

9.2.1.5* A minimum conveying velocity shall be maintained throughout the conveying system to prevent the accumulation of dust at any point and to pick up any dust or powder that can drop out during unscheduled system stoppages.

9.2.1.6* If the conveying gas is air, the combustible metal-to-air ratio throughout the conveying system shall be held below

the minimum explosible concentration (MEC) of the combustible metal dust at normal operating conditions.

9.2.1.7* Where a deflagration hazard exists, deflagration protection such as rupture diaphragms shall be provided on ductwork.

9.2.1.7.1 Deflagration vents shall relieve to a safe location outside the building.

9.2.1.7.1.1 Where provided with deflagration vents, the area within the deflagration vent's discharge area shall be marked.

9.2.1.7.1.2 It shall be permissible to determine the deflagration vent discharge area using NFPA 68, *Standard on Explosion Protection by Deflagration Venting*.

9.2.1.7.1.3* Where ducts are provided with deflagration vents, vent closures shall be clearly marked as follows:

WARNING

Explosion relief device

9.2.1.7.2 Deflagration venting shall not be required for ductwork provided with explosion isolation systems identified in NFPA 69, *Standard on Explosion Prevention Systems*, that can prevent propagation of a deflagration into other parts of the process.

9.2.1.8* Whenever damage to other property or injury to personnel can result from the rupture of the ductwork, or where deflagration relief vents cannot provide sufficient pressure relief, the ductwork shall be designed in accordance with Chapter 13 of NFPA 69, *Standard on Explosion Prevention Systems*.

9.2.1.9 If a portion of the ductwork is located so that no damage to property or injury to personnel will result from its bursting, that portion shall be permitted to be of lightweight construction to intentionally fail, thereby acting as an auxiliary explosion vent for the system.

9.2.2 Conveying Using an Inert Medium.

9.2.2.1* Inert gas-conveying systems shall be permitted if designed in accordance with NFPA 69, *Standard on Explosion Prevention Systems*.

9.2.2.2 The inert gas used shall not react with the specific metal.

9.2.2.3* The concentration of oxygen in the inert gas stream shall be below the limiting oxygen concentration (LOC) of the specific gas in accordance with NFPA 69, *Standard on Explosion Prevention Systems*.

9.2.2.4* A residual level of oxygen below the LOC shall be present in the inert gas stream unless the conveyed material will not be exposed to air in future handling.

9.2.2.5 The oxygen concentration of the inert gas stream shall be monitored in accordance with NFPA 69, *Standard on Explosion Prevention Systems*.

9.2.2.6* The inert gas shall have a dew point so that no free moisture can condense or accumulate at any point in the system.

9.2.2.7* If the conveying gas is inducted into the system in a relatively warm environment and the ducts and collectors are relatively cold, the ducts and collectors shall be either insulated or provided with heating so that the gas temperature does not fall below the dew point, causing condensation.

9.2.2.8* A minimum conveying velocity shall be maintained throughout the conveying system to prevent the accumulation



of dust at any point and to pick up any dust or powder that drops out during an unscheduled system stoppage.

9.2.3 Fan and Blower Construction and Arrangement.

9.2.3.1 Fans and blowers shall be in accordance with 8.6.2.

9.2.3.2 Personnel shall not be permitted within 15 m (50 ft) of the fan or blower while it is operating, except under either of the following conditions:

- (1) If personnel approach the fan or blower to perform a pressure test while the fan is operating, the test shall be done under the direct supervision of competent technical personnel and with the knowledge and approval of operating management and with the flow of combustible metal powder cut off.
- (2) Where the combustible metal powder-conveying system is inerted, personnel shall be permitted to be closer than 15 m (50 ft).

9.2.3.3 No maintenance shall be performed on the fan until it is shut down.

9.2.3.4* Fans or blowers shall be located outside of all manufacturing buildings and shall be located to minimize entrance of dust into the building from the fan exhaust.

9.3 Powder Collection.

9.3.1* Collectors.

9.3.1.1 Dry-type collectors shall be located outside in a safe location and shall be provided with barriers or other means of protection for personnel.

9.3.1.2* The area around the collector shall be posted with a sign that reads as follows:

CAUTION

This collector can contain explosible dust.
Keep outside the marked area while equipment
is operating.

9.3.1.2.1 Where collectors are provided with deflagration vents, the area within the deflagration vent's discharge area shall be marked.

9.3.1.2.2* It shall be permissible to determine the deflagration vent discharge area using NFPA 68, *Standard on Explosion Protection by Deflagration Venting*.

9.3.1.2.3 Where collectors are provided with deflagration vents, vent closures shall be clearly marked as follows:

WARNING

Explosion relief device

9.3.1.3 Collectors shall be constructed of metal that is static dissipative.

9.3.1.4 Ductwork shall comply with the provisions of 9.2.1.

9.3.1.5* The entire collection system, including the collector, shall be completely bonded and grounded to minimize accumulation of static electric charge.

9.3.1.6 Recycling of air from powder collectors into buildings shall be prohibited.

9.3.1.7* Where an explosion hazard exists, dry-type collectors shall be provided with deflagration vents.

9.3.1.7.1 Extreme care shall be taken in the selection of the type and location of vents or weak sections of the collector to minimize injury to personnel and blast damage to nearby equipment or structures.

9.3.1.7.2 Where collectors are provided with deflagration vents, the area within the deflagration vent's discharge area shall be marked.

9.3.1.7.3 It shall be permissible to determine the deflagration vent discharge area using NFPA 68, *Standard on Explosion Protection by Deflagration Venting*.

9.3.1.7.4 Deflagration vents shall be positioned so that a potential blast is not directed toward any combustible or frangible structure.

9.3.1.7.5 Vent closures shall be clearly marked as follows:

WARNING

Explosion relief device

9.3.2 Repairs.

9.3.2.1 Where repairs on dry-type collectors are necessary, the collectors shall be emptied and residual accumulations of dust thoroughly removed.

9.3.2.2* Ductwork leading into the collector shall be disconnected and isolated by blanking before repair work is permitted to be started.

9.3.3 High-Temperature Warning.

9.3.3.1 Cyclone or other dry-type collectors shall be equipped with instruments for recording the surface temperature.

9.3.3.2 An overheating alarm or warning device shall be included, and the limit setting shall be below the maximum service temperature of the filter medium or 50°C (122°F) below the ignition temperature of the powder cloud, whichever is lower.

9.3.3.3 The devices specified in 9.3.3.2 shall give audible and visual alarms at normally attended locations.

9.3.4* Collector Filter Media. Collector filter media made from synthetic fabrics that accumulate static electric charges shall not be used.

9.4* Dust Collection.

9.4.1* Machines that produce fine particles of combustible metal shall be provided with hoods, capture devices, or enclosures that are connected to a dust-collection system having suction and capture velocity to collect and transport all the dust produced.

9.4.2 Hoods and enclosures shall be designed and maintained so that the fine particles will either fall or be projected into the hoods and enclosures in the direction of airflow.

9.4.3* Special attention shall be given to the location of all dust-producing machines with respect to the location of the dust-collection system to ensure that the connecting ducts will be as straight and as short as possible.

9.4.4 The interior of hoods and ducts shall be regularly cleaned wherever there is the possibility of buildup of wax, lint, metal fines, or other combustible material.

9.4.5 Dry-type dust collection systems shall be designed and maintained so that internal cleanliness is ensured. The accumulation of material inside any area of the collector other than in the discharge containers designed for that purpose shall not be permitted.

9.4.6* The accumulation or condensation of water at any point in a dry-type dust collection system shall be prevented.

9.4.7* If the conveying gas is inducted into the system in a relatively warm environment and the ducts and collectors are relatively cold, the ducts and collectors shall be either insulated or provided with heating so that the gas temperature does not fall below the dew point, causing condensation.

9.4.8 Dust collection systems shall not be used to collect incompatible materials or other materials that might react with the conveyed metal.

9.4.9 Operations Generating Hot Metal Particles.

9.4.9.1 For grinding, plasma spray, and other operations generating hot metal particles, media collectors, if used, shall be located at a distance from the point of collection to eliminate the possibility of hot metal particles igniting the filter medium in the collector.

9.4.9.2 Metal temperatures at the dust collector shall be compatible with the limiting temperature of the filter medium element.

9.4.9.3 Grinding operations shall not be served by the same dust-collection system as buffing and polishing operations.

9.4.10 Dust-Collection Ducts and Ductwork.

9.4.10.1 All dust-collection systems shall be installed in accordance with NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*.

9.4.10.2* Inlet and exhaust ducts shall be designed to maintain a velocity to ensure the transport of both coarse and fine particles and to ensure re-entrainment if, for any reason, the particles can fall out before delivery to the collector (for example, in the event of a power failure).

9.4.10.3* The dust loading in ductwork during normal operating conditions shall be held below the MEC in accordance with the deflagration prevention by combustible concentration reduction methods in NFPA 69, *Standard on Explosion Prevention Systems*.

9.4.10.4* Ducts shall be as short as possible and shall have as few bends and irregularities as possible, to prevent interference with free airflow.

9.4.10.5 Duct Construction.

9.4.10.5.1 Ducts shall be constructed of conductive material and shall be carefully fabricated and assembled with smooth interior surfaces and with internal lap joints facing the direction of airflow.

9.4.10.5.2 There shall be no unused capped outlets, pockets, or other dead-end spaces that might allow accumulations of dust.

9.4.10.5.3 Duct seams shall be oriented in a direction away from personnel.

9.4.10.5.4 Additional branch ducts shall not be added to an existing system without reanalysis of the system.

9.4.10.5.5 Branch ducts shall not be disconnected without evaluation of the system, in order to maintain the minimum required conveying velocity throughout the system.

9.4.10.5.6 Unused portions of the system shall not be blanked off without means being provided to maintain required airflow.

9.4.10.5.7* Duct systems, dust collectors, and dust-producing machinery shall be bonded and grounded to minimize accumulation of static electric charge.

9.4.11* Bonding and Grounding.

9.4.11.1 All components of dust-collection systems shall be bonded and grounded.

9.4.11.2 When continuous contact is interrupted, metallic jumpers shall be installed for effective bonding.

9.4.11.3* Dust-collecting filter media shall be designed to be static dissipative.

9.4.12 Wet-Type Dust Collectors.

9.4.12.1* The exhaust vent shall terminate to a safe location outside the building and shall be securely fastened except as provided in 9.4.12.2.1.

9.4.12.2 The clean air shall not be permitted to be returned to an identified deflagration hazard area.

9.4.12.2.1 The cleaned air shall be permitted to be returned to the work area when tests conducted by an approved testing organization prove that the collector's efficiency is great enough to provide, to both personnel and property, safety in the particular installation with regard to particulate matter in the cleaned air and accumulations of particulate matter and hydrogen in the work area.

9.4.12.2.2 The duct shall be as short and straight as possible and shall be designed to withstand the same explosion pressure as the wet-type dust collector.

9.4.12.3* The exhaust vent duct shall be inspected and cleaned frequently to prevent buildup of highly combustible deposits of metal dusts on the interior surfaces of the duct.

9.4.12.4 Arrangement of Wet-Type Dust Collector Components.

9.4.12.4.1 The dust collector shall be arranged so that contact is prevented between dust particles and parts moving at high speed.

9.4.12.4.2 The blower for drawing the dust-laden air into the collector shall be located on the clean-air side of the collector.

9.4.12.4.3* The dust collector shall be arranged so that the dust-laden airstream is thoroughly scrubbed by the liquid to achieve the desired efficiency. The use of an additional dry filter medium either downstream or combined with a wet collector shall not be permitted.

9.4.12.4.3.1 Where required to meet industrial hygiene exposure, dry filter medium shall be permitted to be located downstream of the wet-type collector when equipped with all of the following:

- (1) Differential pressure alarm
- (2) Static dissipative filter media
- (3) A means to limit hydrogen accumulation to 10 percent of the LFL
- (4) High-temperature alarm at the filter media limit



9.4.12.5* Collector Sump Venting.

9.4.12.5.1 Wet-type dust collectors shall be designed so that hydrogen generated from metal contacting the water is vented at all times.

9.4.12.5.2 Vents shall remain open and unobstructed when the machine is shut down.

9.4.12.5.3 When the dust collector is not in operation, ventilation shall be permitted to be provided by an independent blower or by an unimpeded vent.

9.4.12.5.4 Each chamber of the collector shall be vented to dissipate the hydrogen.

9.4.12.5.5 Sludge level buildup in the sludge tank of the wet-type dust collector shall not exceed 5 percent of the tank water capacity as measured by volume.

9.4.12.5.6 Sludge shall be removed from the collector whenever the collector is to remain inoperative for a period of 24 hours or more.

9.4.12.5.7 Wet-type dust collectors shall incorporate the use of positive venting of the sludge tank at all times during shut-down by means of an auxiliary blower that is energized when the main exhaust fan is turned off.

9.4.12.5.8 The auxiliary fan volume shall not be less than 10 percent of the exhaust fan volume.

9.4.12.6 Power Supply Interlock.

9.4.12.6.1* The power supply to the dust-producing equipment shall be interlocked with the airflow from the exhaust blower and the liquid-level controller of the collector so that improper functioning of the dust-collection system will shut down the equipment it serves.

9.4.12.6.2 A time delay switch or equivalent device shall be provided on the dust-producing equipment to prevent the start of the dust-producing process until the collector is in complete operation.

9.4.12.7* Disposal of Sludge from Water Wet-Type Dust Collectors.

9.4.12.7.1 Sludge from water wet-type dust collectors shall be removed at least once each day or more frequently if conditions warrant.

9.4.12.7.2* Covered, vented metal containers shall be used to transport sludge collected for disposal.

9.4.12.7.3 Sludge from wet-type dust collectors shall be permitted to be managed prior to disposal in accordance with applicable federal, state, and local regulations.

9.4.12.7.4 Material removed from wet-type dust collectors shall be permitted to be mixed with an inert material (e.g., sand or material that is nonreactive with the combustible metal) in a volume ratio of five parts inert material to one part metal dust.

9.4.12.7.5* Sludge shall be recycled or disposed of in accordance with federal, state, and local requirements.

9.4.12.7.6 Smoking or open flames shall be prohibited in the disposal area and throughout the disposal process.

9.4.12.7.7 All sludge from wet-type collectors shall be collected in covered, vented metal containers and removed daily, at a minimum, to a safe storage or disposal area that is ventilated.

9.4.12.7.8 Open storage of sludge from wet-type collectors shall be isolated and segregated from other combustible materials and metal scrap to prevent propagation of a fire.

9.4.13* Dry-Type Dust Collectors.

9.4.13.1* Electrostatic collectors shall not be used.

9.4.13.2* Dry-type dust collectors shall be located outside of buildings unless permitted by 9.4.13.15.

9.4.13.3* Individual machines with portable dust-collection capabilities shall be permitted to be used indoors when the object being processed or finished is incapable of being moved to a properly arranged fixed hood or enclosure and shall incorporate the safeguards in 9.4.13.3.1 through 9.4.13.3.4.

9.4.13.3.1 The operation of portable dust-collection devices shall be subject to a hazard analysis to ensure that the risk to personnel and operations from flash fire and shrapnel is minimized.

9.4.13.3.2 Personal protective clothing shall comply with Section 5.3.

9.4.13.3.3 The collector shall be designed to be static dissipative.

9.4.13.3.4* Collector retention capacity shall be limited to 2.2 kg (5 lb).

9.4.13.4 The collector shall be arranged to prevent contact between dust particles and parts moving at high speeds.

9.4.13.5 The blower for drawing the dust-laden air into the collector shall be located on the clean-air side of the collector.

9.4.13.6 Cyclone collectors shall be of conductive metal construction suitable for the service intended.

9.4.13.7 Cyclone collectors shall be solid-welded with smooth internal seams.

9.4.13.8 Discharge containers for collectors shall be emptied before or when 100 percent of the storage capacity of the container is attained.

9.4.13.9 Dust shall be removed from collectors at least once each day and at more frequent intervals if conditions warrant.

9.4.13.9.1 Material removed from the collector shall be permitted to be recycled into a process or mixed with an inert material in a volume ratio of five parts inert material to one part metal dust, and once mixed, it shall be recycled or disposed of in accordance with local, state, and federal regulations.

9.4.13.9.2 Precautions shall be taken to avoid creating dust clouds when removing dust from the collectors.

9.4.13.9.3 The dust removed shall be recycled or disposed of in accordance with local, state, and federal regulations.

9.4.13.10 The dust shall be discharged into metal containers that shall be promptly and tightly covered to avoid the creation of airborne fugitive dust.

9.4.13.11 Recycling of Exhaust Air. Recycling of exhaust air from dry-type dust collectors into buildings shall be prohibited.

9.4.13.12 Repairs.

9.4.13.12.1 Where repairs on dry-type dust collectors are necessary, the collectors shall be emptied and residual accumulations of dust thoroughly removed.

9.4.13.12.2 Ductwork leading into the collector shall be disconnected and blanked off before repair work shall be permitted to be started.

9.4.13.13 Explosion Protection.

9.4.13.13.1 Collectors shall be protected by a minimum of one of the following explosion protection methods:

- (1)*Deflagration venting in accordance with NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, which includes the following:
 - (a) Where deflagration venting is used on indoor dust collectors, the vents shall be ducted to the outside and the flow resistance shall be included in the vent design in accordance with NFPA 68.
 - (b)*Vent ducts shall be designed to prevent accumulation of moisture.
- (2) Oxidant concentration reduction in accordance with NFPA 69, *Standard on Explosion Prevention Systems*, which includes the following:
 - (a) Where oxygen monitoring is used, it shall be installed in accordance with ISA 84.00.01, *Functional Safety: Application of Safety Instrumented Systems for the Process Industry Sector*.
 - (b)*Where the chemical properties of the material being conveyed require a minimum concentration of oxygen to control pyrophoricity, that level of concentration shall be maintained.
- (3) Deflagration pressure containment in accordance with NFPA 69
- (4)*Deflagration suppression in accordance with NFPA 69, where the suppressant has been shown to be chemically compatible and effective with the material collected
- (5)*Dilution with a compatible, noncombustible material to render the mixture noncombustible
- (6)*Deflagration venting through a listed dust retention and flame-arresting device that has been shown effective with the metal being collected.

9.4.13.13.2 If the method in 9.4.13.13.1(5) is used, test data for specific dust and diluent combinations shall be provided and shall be acceptable to the authority having jurisdiction.

9.4.13.13.3 Where an explosion hazard exists and is not protected by 9.4.13.13.1(2) or 9.4.13.13.1(5), isolation devices that have been shown to be compatible and effective with the material collected shall be provided to prevent deflagration propagation between connected equipment in accordance with NFPA 69, *Standard on Explosion Prevention Systems*.

9.4.13.13.3.1* Explosion isolation shall be provided in accordance with NFPA 69, *Standard on Explosion Prevention Systems*, between the dust collector and the upstream.

9.4.13.13.3.2 Where explosion isolation is not provided, a documented risk assessment acceptable to the authority having jurisdiction shall be permitted to be conducted to determine alternate protection methods.

9.4.13.13.4 The selection of the type and location of vents or weak sections of the collector shall be designed to minimize injury to personnel and to minimize blast and fire damage to nearby equipment or structures.

9.4.13.13.5 Where collectors are provided with deflagration vents, the area within the deflagration vent's discharge area shall be marked.

9.4.13.13.6 Signage shall be posted near the dust collector that reads as follows:

CAUTION

This dust collector can contain explosible dust. Keep outside the marked area while equipment is operating.

9.4.13.13.7 Where collectors are provided with deflagration vents, vent closures shall be clearly marked as follows:

WARNING

Explosion relief device

9.4.13.14 Media Collectors.

9.4.13.14.1* Media collectors shall not be permitted unless the combustible dust K_{St} is less than 150 bar-m/s and the requirements of 9.4.13.14 are met.

9.4.13.14.2 Media collectors shall not be used for dust being collected in air for metals covered by chapters on niobium, tantalum, titanium, zirconium, and hafnium unless their use is supported by a risk assessment that is acceptable to the AHJ.

9.4.13.14.3 Media dust collectors shall be provided with all of the following ignition prevention measures:

- (1) Where the MIE of the dust is less than 1000 mJ, the filter media shall be conductive and shall be effectively bonded to the conductive filter frame.
- (2) Accumulations on filter media are limited to levels below the thresholds for any oxidative self-heating ignition and any possible ignition due to exothermic reaction with humid air. These thresholds shall be determined as part of the dust collection risk analysis conducted in accordance with Section 5.2.
- (3) Accumulation levels during operation shall be monitored by a pressure drop across the media or some equivalent sensor and, if the accumulation exceeds the predetermined limits, a controlled shutdown of the collector and dust generation equipment shall be implemented.
- (4) Periodic inspections and replacement of media shall be based on intervals determined by the pressure drop across the filter media or by indication of self-heating detection equipment based on moisture reactivity.

9.4.13.14.4* Spark detection and either extinguishing methods or methods of diversion away from the collector shall be installed in the duct away from any operations prone to spark generation. (See 6.3.3.)

9.4.13.14.5 The filter media shall not be chemically reactive with the collected dust, including any contaminants carried in the dust stream with the combustible metal.

9.4.13.14.5.1 Reactivity shall be evaluated as part of the documented risk analysis conducted in accordance with Section 5.2.

9.4.13.14.6 The collector design shall prevent the accumulation of hydrogen due to a metal-moisture reaction.

9.4.13.14.7* Removal and replacement of filter media containing combustible dust shall be performed based on a standardized procedure that addresses the hazard of the combustible dust, work methods, and personal protective equipment.

9.4.13.15 Indoor Dry-Type Dust Collectors.

9.4.13.15.1 Indoor dry-type dust collectors shall be permitted for only metals covered by Chapter 18.



9.4.13.15.2 Enclosureless collectors shall be prohibited.

9.4.13.15.3 Self-contained, dry down draft benches shall be prohibited.

9.4.13.15.4 Dry-type dust collectors shall be permitted to be located indoors where the requirements of 9.4.13.15.4.1 and 9.4.13.15.4.2 are met.

9.4.13.15.4.1 A hazards analysis shall be conducted in accordance with Section 5.2 to ensure that the risk to personnel and operations is minimized for both new and existing systems.

9.4.13.15.4.2* The material being collected shall meet all of the following criteria:

- (1) The $P_{\max}$ is less than 8 bar-g as measured using the ASTM E1226 test method.
- (2) The K_{St} is less than 150 bar-m/s as measured using the ASTM E1226 test method.
- (3) The minimum ignition energy (MIE) is greater than 100 mJ as measured using the ASTM E2019.
- (4) The material is not a UN Class 4.2 solid as tested using UN 4.2 self-heating test methods.

9.4.13.15.5 The collector shall be designed to comply with all applicable requirements in this chapter.

9.4.13.15.6* The collector shall include a data plate listing the type of combustible metal dust that the material is designed to collect and a visible warning label that states collecting other materials can create a fire or explosion hazard.

9.4.13.15.6.1 The data plate on the collector shall include the following information:

- (1) The metal collected by the collector
- (2) The maximum $P_{\max}$ and K_{St} of dust that can be collected by the dust collector
- (3) The minimum MIE of dust that can be collected by the dust collector

9.4.13.15.6.2 The collection of any metal other than metal for which the system was designed to collect shall be prohibited.

(A) If other materials are to be collected, the modified process shall first be reviewed under management of change to ensure that the requirements of this chapter are maintained.

9.4.13.15.7 Fire Protection. The requirements for fire protection for indoor dry-type dust collection systems shall apply retroactively.

9.4.13.15.7.1 An automatic fixed fire suppression system shall be provided with a fire extinguishing agent that has been shown to be effective with the material collected for indoor collectors.

9.4.13.15.7.2 An automatic fixed fire suppression system shall not be required where the amount of material collected is less than 0.45 kg (1 lb) combustible metal and the dust collector is emptied after each day of operation.

9.4.13.15.7.3 Collected material shall not be stored in the collector, but shall be continually emptied from the collector into a sealed metal container through an isolation device in accordance with NFPA 69, *Standard on Explosion Prevention Systems*.

9.4.13.15.7.4 The collection of materials other than iron or steel dust shall be prohibited in collectors with a dirty volume greater than 0.57 m^3 (20 ft^3) or an airflow greater than $2549 \text{ m}^3/\text{hr}$ (1500 cfm).

9.4.13.15.7.5 Recirculation of exhaust air from a dry-type dust collector into the building shall be prohibited.

9.4.13.15.7.6* Media collectors shall contain a filter break detection system that automatically shuts down the collector and connected equipment if a filter break is detected.

9.4.13.15.7.7 The collector exhaust duct shall exit the building using as straight and short a path as possible.

9.4.13.15.7.8* The collector inlet duct, exhaust duct, and blower shall be inspected at least every 6 months to ensure that material is not accumulating.

9.4.13.15.7.9 The collector exhaust duct located inside the building shall use one of the following deflagration protection methods:

- (1) Deflagration pressure containment in accordance with NFPA 69, *Standard on Explosion Prevention Systems*
- (2)*Deflagration isolation in accordance with NFPA 69

9.4.13.15.7.10* The collector shall include a data plate listing the type of combustible metal dust that the collector is designed to collect and a visible warning label that collecting other materials can create a fire or explosion hazard.

9.4.13.15.7.11* If the material does not meet both of the following criteria, the additional requirements in 9.4.13.15.7.11 to 9.4.13.15.7.11 apply:

- (1) The material is not a UN Class 4.3 solid as tested using UN 4.3 water reactivity test methods.
- (2)*Water has been shown to be an effective extinguishing agent (*see Table A.6.3.3*).

(A)* Media collectors should include automatic cleaning of filters, and the pressure drop across the filter shall be continuously monitored and alarms activate if the pressure is outside of established operating ranges.

(B) The collector shall contain a warning sign stating "This Collector Contains Combustible Metal Dust, Do not Extinguish with Water."

(C) The emergency response plan required in Section 6.4 shall include the following information to emergency responders:

- (1) Location of indoor dry-type dust collectors
- (2) Direction that the collector shall not be opened to extinguish a fire
- (3)*Direction that a fire in the collector shall not be extinguished with water
- (4) A description of the automatic fire extinguishing system on the collector
- (5) A list of effective extinguishing agents for the material being collected in the collector

9.5* Vacuum Cleaning Systems.

9.5.1 Vacuum cleaning systems shall be used only for removal of dust accumulations too small, too dispersed, or too inaccessible to be thoroughly removed by hand brushing.

9.5.2* Vacuum cleaning systems shall be bonded and grounded to minimize accumulation of static electric charge.

9.5.3 The permanently installed vacuum cleaning systems shall be in accordance with Section 9.4.

9.5.4 Due to the inherent hazards associated with the use of fixed and portable vacuum cleaning systems for finely divided

combustible metal dust, special engineering consideration shall be given to the design, installation, maintenance, and use of such systems.

9.5.5 Combustible metal dust picked up by a permanently installed vacuum cleaning system shall be discharged into a container or collector located outside the building.

9.5.6* Portable Vacuum Systems.

9.5.6.1* When being used for combustible metal powders and dust, portable vacuum cleaners shall be used only if listed or approved for use with Group E dusts (combustible metal dust) and shall be identified for use with specific metals only.

9.5.6.2* When a vacuum cleaner is used for other materials, the equipment shall be thoroughly cleaned prior to use and identified accordingly.

9.5.6.3 Vacuum cleaner hose shall be conductive, and nozzles or fittings shall be made of conductive, spark-resistant material.

9.5.6.3.1 Assembled components shall be conductive and bonded, where necessary, to maintain continuity.

9.5.6.3.2 Periodic tests for continuity shall be performed.

Chapter 10 Performance-Based Design Option

10.1 General Requirements.

10.1.1 Approved Qualifications. The performance-based design shall be prepared by a person with qualifications acceptable to the owner/operator.

10.1.2 Independent Review. The authority having jurisdiction shall be permitted to obtain an independent third-party review of the proposed design.

10.1.3* Performance-based designs shall be documented with all calculations, references, assumptions, and sources from which material characteristics and other data have been obtained or on which the designer has relied for some material aspect of the design in accordance with Chapter 5 of NFPA 101, *Life Safety Code*.

10.1.3.1 A sensitivity analysis shall be performed for each assumption that is not provided in an authoritative reference acceptable to the authority having jurisdiction to show that variation of said assumption does not result in a failure to meet design criteria.

10.1.3.2 The source of all calculation methods and models shall be documented with their limits of applicability.

10.1.4* Performance-based designs and documentation shall be updated and subject to re-approval if any of the assumptions on which the original design was based are changed.

10.1.5 Sources of Data.

10.1.5.1 Data sources shall be identified and documented for each input data requirement that must be met using a source other than a design fire scenario, an assumption, or a building design specification.

10.1.5.2 The degree of conservatism reflected in such data shall be specified, and a justification for the sources shall be provided.

10.2 Design Objectives.

10.2.1 Life Safety.

10.2.1.1 The facility, combustible particulate processes, and human element programs shall be designed, constructed, equipped, and maintained to protect personnel not in the immediate proximity of the ignition from the effects of fire, deflagration, explosion, or the release of hazardous materials for the time needed to evacuate, relocate, or take refuge.

10.2.1.2 The structure shall be located, designed, constructed, and maintained to minimize the propagation of fire, explosion, or the release of hazardous materials to adjacent properties and to avoid injury to the public.

10.2.2 Structural Integrity. The facility shall be designed, constructed, and equipped to maintain its structural integrity in spite of the effects of fire, explosion, or the release of hazardous materials for the time necessary to evacuate, relocate, or defend in place occupants not in the immediate proximity of the ignition.

10.2.3* Mission Continuity. The facility, processes and equipment, and human element program shall be designed, constructed, equipped, and maintained to limit damage to levels that ensure the ongoing mission, production, or operating capability of the facility to a degree acceptable to the owner/operator.

10.2.4 Mitigation of Fire Spread, Explosions, or Releases of Hazardous Materials. The facility and processes shall be designed to prevent fires, explosions, or releases of hazardous materials that can cause failure of adjacent compartments, emergency life safety systems, adjacent properties, adjacent storage, or the facility's structural elements.

10.2.4.1* The structure shall be designed, constructed, and maintained to prevent fire or explosions from causing failure of load-bearing structural members, propagating into adjacent interior compartments, and incapacitating fire-protective and emergency life safety systems in adjacent compartments.

10.2.4.2 The structure shall be located, designed, constructed, equipped, and maintained to prevent the propagation of fire or explosion to or from adjacent storage or structures.

10.3 Performance Criteria. A system and facility design shall be deemed to meet the objectives specified in Section 10.2 if its performance meets the criteria in 10.3.1 through 10.3.5.

10.3.1 Life Safety.

10.3.1.1 The life safety objectives of 10.2.1 with respect to a fire hazard shall be achieved if either of the following criteria is met:

- (1) Ignition has been prevented.
- (2) Under all fire scenarios, no person, other than those in the immediate proximity of the ignition, is exposed to untenable conditions due to the fire, and no critical structural element of the building is damaged to the extent that it can no longer support its design load during the period of time necessary to effect complete evacuation.

10.3.1.2 The life safety objectives of 10.2.1 with respect to an explosion hazard shall be achieved if either of the following criteria is met:

- (1) Ignition has been prevented.
- (2) Under all explosion scenarios, no person, other than those in the immediate proximity of the ignition, is



exposed to untenable conditions, including missile impact or overpressure, due to the occurrence of an explosion, and no critical structural element of the building is damaged to the extent that it can no longer support its design load during the period of time necessary to effect complete evacuation.

10.3.1.3 The life safety objectives of 10.2.1 with respect to the release of hazardous materials that don't result in a fire or explosion shall be achieved if the following criteria are met:

- (1) The physical and health hazards identified are mitigated.
- (2) Releases of all hazardous materials offsite are minimized.

10.3.2 Structural Integrity. The structural integrity objective of 10.2.2 with respect to fire and explosion shall be achieved when no critical structural element of the building is damaged to the extent that it can no longer support its design load under all fire and explosion scenarios.

10.3.3 Mission Continuity. The mission continuity objectives of 10.2.3 shall be achieved when damage to equipment and the facility has been limited to a level of damage acceptable to the owner/operator.

10.3.4 Mitigation of Fire Spread, Explosions, or the Release of Hazardous Materials. When limitation of fire spread is to be achieved, all of the following criteria shall be demonstrated:

- (1) Adjacent combustibles shall not attain their ignition temperature.
- (2) Building design and housekeeping shall prevent combustibles from accumulating exterior to the enclosed process system to a concentration that is capable of supporting propagation.
- (3) Particulate processing systems shall prevent fire or explosion from propagating from one process system to an adjacent process system or to the building interior.

10.3.5 Effects of Explosions. Where the prevention of damage due to explosion is to be achieved, deflagrations shall not produce any of the following conditions:

- (1) Internal pressures in the room or equipment sufficient to threaten its structural integrity
- (2) Extension of the flame front outside the compartment or equipment of origin except where intentionally vented to a safe location
- (3)*Rupture of the compartment or equipment of origin and the ejection of fragments that can constitute missile hazards

10.4* Design Scenarios.

10.4.1 Fire Scenarios.

10.4.1.1* Each fuel object in the compartment shall be considered for inclusion as a fire scenario.

10.4.1.2 The fuel object that produces the most rapidly developing fire during startup, normal operating conditions, or shutdown shall be included as a fire scenario.

10.4.1.3 The fuel object that produces the most rapidly developing fire under conditions of a production upset or single equipment failure shall be included as a fire scenario.

10.4.1.4 The fuel object that produces the greatest total heat release during startup, normal operating conditions, or shutdown shall be included as a fire scenario.

10.4.1.5 The fuel object that produces the greatest total heat release under conditions of a production upset or single equipment failure shall be included as a fire scenario.

10.4.1.6 The fuel object that can produce a deep-seated fire during startup, normal operating conditions, or shutdown shall be included as a fire scenario.

10.4.1.7 The fuel object that can produce a deep-seated fire under conditions of a production upset or single equipment failure shall be included as a fire scenario.

10.4.2 Explosion Scenarios.

10.4.2.1 Each duct, enclosed conveyor, silo, bunker, cyclone, dust collector, or other vessel containing a combustible metal dust in sufficient quantity or conditions to support the propagation of a flame front during startup, normal operating conditions, or shutdown shall be included as an explosion scenario.

10.4.2.2 Each duct, enclosed conveyor, silo, bunker, cyclone, dust collector, or other vessel containing a combustible metal dust in sufficient quantity or conditions to support the propagation of a flame front under conditions of production upset or single equipment failure shall be included as an explosion scenario.

10.4.2.3 Each building or building compartment containing a combustible metal dust in sufficient quantity or conditions to support the propagation of a flame front during startup, normal operating conditions, or shutdown shall be included as an explosion scenario.

10.4.2.4 Each building or building compartment containing a combustible metal dust in sufficient quantity or conditions to support the propagation of a flame front under conditions of production upset or single equipment failure shall be included as an explosion scenario.

10.4.2.5 Other Explosions Such as Hydrogen, Steam, Chemical, or Hazardous Materials Reactions. (Reserved)

10.5 Evaluation of Proposed Design.

10.5.1* General. A proposed design's performance shall be assessed relative to each performance objective in Section 10.2 and each applicable scenario in Section 10.4, with the assessment conducted through the use of appropriate calculation methods acceptable to the authority having jurisdiction.

10.5.2 The design professional shall establish numerical performance criteria for each of the objectives in Section 10.2.

10.5.3 The design professional shall use the assessment methods to demonstrate that the proposed design will achieve the goals and objectives, as measured by the performance criteria in light of the safety margins and uncertainty analysis, for each scenario, given the assumptions.

10.6 Retained Prescriptive Requirements. (Reserved)

Chapter 11 Alkali Metals

11.1* General Provisions.

11.1.1 Retroactivity. The requirements of 11.1.2 through 11.1.4 shall apply to new and existing facilities.

11.1.2 Housekeeping.

11.1.2.1* Special Consideration. Alkali metals shall be kept away from sources of moisture.

11.1.3 Personal Protective Equipment (PPE). In addition to the requirements of this section, PPE shall be in accordance with Section 5.3.

11.1.3.1* PPE for Handling Solid Alkali Metals.

11.1.3.1.1 Personnel shall wear eye protection while handling solid alkali metals.

11.1.3.1.2 Personnel shall wear gloves while handling solid alkali metals.

11.1.3.1.3 Gloves shall have tight-fitting cuffs and shall be made of a material suitable for protection from caustic hazards.

11.1.3.1.4 Clothing worn by personnel handling solid alkali metals shall have no exposed pockets or cuffs that could trap and carry alkali metal residues.

11.1.3.2* PPE for Handling Molten Alkali Metals.

11.1.3.2.1 Personal protective equipment shall be worn and shall be compatible with the hazards of molten alkali metals.

11.1.3.2.2* An external clothing layer that is impervious to body moisture shall be worn for protection from splash.

11.1.4 Reactivity.

11.1.4.1* Thermite Reactions. Caution shall be exercised in the mixing of fines or molten material with metal oxides [e.g., iron oxide (rust)].

11.1.4.2 Eutectic Reactions. (Reserved)

11.1.5 Management of Change. Management of change shall be in accordance with Section 5.1.

11.1.6 Alternative Methodologies. (Reserved)

11.1.7 Test Results. (Reserved)

11.1.8 Other.

11.2* Facility Design Requirements.

11.2.1 Building Construction.

11.2.1.1 Section 11.2 shall apply to buildings or portions of buildings that are dedicated to the handling, processing, or storage of solid or molten alkali metal.

11.2.1.2 Noncombustible Materials.

11.2.1.2.1 Buildings dedicated to the storage, handling, processing, or use of alkali metals shall be constructed of noncombustible materials.

11.2.1.2.2 Construction of other than noncombustible materials shall be permitted if equivalent protection can be demonstrated.

11.2.1.3 Buildings shall comply with applicable provisions of NFPA 101, *Life Safety Code*.

11.2.1.4* Roof decks shall be watertight.

11.2.1.5 Walls and ceilings shall be constructed with noncombustible insulation that has been tested in accordance with ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*.

11.2.1.6* In areas where alkali metals are stored, handled, or processed, floors shall be a solid surface and shall be constructed with materials that are compatible and nonreactive with alkali metals and capable of providing containment of molten alkali metals resulting from fire.

11.2.1.7* Floor drains shall not be permitted.

11.2.1.8 Where molten alkali metals are handled, dispensed, or stored, the handling area shall be provided with compatible and nonreactive containment.

11.2.1.8.1 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.

11.2.1.8.2 In areas where molten alkali metals are handled, wall-to-floor connections shall be sealed against the penetration of molten alkali metals.

11.2.1.9 Separation from Water.

11.2.1.9.1* Nonprocess piping that can contain water or steam under normal use (e.g., domestic water pipes, roof drains, waste pipes) shall not be permitted in areas containing alkali metals.

11.2.1.9.1.1 Water pipes required for safety operations shall be permitted.

11.2.1.9.1.2 Piping permitted by 11.2.1.9.1.1 shall be equipped with an emergency shutoff that is identified and located outside the area.

11.2.1.9.1.3 Piping permitted by 11.2.1.9.1.1 shall be constructed of steel.

11.2.1.9.2 A sprinkler system(s) deemed appropriate in accordance with 6.3.2 shall be permitted.

11.2.1.9.3 Portions of buildings where alkali metals are stored, handled, processed, or used shall be separated by watertight walls, ceilings, and door systems from adjacent areas where water can be present.

11.2.1.9.4 The floor shall be sloped in such a manner to prevent water from entering the alkali metals area.

11.2.1.10* Ventilation.

11.2.1.10.1 Roof ventilation shall be provided for dissipation of hydrogen to the atmosphere for areas handling, processing, or storing alkali metals.

11.2.1.10.2 Mechanical ventilation systems shall be designed and installed in accordance with NFPA 5000, *Building Construction and Safety Code*.

11.2.1.11 NFPA Hazard Identification Markings.

11.2.1.11.1 Alkali metal handling, processing, and storage areas having quantities greater than 2.3 kg (5 lb) shall have diamond markings as specified in NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, to make emergency responders aware of the presence of water-reactive materials within the area.

11.2.1.11.2 The diamond markings shall be at least 457.2 mm (18 in.) on each side with appropriate size numbers and symbols as specified in NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*.

11.2.2 Fire Protection.

11.2.2.1 Fire Protection. Fire protection shall be established in accordance with Chapter 6.

11.2.2.2* Because of the unique nature of alkali metal fires, a comprehensive fire protection plan shall be developed where alkali metal is processed, handled, used, or stored in accordance with Chapter 6.

11.2.3 Dust Collection. (Reserved)

11.2.4 Hazard Analysis. The hazard analysis shall be in accordance with Section 5.2.

11.3 Primary Metal Production.

11.3.1 Reduction. (Reserved)

11.3.2 Melting and Casting.

11.3.2.1* Mineral oils or organic materials shall not be used to protect potassium or NaK from moisture or oxygen.

11.3.2.2 Molten alkali metals shall be contained in closed systems that prevent contact with air or reactive materials, except as required for the process.

11.3.2.3 Molten alkali metal piping systems shall be designed in conformance with ANSI/ASME B31.3, *Process Piping Design*.

11.3.2.3.1 All pump seals and flange gaskets shall be made of compatible materials.

11.3.2.4 Molten alkali metal 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, including moisture.

11.3.2.5 Molten alkali metals shall be handled in a detached building or in portions of a building separated from other exposures by fire-rated construction.

11.3.2.6 Where molten alkali metal is cast, molds, ladles, and other components that could come in contact with the molten alkali metal shall be free of incompatible materials, including moisture.

11.3.3 Refining. (Reserved)

11.4 Powder Production. (Reserved)

11.5 End Users of Powder. (Reserved)

11.6 Processing and Handling.

11.6.1 Machinery and Operations.

11.6.1.1* Where alkali metals are processed with a flammable or combustible liquid, the requirements of NFPA 30, *Flammable and Combustible Liquids Code*, shall also be followed for the flammable or combustible liquids.

11.6.1.2 Moisture Protection.

11.6.1.2.1 Solid alkali metals shall be protected from moisture during handling.

11.6.1.2.2* Mineral oils or organic materials shall not be used to protect potassium or NaK from moisture or oxygen.

11.6.1.2.3* Only the amount of alkali metal needed for an individual task or procedure shall be removed from containers.

11.6.1.2.4* Surplus alkali metal shall be placed in a container protected from moisture and sealed immediately.

11.6.1.3 Machining and Operations. (Reserved)

11.6.2 Flake and Paste. (Reserved)

11.6.3 Plasma Spray Operations. (Reserved)

11.6.4 Transfer Operations.

11.6.4.1 General Precautions.

11.6.4.1.1 Alkali metals shall be handled only by trained personnel who are knowledgeable of the hazards associated with alkali metals.

11.6.4.1.2 The number of persons in alkali metal-handling areas during operations shall be limited to those necessary for the operation.

11.6.4.1.3 Access to alkali metal-handling areas by unauthorized personnel shall not be permitted.

11.6.4.1.4* Alkali metals shall not be handled in the presence of incompatible materials.

11.6.4.1.5 Dedicated storage of ordinary combustible materials or flammable or combustible liquids shall be prohibited in areas where alkali metals are handled, processed, or stored.

11.6.4.1.5.1 Quantities of dry mineral oil necessary for safe storage and handling shall be permitted where lithium is processed, handled, or stored.

11.6.4.1.6* Allowable Quantity. The quantity of alkali metals permitted in processing areas shall be limited to that necessary for operations, but it shall not exceed the quantity required for 1 day or as needed for batch processing.

11.6.5 Processing Recycled Material. (Reserved)

11.7* Machining, Fabrication, Finishing, and Media Blasting.

11.7.1 Hot Work Operations.

11.7.1.1 Hot work operations shall be in accordance with Section 8.2.

11.7.2 Chip Processing. (Reserved)

11.7.3 Dust Collection. (Reserved)

11.8 Storage and Handling.

11.8.1* Storage of Product.

11.8.1.1 Alkali metals shall be handled, processed, and stored only in accordance with the requirements of this chapter.

11.8.1.2 Storage of Solid or Molten Alkali Metals.

11.8.1.2.1 General Precautions.

11.8.1.2.1.1* Alkali metals shall be permitted to be stored in shipping containers that meet the requirements of UN “Recommendations for the Transport of Dangerous Goods: Model Regulations—Manual of Tests and Criteria” for the transportation of dangerous goods for alkali metals or in clean, moisture-free, compatible, and nonreactive metal-sealed containers dedicated for the storage of alkali metals.

11.8.1.2.1.2 Alkali metals shall not be stored in containers previously used for the storage of incompatible materials.

11.8.1.2.1.3* Alkali metals shall not be stored in an area with incompatible materials.

11.8.1.2.1.4 Alkali metals in nonbulk containers shall not be stored outside.

11.8.1.3 Solid Alkali Metals Storage.

11.8.1.3.1 Solid alkali metals shall be stored only on the ground floor.

11.8.1.3.2 There shall be no basement or depression below the alkali metals storage area into which water or molten metal could flow or fall during a fire.

11.8.1.3.3 The solid alkali metals storage area shall be isolated from water except for approved installation of automatic sprinkler systems for use in alkali metal storage.

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

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

11.8.1.3.4.2 Containers on pallets and not stored in racks shall be stacked in a stable manner not to exceed three pallets high.

11.8.1.3.4.3 Aisle widths shall be established and approved by the authority having jurisdiction to provide for access to and for the removal of materials during emergency situations.

11.8.1.3.4.4 Idle pallet storage shall not be permitted in alkali metal storage areas.

11.8.1.3.4.5 Idle metal pallets shall be permitted in alkali metal storage areas.

11.8.1.4 Molten Alkali Metal Storage. Molten alkali metal storage shall be in closed systems and in separate buildings or portions of buildings designed solely for that purpose.

11.8.2 Scrap Handling, Storage and Disposal. Alkali metals shall be handled, processed, and stored in accordance with the requirements of this chapter.

11.8.2.1 NFPA Hazard Identification Markings.

11.8.2.1.1 Alkali metal handling, processing, and storage areas having quantities greater than 2.3 kg (5 lb) shall have diamond markings as specified in NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, to make emergency responders aware of the presence of water-reactive materials within the area.

11.8.2.1.2 The diamond markings shall be at least 457.2 mm (18 in.) on each side with appropriate size numbers and symbols as specified in NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*.

11.8.3 Recycling.

11.8.4 Chip Processing. (Reserved)

11.9* Fire and Explosion Protection.

11.9.1 Fire and explosion protection shall be in accordance with Chapter 6.

11.9.1.1* Alkali metal fire residues shall be stored in a designated and isolated location.

11.9.2 Housekeeping.

11.9.2.1 Dust Control. (Reserved)

11.9.2.2* Special Consideration. Alkali metals shall be kept away from sources of moisture.

11.9.3 Control of Ignition Sources.

11.9.3.1 Control of ignition sources shall be in accordance with Chapter 8.

11.9.3.2 Alkali metal fire residue containers shall be permitted to be stored outside where placed in a steel overpack drum and inspected daily.

11.9.3.2.1* Alkali metal fire residues shall be disposed of within 7 days unless the AHJ allows longer storage.

11.9.3.2.2 Alkali metal fire residues shall be protected to prevent adverse reactions and to prevent the formation of reactive or unstable compounds.

11.9.3.2.3 Alkali metal fire residues shall be disposed of in accordance with federal, state, and local regulations.

11.9.3.2.4 Prior to disposal, containers of alkali metal fire residue shall be inspected and the results recorded daily by individuals who are trained in the hazards of alkali metals and able to recognize potential problems associated with these containers.

11.9.3.2.5 Alkali metal fire residues shall be stored in metal containers that are recommended by the alkali metal manufacturer.

11.9.4* Hot Work Operations.

11.9.4.1 Hotwork operations shall be in accordance with Section 8.2.

11.9.5 Control of Combustible Materials.

11.9.5.1 Areas in which flammable and combustible liquids are used shall be in accordance with the requirements of NFPA 30, *Flammable and Combustible Liquids Code*.

11.9.5.1.1 Forge presses, heavy grinders, and other milling equipment operated by hydraulic systems of 189 L (50 gal) or greater shall use a less hazardous hydraulic fluid with a flash point greater than 93°C (200°F).

11.9.5.1.2 Dipping and coating applications of flammable or combustible liquids shall be done in accordance with NFPA 34, *Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*.

11.9.5.1.3 Spray application of flammable or combustible liquids shall be done in accordance with NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*.

11.9.5.2 Ordinary Combustible Storage.

11.9.5.2.1 Ordinary combustible materials such as paper, wood, cartons, and packing material shall not be stored or allowed to accumulate in processing areas unless necessary for the process and then only in designated areas.

11.9.5.2.2 Ordinary combustible materials shall not be discarded in containers used for the collection of combustible metal waste.

11.9.5.3 Removal of Combustible Metal Chips, Fines, Swarf, Paste, Powder, Dust, and Sweepings.

11.9.5.3.1 All combustible metal chips, lathe turnings, and swarf shall be collected in closed-top metal containers and removed daily, as a minimum, to a safe storage or disposal area.

11.9.5.3.2 Open storage of sponge, chips, fines, and dust that are readily ignitable shall be isolated and segregated from

other combustible materials and metal scrap to prevent propagation of a fire.

11.9.6 Inspection, Maintenance, and Training. (Reserved)

11.10 Other. (Reserved)

Chapter 12 Aluminum

12.1* General Provisions.

12.1.1 Retroactivity. The requirements of 12.1.3 through 12.1.8 shall apply to new and existing facilities where aluminum dusts, pastes, and/or powders are produced or handled.

12.1.1.1 In aluminum powder-handling or manufacturing buildings and in the operation of powder-conveying systems, precautions shall be taken to avoid the production of sparks from static electricity; electrical faults; impact, such as iron or steel articles on each other, on stones, or on concrete; frictional heating; or other energy sources.

12.1.2 Housekeeping. Housekeeping shall be in accordance with Chapter 7.

12.1.3* Personal Protective Equipment (PPE). PPE shall be in accordance with Section 5.3.

12.1.4 Reactivity.

12.1.4.1 It shall be the responsibility of the facility to evaluate processes and materials for potentially dangerous reactions that could occur in the course of their operations.

12.1.4.2 Contact with Water.

12.1.4.2.1* Water leakage inside or into any building where the water can contact aluminum powder shall be prevented to avoid possible spontaneous heating.

12.1.4.3 Thermite Reaction.

12.1.4.3.1* Caution shall be exercised in the mixing of aluminum fines and metal oxides [e.g., iron oxide (rust)].

12.1.4.4 Eutectic Reactions. (Reserved)

12.1.5 Alternative Methodologies. (Reserved)

12.1.6 Test Results. (Reserved)

12.1.7 Other. (Reserved)

12.1.8 Management of Change. Management of change shall be in accordance with Section 5.1.

12.2 Facility Design Requirements.

12.2.1 Building Construction.

12.2.1.1 Location of Aluminum Powder Production Plants.

12.2.1.1.1 Aluminum powder production plants shall be located on a site large enough that the buildings in which powder is manufactured are at least 90.9 m (300 ft) from public roads and from any occupied structure, such as public buildings, dwellings, and business or manufacturing establishments, other than those buildings that are a part of the aluminum powder production plant.

12.2.1.1.2 A hazards analysis shall be conducted to determine the minimum separation distance for individual buildings and operations within aluminum powder production plants.

12.2.1.2 All buildings used for the manufacture, packing, or loading for shipment of aluminum powders shall be constructed of noncombustible materials throughout and shall have non-load-bearing walls.

12.2.1.3 The buildings specified in 12.2.1.2 shall be designed so that all internal surfaces are readily accessible, to facilitate cleaning.

12.2.1.4 All walls of areas where fugitive dust can be produced shall have a smooth finish and shall be sealed so as to leave no interior or exterior voids where aluminum powder can infiltrate and accumulate.

12.2.1.5 The annuli of all pipe, conduit, and ventilation penetrations shall be sealed.

12.2.1.6 Floors shall be hard surfaced and shall be installed with a minimum number of joints in which aluminum powder or dust can collect.

12.2.1.7 The requirements of 12.2.1.6 shall also apply to elevated platforms, balconies, floors, and gratings.

12.2.1.8 Roofs of buildings that house combustible aluminum dust-producing operations shall be supported on girders or structural members designed to minimize surfaces on which dust can collect.

12.2.1.9* Interior surfaces where dust accumulations can occur shall be designed and constructed to facilitate cleaning and to minimize combustible dust accumulations.

12.2.1.10 Where surfaces on which dust can collect are unavoidably present, they shall be covered by a smooth concrete, plaster, or noncombustible mastic fillet having a minimum slope of 55 degrees to the horizontal.

12.2.1.11 Roof decks and basements shall be watertight.

12.2.1.12 Explosion venting in accordance with NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, shall be provided for buildings where aluminum powder is processed.

12.2.1.13 Deflagration venting shall not be required for areas where aluminum powder is stored or moved only in covered or sealed containers.

12.2.1.14 Door and Window Construction.

12.2.1.15 All doors in interior fire-rated partitions shall be listed self-closing fire doors, installed in accordance with NFPA 80, *Standard for Fire Doors and Other Opening Protectives*.

12.2.1.16* Emergency exits shall be provided in compliance with NFPA 101, *Life Safety Code*.

12.2.1.17 Enclosed Passageways.

12.2.1.17.1* Where buildings or process areas are interconnected by enclosed passageways, the passageways shall be designed to prevent propagation of an explosion or fire from one unit to another in accordance with NFPA 68, *Standard on Explosion Protection by Deflagration Venting*.

12.2.1.17.2 All enclosed passageways that connect with one or more processing areas shall be provided with means of egress in accordance with NFPA 101, *Life Safety Code*.

12.2.1.18 Grounding and Lightning Protection.

12.2.1.18.1 All buildings shall be provided with a lightning protection system in accordance with NFPA 780, *Standard for the Installation of Lightning Protection Systems*.

12.2.1.18.2 Lightning protection systems shall not be required for office buildings and buildings that are used for storage and handling of closed containers.

12.2.1.19 Heating and Cooling of Aluminum Powder-Production Buildings.

12.2.1.19.1 Buildings shall be permitted to be heated by indirect hot-air heating systems or by bare-pipe heating systems using steam or hot water as the heat transfer medium, or by listed electric heaters.

12.2.1.19.2 Indirect hot air shall be permitted if the heating unit is located in an adjacent room or area that is free of combustible aluminum dust.

12.2.1.19.3 Fans or blowers used to convey heated or cooled air shall be located in an area that is free of combustible aluminum dust.

12.2.1.19.4 The air supply shall be taken from outside or from a location that is free of combustible aluminum dust.

12.2.1.19.5 Makeup air for building heating or cooling shall have a dew point low enough to ensure that no free moisture can condense at any point where the air is in contact with combustible aluminum dust or powder.

12.2.1.19.6 The requirements of 12.2.1.19.1 through 12.2.1.19.5 shall not apply to areas where aluminum metal is melted.

12.2.2 Fire Protection.

12.2.2.1 Extinguishing Agents and Application Techniques for Use on Combustible Aluminum Dusts.

12.2.2.1.1* An incipient fire shall be ringed with a dam of dry sand, dry inert granular material, or a listed Class D extinguishing powder in accordance with the manufacturer's instructions.

12.2.2.1.2 Application of dry extinguishing agent shall be conducted in such a manner as to avoid any disturbance of the combustible aluminum dust, which could cause a dust cloud.

12.2.2.1.3 The dry extinguishing agent shall be stored in such a manner that it remains clean and dry.

12.2.2.1.4* The dry extinguishing agent shall be carefully applied with a nonsparking metal scoop or shovel or applied from a listed Class D fire extinguisher.

12.2.2.1.5 Drafts shall be eliminated by shutting off fans and machinery and by closing doors and windows.

12.2.2.2 Fire Extinguishers. Portable or wheeled fire extinguishers shall be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

12.2.2.2.1 Areas where dry combustible aluminum dust is present shall not have fire extinguishers rated for Class A, Class B, or Class C fires.

12.2.2.2.2 Where Class A, Class B, or Class C fire hazards are in the combustible aluminum powder area, extinguishers suitable for use on such fires shall be permitted, provided they are marked "Not for Use on Aluminum Powder Fires."

12.2.2.2.3* Extinguishers listed for use on Class B fires shall be provided in areas where solvent cleaning and washing are performed.

12.2.2.2.3.1 Conspicuous signs shall be placed adjacent to such extinguishers, stating that the extinguishers shall not be used for combustible aluminum dust fires.

12.2.2.2.3.2 Halogenated extinguishing agents shall not be used.

12.2.2.2.4* Solvent-Wetted Powders.

12.2.2.2.4.1 An incipient fire occurring while the aluminum powder is in slurry form shall be permitted to be fought using listed Class B extinguishing agents, except that halogenated extinguishing agents shall not be used.

12.2.2.2.4.2* An incipient fire occurring in semi-wet material or filter cake shall be fought using a listed Class B extinguishing agent.

12.2.2.2.5 Carbon Dioxide Use.

12.2.2.2.5.1* Where carbon dioxide is used to extinguish fires involving solvent-wetted aluminum, the residual material shall be immediately covered with dry sand, with dry inert granular material, or with other listed Class D extinguishing agent, and the entire mass shall be allowed to cool until it reaches ambient temperature.

12.2.2.2.5.2 When the material has cooled and it has been determined that there are no hot spots, the covered material shall be carefully removed for disposal.

12.2.2.2.5.3* The material shall be handled in small quantities in covered containers.

12.2.2.3 Water Use. Manual water application shall be used on a solvent-metal powder fire only as a last resort, when other methods of control have failed and the fire shows evidence of burning out of control.

12.2.2.3.1 Only low-velocity spray or fog nozzles shall be used.

12.2.2.3.2 Manual application of water shall be conducted in such a manner as to avoid creating a dust cloud.

12.2.2.3.3 Once water is used, its use shall be continued until the fire is extinguished or until the area becomes untenable.

12.2.2.3.4 After extinguishment, the area shall be immediately cleaned of all wetted powder, paste, or slurry.

12.2.2.3.5 Ventilation shall be provided during cleanup to avoid concentrations of hydrogen from the exothermic reaction of the aluminum with water.

12.2.2.3.6* Fire flow containment shall not be required for existing facilities.

12.2.2.4 Automatic Sprinkler Protection.

12.2.2.4.1 Automatic sprinkler protection shall not be permitted in areas where dry aluminum powders are produced or handled.

12.2.2.4.1.1* Where both dry aluminum and other combustibles such as solvents are present, automatic sprinkler protection shall be permitted if a hazards analysis acceptable to the authority having jurisdiction indicates that automatic sprinkler systems could reduce the risk to life and damage to property.

12.2.2.4.1.2 The hazards analysis shall consider the possibility of fires and explosions involving both dry aluminum and the other combustibles.



12.2.2.4.2 The special hazards associated with aluminum powder in contact with water shall be considered in the selection, design, and installation of automatic sprinkler systems.

12.2.2.4.3 Automatic sprinkler systems shall be designed and installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

12.2.2.4.4 Employee training and organizational planning shall be provided to ensure safe evacuation of the sprinkler-protected area in case of fire.

12.2.2.5 Fire Fighting.

12.2.2.5.1 Incipient Fire Fighting. Facilities handling finely divided aluminum shall develop a response plan for fighting fires, in accordance with Chapter 6.

12.2.3 Dust Collection. Dust collection shall be in accordance with Chapter 9.

12.2.4 Hazard Analysis. Hazard analysis shall be in accordance with Section 5.2.

12.3 Primary Metal Production.

12.3.1 This standard shall not apply to the primary production of aluminum.

12.3.2 Melting and Casting. (Reserved)

12.3.3 Refining. (Reserved)

12.4 Aluminum Powder Production.

12.4.1 Handling and Conveying of Aluminum Powder.

12.4.1.1 Where aluminum powder is present, good housekeeping practices shall be maintained.

12.4.1.2 Aluminum powder shall be handled so as to avoid spillage and the creation of airborne dust.

12.4.1.3 Scoops, shovels, and scrapers used in the handling of aluminum powder shall be electrically conductive and shall be grounded when necessary, and hand tools shall be made of spark-resistant materials.

12.4.1.4 Each container for aluminum powders shall be conductive and covered while in storage or in transit.

12.4.1.5 When aluminum powders are being charged to or discharged from machines, the containers shall be bonded to the grounded machine.

12.4.1.6 When aluminum powder is being transferred between containers, the containers shall be bonded and at least one of the containers shall be grounded.

12.4.2 Portable Containers.

12.4.2.1 In-plant transport of aluminum powders shall be done in covered conductive containers as described in 12.4.1.4.

12.4.3 Ductwork for Pneumatic Conveying Systems. Ductwork for pneumatic conveying systems shall be in accordance with 9.2.1.

12.4.4 Conveying Using an Inert Medium. Conveying using an inert medium shall be in accordance with 9.2.2.

12.4.5 Fan and Blower Construction and Arrangement. Fan and blower construction and arrangement shall be in accordance with 9.3.3.

12.4.6 Powder Collection. Powder collection shall be in accordance with Section 9.4.

12.5 End Users of Powder.

12.5.1 Aluminum Powder Handling and Use.

12.5.1.1 Scope. The provisions of Section 12.5 shall apply to operations including, but not limited to, the use of aluminum powder in the production of paste, flake powders, powdered metallurgy component manufacturing, fireworks and pyrotechnics, propellants, plasma spray coating, chemical processing, and refractories.

12.5.1.2 Storage. Dry aluminum powder and aluminum paste shall be stored in accordance with the provisions of 12.8.1.

12.5.1.3* Handling. The requirements of Section 12.5 shall apply to both regular and “nondusting” grades of aluminum powder, as well as to aluminum paste.

12.5.1.4 Where aluminum powder or paste is used or handled, good housekeeping practices shall be maintained in accordance with 12.1.2.

12.5.1.5 Scoops, shovels, and scrapers used in the handling of aluminum powder and paste shall be electrically conductive and shall be grounded when necessary, and hand tools shall be made of spark-resistant materials.

12.6 Processing.

12.6.1 Machining and Operations.

12.6.1.1 Requirements for Machinery.

12.6.1.2 All combustible aluminum dust-producing machines and conveyors shall be designed, constructed, and operated so that fugitive dust is minimized.

12.6.1.3* All machinery shall be bonded and grounded to minimize accumulation of static electric charge.

12.6.1.4 Bearings.

12.6.1.4.1* Ball or roller bearings shall be sealed against dust.

12.6.1.4.2 Where exposed bearings are used, the bearings shall be protected to prevent ingress of combustible aluminum dust and shall have a lubrication program.

12.6.1.5 Clearances between moving surfaces that are exposed to paste, powder, or dust shall be maintained to prevent rubbing or jamming.

12.6.1.6 Permanent magnetic separators, pneumatic separators, or screens shall be installed ahead of mills, stamps, or pulverizers wherever there is any possibility that tramp metal or other foreign objects can be introduced into the manufacturing operation.

12.6.1.7 Startup Operations. All areas of processing machinery that will be in contact with aluminum powder shall be free of foreign material and water before being placed in operation.

12.6.2 Flake and Paste.

12.6.2.1 Machinery and Operations.

12.6.2.1.1* Wet Milling of Aluminum Powder. The requirements of 12.6.2.1.1.1 through 12.6.2.1.1.6 shall not apply to machining and rolling operations.

12.6.2.1.1.1* Where aluminum is added to a mill in the presence of a liquid that is chemically inert with respect to the metal, the milling shall be done in air in a vented mill or in an inerting atmosphere containing sufficient oxygen to oxidize any newly exposed surfaces as they are formed.

12.6.2.1.1.2* Where aluminum is slurried in tanks or processed in blenders or other similar equipment in the presence of a liquid that is chemically inert with respect to the metal, the operation shall be carried out in air or in an inerting atmosphere containing sufficient oxygen to oxidize any newly exposed surfaces as they are formed.

12.6.2.1.1.3 The dew point of the atmospheres in 12.6.2.1.1.1 and 12.6.2.1.1.2 shall be maintained below the point where condensation occurs.

12.6.2.1.1.4 Bearings of wet mills shall be grounded across the lubricating film by use of current collector brushes, a conductive lubricant, or other applicable means.

12.6.2.1.1.5* Ventilation in accordance with NFPA 30, *Flammable and Combustible Liquids Code*, shall be maintained in areas where flammable or combustible solvents are handled, particularly in areas where combustible aluminum dusts or powders are present.

12.6.2.1.1.6 Solvent or slurry pumps shall be installed with controls that ensure that a flow exists and that the pumps run with safe operating temperatures.

12.6.3 Plasma Spray Operations.

12.6.3.1 For plasma spray operations, media collectors, if used, shall be located at a distance from the point of collection to eliminate the possibility of hot metal particles igniting the filter media in the collector.

12.6.3.2 Metal overspray temperatures at the dust collector shall be compatible with the limiting temperature of the filter media element.

12.6.4 Transfer Operations.

12.6.4.1* Operations involving the transfer of combustible aluminum dusts or powders from one container to another shall be designed and operated to protect personnel, equipment, and buildings from the fire or dust explosion hazard produced by airborne suspensions of combustible aluminum dusts or powders.

12.6.4.2 Prevention of Fugitive Dust Accumulations. See 12.1.2.

12.6.5 Processing Recycled Material. The requirements of Chapter 19 shall apply to processes handling recycled aluminum, which is in a combustible form.

12.7* Machining, Fabrication, Finishing, and Media Blasting.

12.7.1 Hot Work Operations.

12.7.1.1 Hot work operations in facilities covered by this standard shall be in accordance with Section 8.2.

12.7.2 General Precautions.

12.7.2.1 Any equipment used for the machining, fabrication, or finishing of aluminum shall be dedicated to aluminum only and marked with a placard that reads as follows:

WARNING

Aluminum Metal Only — Fire or Explosion Can Result
with Other Metals.

12.7.2.2 Equipment producing aluminum in a combustible form shall be permitted to be used for other materials only when the system is thoroughly cleaned of all incompatible materials prior to and after its use.

12.7.3 Chip Processing.

12.7.3.1 Machining and Sawing Operations.

12.7.3.2* Cutting tools shall be of proper design and shall be kept sharp for satisfactory work with aluminum.

12.7.3.3* Sawing, grinding, and cutting equipment shall be grounded.

12.7.3.4 All aluminum chips, oily crushed lathe turnings, raw turnings, and swarf shall be collected in closed-top containers dedicated to aluminum only and removed daily, at a minimum, to a safe storage or disposal area.

12.7.3.5 Coolant.

12.7.3.5.1* Coolants with a flash point less than 200°F shall not be used for wet grinding, cutting, or sawing operations.

12.7.3.5.2 The coolant shall be filtered on a continuous basis, and the collected solids shall not be allowed to accumulate in quantities greater than 19 L (5 gal) and shall be removed to a safe storage or disposal area.

12.7.4 Dust Collection. Dust collection shall be in accordance with Chapter 9.

12.8 Storage and Handling.

12.8.1 Storage of Aluminum Powder. When aluminum powder is stored in sealed containers, the procedures of 12.8.1.1 through 12.8.1.7 shall apply.

12.8.1.1 Containers from which a portion of powder has been removed shall be carefully covered and resealed.

12.8.1.2 Containers shall be kept free of contact with water or moisture.

12.8.1.3 Aluminum powder packed in sealed containers shall be permitted to be stored in commercial or public warehouses if they are of fire-resistive, noncombustible, or limited-combustible construction as defined in NFPA 220, *Standard on Types of Building Construction*, or are of other construction types protected with an automatic sprinkler system.

12.8.1.4* Aluminum powder shall be segregated from incompatible materials and combustible materials.

12.8.1.5 When aluminum powder is stored in sealed containers, storage shall be limited to one-drum tiers per pallet with a height of no more than four pallet loads.

12.8.1.5.1 Stacked storage shall be arranged to ensure stability.

12.8.1.5.2 Aisles shall be provided for maneuverability of material-handling equipment, for ready accessibility, and to facilitate incipient fire-fighting operations.

12.8.1.6 Leakage or condensation from roof, floor, walls, drains, steam, water lines, or radiators shall be avoided.

12.8.1.7 Smoking and open flames shall be prohibited in areas where aluminum powder is stored.

12.8.2 Scrap Handling, Storage, and Disposal. (Reserved)

12.8.3 Recycling.

12.8.3.1 Where a recycling facility handles aluminum in a combustible form, the requirements of Chapter 19 shall apply.

12.8.4 Chip Processing. (Reserved)



12.9 Fire and Explosion Protection.

12.9.1 Scope. Section 12.9 shall apply to new and existing facilities where combustible aluminum dusts, pastes, and powders are present.

12.9.1.1 Fire and explosion protection shall be in accordance with Chapter 6.

12.9.2 Control of Ignition Sources. Control of ignition sources shall be in accordance with Chapter 8.

12.9.3 Hot Work Operations.

12.9.3.1 Hot work operations in facilities covered by this standard shall be in accordance with Section 8.2.

12.9.4 Control of Combustible Materials.

12.9.4.1 Areas in which flammable and combustible liquids are used shall be in accordance with the requirements of NFPA 30, *Flammable and Combustible Liquids Code*.

12.9.4.1.1 Forge presses, heavy grinders, and other milling equipment operated by hydraulic systems of 189 L (50 gal) or greater shall use a less hazardous hydraulic fluid with a flash point greater than 93°C (200°F).

12.9.4.1.2 Dipping and coating applications of flammable or combustible liquids shall be done in accordance with NFPA 34, *Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*.

12.9.4.1.3 Spray application of flammable or combustible liquids shall be done in accordance with NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*.

12.9.4.2 Ordinary Combustible Storage.

12.9.4.2.1 Ordinary combustible materials, such as paper, wood, cartons, and packing material, shall not be stored or allowed to accumulate in processing areas unless necessary for the process, and then only in designated areas.

12.9.4.2.2 Ordinary combustible materials shall not be discarded in containers used for the collection of combustible metal waste.

12.9.4.3 Removal of Combustible Metal Chips, Fines, Swarf, Paste, Powder, Dust, and Sweepings.

12.9.4.3.1 All combustible metal chips, lathe turnings, and swarf shall be collected in closed-top metal containers and removed daily, as a minimum, to a safe storage or disposal area.

12.9.4.3.2 Open storage of sponge, chips, fines, and dust that are readily ignitable shall be isolated and segregated from other combustible materials and metal scrap to prevent propagation of a fire.

12.9.5 Inspection, Maintenance, and Training.

12.9.5.1 Safety Inspection. A thorough inspection of the operating area shall take place on an as-needed basis to help ensure that the equipment is in good condition and that proper work practices are being followed.

12.9.5.1.1 The inspection shall be conducted at least quarterly but shall be permitted to be done more often.

12.9.5.1.2 The inspection shall be conducted by a person(s) knowledgeable in the proper practices, who shall record the findings and recommendations.

12.9.5.2* Employee Training Program. Training programs shall be instituted to inform employees about the hazards involved in the manufacture of aluminum powder, paste, or granules and the hazards involved in processing or finishing operations that generate fine combustible aluminum dust, as appropriate to the operation.

12.9.5.3 Emergency Procedures.

12.9.5.3.1 Emergency procedures to be followed in case of fire or explosion shall be established.

12.9.5.3.2* All employees shall be trained in the emergency procedures specified in 12.9.5.3.1.

12.10 Other. (Reserved)

Chapter 13 Magnesium

13.1* General Provisions.

13.1.1 Retroactivity. The requirements of 13.1.3 through 13.1.5 shall apply to new and existing facilities where magnesium dusts, pastes, and or powders are produced or handled.

13.1.1.1 In magnesium powder-handling or manufacturing buildings and in the operation of powder-conveying systems, precautions shall be taken to avoid the production of sparks from static electricity; electrical faults; impact, such as iron or steel articles on each other, on stones, or on concrete; frictional heating, or other energy sources.

13.1.2 Housekeeping. Housekeeping shall be in accordance with Chapter 7.

13.1.3 Personal Protective Equipment (PPE). PPE shall be in accordance with Section 5.3.

13.1.4 Reactivity. It shall be the responsibility of the facility to evaluate processes and materials for potentially dangerous reactions that could occur in the course of their operations.

13.1.4.1 Thermite Reaction.

13.1.4.1.1* Caution shall be exercised in the mixing of magnesium fines or molten magnesium with metal oxides [e.g., iron oxide (rust)].

13.1.4.2 Eutectic Reactions. (Reserved)

13.1.5 Management of Change. Management of change shall be in accordance with Section 5.1.

13.1.6 Alternative Methodologies. (Reserved)

13.1.7 Test Results. (Reserved)

13.2 Facility Design Requirements.

13.2.1 Building Construction.

13.2.1.1 Location.

13.2.1.1.1 Magnesium powder production plants shall be located on a site large enough so that the buildings in which the powder is manufactured are at least 91.5 m (300 ft) from public roads and from any occupied structure, such as public buildings, dwellings, and business or manufacturing establishments, other than those buildings that are a part of the magnesium powder production plant.

13.2.1.1.2 Different production operations shall be located in separate but not adjoining buildings that are located at least 15 m (50 ft) from each other.

13.2.1.1.3 Two buildings less than 15 m (50 ft) apart shall be permitted if the facing wall of the exposed building is capable of resisting a blast with a gauge pressure of 13.8 kPa (2.0 psi) and is non-load-bearing, noncombustible, and without openings.

13.2.1.1.4 Separate buildings shall be required where different operations such as, but not limited to, atomization, grinding, crushing, screening, blending, or packaging are performed.

13.2.1.1.5 More than one operation within the same building shall be permitted if the design provides equivalent protection.

13.2.1.1.6 All buildings used for the manufacture, packing, or loading for shipment of magnesium powders shall be single story, shall not have basements, shall be constructed of noncombustible materials throughout, and shall have non-load-bearing walls.

13.2.1.1.7 The buildings shall be designed so that all internal surfaces are readily accessible to facilitate cleaning.

13.2.1.1.8 Construction of other than noncombustible materials shall be permitted if equivalent protection can be demonstrated.

13.2.1.1.9 Explosion venting in accordance with NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, shall be provided for buildings where magnesium powder is processed.

13.2.1.1.10 All walls or areas that are not of monolithic construction and where dust can be produced shall have all masonry joints thoroughly slushed with mortar and troweled smooth so as to leave no interior or exterior voids where magnesium powder can infiltrate and accumulate.

13.2.1.1.11* Interior surfaces where dust accumulations can occur shall be designed and constructed to facilitate cleaning and to minimize combustible dust accumulation.

13.2.1.1.12 Floors shall be of a noncombustible hard surface, nonslip, and installed with a minimum number of joints in which powder can collect.

13.2.1.1.13 The requirements of 13.2.1.1.10 shall also apply to elevated platforms, balconies, floors, and gratings.

13.2.1.1.14 Roofs of buildings that house dust-producing operations shall be supported on girders or structural members designed to minimize surfaces on which dust can collect.

13.2.1.1.15 Roof decks shall be watertight.

13.2.1.1.16 Doors and Windows.

13.2.1.1.16.1 All exits shall conform to NFPA 101, *Life Safety Code*.

13.2.1.1.16.2 All doors in fire-rated partitions shall be approved, self-closing fire doors, installed in accordance with NFPA 80, *Standard for Fire Doors and Other Opening Protectives*.

13.2.1.1.16.3* Windows shall be held in place by friction latches and shall be installed so that they open outward.

13.2.1.1.17* Grounding of Equipment. All process equipment and all building steel shall be securely grounded by permanent ground wires to prevent accumulation of static electricity.

13.2.1.1.18 Security. Paragraph 13.2.1.1.18 shall apply to new and existing magnesium powder production plants. (See 13.1.1.)

13.2.1.1.18.1 The intent of 13.2.1.1.18 shall be to restrict access by the general public to magnesium powder production plants and to establish adequate exits for personnel.

13.2.1.1.18.2 The powder production plant shall be surrounded by strong fencing at least 1.8 m (7 ft) high and with suitable entrance gates or shall be otherwise rendered inaccessible.

13.2.1.1.18.3 Security measures taken shall be in accordance with NFPA 101, *Life Safety Code*.

13.2.1.1.19 Electrical Power and Control.

13.2.1.1.19.1 Electrical power and control shall be in accordance with Chapter 8.

13.2.1.1.19.2 Buildings of area less than 19 m² (200 ft²) that are not normally occupied shall not be required to have emergency lighting systems.

13.2.2 Fire Protection.

13.2.3* Grounding of Equipment. All equipment shall be securely grounded by permanent ground wires to prevent accumulation of static electricity.

13.2.4 Dust Collection. Dust collection shall be in accordance with Chapter 9.

13.2.5 Hazard Analysis. Hazard analysis shall be in accordance with Section 5.2.

13.3 Primary Metal Production. This standard shall not apply to the primary production of magnesium.

13.3.1 Reduction.

13.3.2* Melting and Casting.

13.3.2.1 Buildings used for the melting and casting of magnesium shall be noncombustible.

13.3.2.1.1 Melt rooms shall provide access to facilitate fire control.

13.3.2.1.2* Floors shall be of noncombustible construction and shall be kept clean and free of moisture and standing water.

13.3.2.2* All solid metal shall be thoroughly dried by preheating and shall be at a temperature not less than 121°C (250°F) throughout when coming into contact with molten magnesium.

13.3.2.3 Fuel supply lines to melting pots and preheating installations shall have remote fuel shutoffs and combustion safety controls in accordance with NFPA 86, *Standard for Ovens and Furnaces*, or equivalent.

13.3.2.4* Prevention of Molten Magnesium Contact with Foreign Materials.

13.3.2.4.1 Areas of furnaces that can come into contact with molten magnesium in the event of a runout shall be kept dry and free of iron oxide.

13.3.2.4.2 Crucible interiors and covers shall be maintained free of iron oxide scale, which could fall into the molten metal.

13.3.2.4.3 Molten magnesium 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.



13.3.2.4.4 Melting pots and crucibles shall be inspected regularly.

13.3.2.4.5 Pots and crucibles that show evidence of possible failure or that allow molten metal to contact iron oxide, concrete, or other incompatible materials shall be repaired or discarded.

13.3.2.5 Ladles, skimmers, and sludge pans shall be thoroughly dried and preheated before contacting molten metal.

13.3.2.6 Extreme care shall be exercised in pouring magnesium castings, to avoid spillage.

13.3.2.7 All molds shall be thoroughly preheated before pouring magnesium castings.

13.3.2.8 Operators in melting and casting areas shall wear flame-resistant clothing, high foundry shoes, and face protection.

13.3.2.9 Clothing worn where molten magnesium is present shall have no exposed pockets or cuffs that could trap and retain magnesium.

13.3.3 Refining. (Reserved)

13.4 Powder Production.

13.4.1 General Precautions.

13.4.1.1 In powder-handling or manufacturing buildings and in the operation of dust-conveying systems, every precaution shall be taken to avoid the production of sparks from static electricity, electrical faults, friction, or impact (e.g., iron or steel articles on stones, on each other, or on concrete).

13.4.1.2 Water leakage within or into any building where it can contact magnesium powder shall be prevented to avoid possible spontaneous heating and hydrogen generation.

13.4.1.3 Electrical heating of any resistance element or load to a high temperature in an area containing a dust hazard shall be prohibited.

13.4.1.4* Frictional heating shall be minimized by the use of lubrication, inspection programs, and maintenance programs and by techniques recommended by the equipment manufacturer.

13.4.2 Requirements for Machinery.

13.4.2.1 All combustible magnesium dust-producing machines and conveyors shall be designed, constructed, and operated so that fugitive dust is minimized.

13.4.2.2* All machinery shall be bonded and grounded to minimize the accumulation of static electric charge.

13.4.2.2.1 The requirement of 13.4.2.2 shall apply to stamp mortars, mills, fans, and conveyors in all areas where dust is produced or handled.

13.4.2.2.2 Static-conductive belts shall be used on belt-driven equipment.

13.4.2.3* Only grounded and bonded bearings, properly sealed against dust, shall be used.

13.4.2.4 Internal machine clearances shall be maintained to prevent internal rubbing or jamming.

13.4.2.5 High-strength permanent magnetic separators, pneumatic separators, or screens shall be installed ahead of mills, stamps, or pulverizers wherever there is any possibility

that tramp metal or other foreign objects can be introduced into the manufacturing operations.

13.4.3 Startup Operations. All the machine-processing contact areas shall be thoroughly cleaned and free from water before being charged with metal and placed into operation.

13.4.4 Charging and Discharging.

13.4.4.1 All magnesium powder containers not used for shipping into or out of the plant shall be made of metal.

13.4.4.2 Where magnesium powders are charged to (or discharged from) machines, the containers shall be bonded to the equipment and grounded by a suitable grounding conductor.

13.4.5 Packaging and Storage.

13.4.5.1 Magnesium powder shall be stored in steel drums or other closed conductive containers.

13.4.5.2 The containers shall be tightly sealed and stored in a dry location until ready for shipment or repacking.

13.4.6 In-Plant Conveying of Magnesium Powder.

13.4.6.1 Containers.

13.4.6.1.1* In-plant transfer of powders shall be done in covered conductive containers, as described in Section 13.4.

13.4.6.1.2 Powered industrial trucks shall be selected in accordance with NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*, and consistent with 8.8.1.

13.4.6.1.3 All wheeled containers, hand trucks, and lift trucks shall be grounded.

13.4.7 Pneumatic Conveying. Pneumatic conveying shall be in accordance with Section 9.2.

13.4.8 Ductwork for Conveying Systems. Ductwork for conveying systems shall be in accordance with 9.2.1.

13.4.9 Fan Construction and Arrangement. Fan construction and arrangement shall be in accordance with 9.2.3.

13.4.10 Dust Collectors. Dust collectors shall be in accordance with Chapter 9.

13.5 End Users of Powder. (Reserved)

13.6 Processing.

13.6.1 Machinery and Operations. (Reserved)

13.6.2 Flake and Paste. (Reserved)

13.6.3 Plasma Spray Operations. (Reserved)

13.6.4 Transfer Operations. (Reserved)

13.6.5 Processing Recycled Material. The requirements of Chapter 19 shall apply to processes handling recycled magnesium, which is in a combustible form.

13.7* Machining, Fabrication, Finishing, and Media Blasting.

13.7.1 Hot Work Operations. Hot work operations in facilities covered by this standard shall be in accordance with Section 8.2.

13.7.2 Chip Processing.

13.7.2.1* Magnesium Chips or Powder.

13.7.2.2 Periodic cleaning of magnesium chips from buildings and machinery shall be carried out as frequently as conditions warrant.

13.7.2.3 Chips shall be removed to a safe storage or disposal area.

13.7.2.4 Areas in which flammable and combustible liquids are used shall be in accordance with the requirements of NFPA 30, *Flammable and Combustible Liquids Code*.

13.7.2.5 Smoking shall not be permitted in areas where ignitable magnesium chips are present.

13.7.2.5.1 Areas in which ignitable magnesium chips are present shall be posted with "No Smoking" signs.

13.7.2.5.2 Where smoking is prohibited throughout the entire plant, the use of signage shall be at the discretion of the facility management.

13.7.3 Dust Collection. Dust collection shall be in accordance with Chapter 9.

13.7.4* Machining.

13.7.4.1 Cutting tools shall not be permitted to ride on the metal without cutting, because frictional heat can ignite any fine metal that is scraped off.

13.7.4.1.1 Because frictional heat can ignite any fine metal that is scraped off, the tool shall be backed off as soon as the cut is finished.

13.7.4.1.2 Cutting tools shall be kept sharp and ground with sufficient rake clearance to minimize rubbing on the end and sides of the tool.

13.7.4.2* When drilling deep holes (depth greater than five times the drill diameter) in magnesium, high-helix drills (45 degrees) shall be used to prevent packing of the chips produced.

13.7.4.3 Relief shall be maintained on tools used in grooving and parting operations, because the tool tends to rub the sides of the groove as it cuts.

13.7.4.3.1 Side relief shall be 5 degrees.

13.7.4.3.2 End relief shall be from 10 degrees to 20 degrees.

13.7.4.4 If lubrication is needed, as in tapping or extremely fine grooving, a high-flash point lubricant shall be used.

13.7.4.4.1 Water, water-soluble oils, and oils containing more than 0.2 percent fatty acids shall not be used, because they can generate flammable hydrogen gas.

13.7.4.4.2 Special formulated coolant fluids (water-oil emulsions) that specifically inhibit the formation of hydrogen gas shall be permitted.

13.7.4.5 Where compressed air is used as a coolant, special precautions shall be taken to keep the air dry.

13.7.4.6 All machines shall be provided with a pan or tray to catch chips or turnings.

13.7.4.6.1 The pan or tray shall be installed such that it can be readily withdrawn from the machine in case of fire.

13.7.4.6.2 The pan shall be readily accessible for chip removal and for application of an extinguishing agent to control a fire.

13.7.4.6.3 During magnesium-machining operations, chips shall be removed from the point of generation by continuous or batch removal.

13.7.4.6.3.1 Accumulation of chips at the point of generation shall not exceed 1.4 kg (3 lb) dry weight.

13.7.4.6.3.2 All chips shall be stored in covered noncombustible containers and removed to a storage area in accordance with 13.8.1.

13.7.4.6.4 In case of a fire in the chips, the pan or tray shall be immediately withdrawn from the machine but shall not be picked up or carried away until the fire has been extinguished.

13.7.5 Cleaning.

13.7.5.1 Systematic cleaning of the entire grinding area, including roof members, pipes, conduits, and so on, shall be carried out daily or as often as conditions warrant.

13.7.5.2 Cleaning shall be done using soft brushes and conductive, nonsparking scoops and containers.

13.7.5.3* Vacuum cleaners shall not be used unless they are specifically listed for use with magnesium powder or dusts.

13.7.5.4 Machinery and equipment described in 13.4.2 shall not be used for processing other metals until the entire grinder and the dust collection system are thoroughly cleaned, and the grinding wheel or belt shall be replaced prior to work on other metals.

13.7.6* Grinding Wheels.

13.7.6.1 Wheels used for grinding magnesium castings shall be relocated for dressing.

13.7.6.2 If it is not feasible to move the grinding wheels to a safer location for dressing, the hoods shall be thoroughly cleaned or removed entirely before dressing operations are started, and all deposits of dust on and around the wheel shall be removed before, during, and after dressing.

13.7.6.3 Dust collection equipment shall not have filters or other obstructions that will allow the accumulation of magnesium dust.

13.7.7 Drawing, Spinning, and Stamping.

13.7.7.1 Reliable means to prevent overheating shall be provided where magnesium is heated for drawing or spinning.

13.7.7.2 Clippings and trimmings shall be collected at frequent intervals and placed in clean, dry steel or other noncombustible containers.

13.7.7.3 Fine particles shall be handled according to the requirements of Section 13.4.

13.7.8* Heat Treating.

13.7.8.1 A standard procedure for checking the uniformity of temperatures at various points within heat-treating furnaces shall be established.

13.7.8.2 Furnaces shall be checked prior to use and at regular intervals during use to identify undesirable hot spots.

13.7.8.3* Gas- or oil-fired furnaces shall be provided with combustion safety controls.

13.7.8.4 All furnaces shall have two sets of temperature controls operating independently.

13.7.8.4.1 One set of temperature controls shall maintain the desired operating temperature.

13.7.8.4.2* The other set of temperature controls, operating as a high-temperature limit control, shall cut off fuel or power to the heat-treating furnace at a temperature above the desired operating temperature.



13.7.8.5 Magnesium parts to be put in a heat-treating furnace shall be free of magnesium turnings, chips, and swarf.

13.7.8.6 Combustible spacers on pallets shall not be used in a heat-treating furnace.

13.7.8.7* Aluminum parts, sheets, or separators shall not be included in a furnace load of magnesium.

13.7.8.8 There shall be strict adherence to the heat-treating temperature cycle recommended by the alloy manufacturer.

13.7.8.9* Molten salt baths containing nitrates or nitrites shall not be used for heat-treating magnesium alloys.

13.7.8.10* Magnesium and aluminum metals shall be segregated and easily identified to avoid the possibility of accidental immersion of magnesium alloys in salt baths used for aluminum.

13.7.8.11* Furnaces used to heat magnesium or magnesium alloys shall be inspected and cleaned as necessary to remove any accumulation of loose iron oxide scale.

13.8 Storage and Handling.

13.8.1 Storage of Magnesium Solids.

13.8.1.1* Storage of Pigs, Ingots, and Billets.

13.8.1.1.1 The size of piles of magnesium pigs, ingots, and billets shall be limited.

13.8.1.1.1.1 Minimum aisle widths shall be based on the height of the pile per 13.8.1.1.2.4.

13.8.1.1.1.2 The pile height shall not exceed 7.1 m (20 ft).

13.8.1.1.2 Yard (Outdoor) Storage.

13.8.1.1.2.1 Magnesium ingots shall be carefully piled on firm and generally level areas to prevent tilting or toppling.

(A) Storage areas and yard pavements shall be well drained.

(B) The storage area shall be kept free of grass, weeds, and accumulations of combustible materials.

13.8.1.1.2.2 Combustible flooring or supports shall not be used under piles of ingots.

13.8.1.1.2.3 The quantity of magnesium stored in any pile shall be kept to a minimum.

(A) In no case, other than under the conditions of 13.8.1.1.2.3, shall the amount of magnesium stored exceed 45,400 kg (100,000 lb).

(B) The quantities of magnesium stored shall be permitted to be increased up to a maximum of 454,000 kg (1,000,000 lb) per pile when the following requirements are met:

- (1) Provision has been made for drainage of water away from stored material.
- (2) The aisle widths are equal to the pile height plus 3.1 m (10 ft) but no less than 4.5 m (15 ft).
- (3) The piles are not more than 3.1 m (10 ft) wide.

13.8.1.1.2.4 Aisle width shall be at least one-half the height of the piles and shall be at least 3.1 m (10 ft).

13.8.1.1.2.5 Readily combustible material shall not be stored within a distance of 7.7 m (25 ft) from any pile of magnesium ingots.

13.8.1.1.2.6 An open space equal to the height of the piles plus 3.1 m (10 ft) shall be provided between the stored magnesium ingots and adjoining property lines where combus-

tible material or buildings are exposed or where the adjacent occupancy can provide fire exposure to the magnesium.

13.8.1.1.3* Indoor Storage.

13.8.1.1.3.1 Indoor storage shall be in buildings of noncombustible construction.

13.8.1.1.3.2 Floors shall be well drained to prevent accumulations of water in puddles.

13.8.1.1.3.3 Supports and pallets used under piles of magnesium ingots shall be noncombustible.

13.8.1.1.3.4 The quantity of magnesium ingots stored in any one pile shall be kept to a minimum.

(A) In no case, other than under the conditions of 13.8.1.1.3.4, shall the amount of magnesium stored exceed 23,000 kg (50,000 lb).

(B) The quantities of magnesium stored shall be permitted to be increased up to a maximum of 227,800 kg (500,000 lb) per pile when the following requirements are met:

- (1) The piles are not more than 3.1 m (10 ft) wide.
- (2)*The building is sprinklered if combustible materials are stored without the benefit of separation by fire wall or fire barrier wall from the magnesium storage.

13.8.1.1.3.5 Aisle widths shall comply with 13.8.1.1.2.4.

13.8.1.1.3.6 Combustible material shall not be stored within a distance of 7.7 m (25 ft) from any pile of magnesium pigs, ingots, and billets.

13.8.1.2 Storage of Heavy Castings.

13.8.1.2.1 Except under the conditions of 13.8.1.2.2, buildings used for the storage of heavy magnesium castings shall be of noncombustible construction.

13.8.1.2.2 Storage shall be permitted in buildings of combustible construction if the buildings are fully protected by an automatic sprinkler system.

13.8.1.2.3* Floors shall be of noncombustible construction and shall be well drained to prevent accumulations of water in puddles.

13.8.1.2.4 All magnesium castings shall be clean and free of chips or fine particles of magnesium when being stored.

13.8.1.2.5 Storage Piles.

13.8.1.2.5.1 The size of storage piles of heavy magnesium castings, either in cartons or crates or free of any packing material, shall be limited to 36 m³ (1270 ft³).

13.8.1.2.5.2 Aisles shall be maintained to allow inspection and effective use of fire protection equipment.

13.8.1.2.6 Aisle width shall be at least one-half the height of the piles and shall be at least 3.1 m (10 ft).

13.8.1.2.7* Automatic sprinkler protection shall be permitted to be installed in magnesium storage buildings where combustible cartons, crates, or other packing materials are present.

13.8.1.3 Storage of Light Castings.

13.8.1.3.1 Building Construction.

13.8.1.3.1.1 Except under the conditions of 13.8.1.3.1.2, light magnesium castings shall be stored in noncombustible buildings and shall be segregated from other storage by 7.7 m (25 ft).