

NFPA® 484

Standard for Combustible Metals

2012 Edition



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NFPA® 484

Standard for

Combustible Metals

2012 Edition

This edition of NFPA 484, *Standard for Combustible Metals*, was prepared by the Technical Committee on Combustible Metals and Metal Dusts and acted on by NFPA at its June Association Technical Meeting held June 12–15, 2011, in Boston, MA. It was issued by the Standards Council on August 11, 2011, with an effective date of August 31, 2011, and supersedes all previous editions.

This edition of NFPA 484 was approved as an American National Standard on August 31, 2011.

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, house-keeping, 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 contains the following changes:

- (1) A unified format has been applied for chapter-to-chapter consistency for the individual combustible metals in the document.
- (2) New definitions have been 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 has also been added. The Committee clarified when the standard would apply rather than when the standard would not apply. New information has been included in Chapter 16 to clarify the testing and classification of potentially combustible metals.
- (3) Management of change requirements has been added to chapters where it was not previously identified as a requirement.

- (4) New information has been included on wet dust collection systems. Additional information has been added addressing housekeeping, an important issue for the prevention of fires and explosions. Personal protective equipment (PPE) requirements have been identified.
- (5) Chapter 15, Fire Prevention, Fire Protection, and Emergency Response, remains retroactive for all of the specific metal chapters and for the general metal chapter.
- (6) Chapter 16, Combustible Metal Recycling Facilities, is retroactive. Additional information has been added to address emergency response requirements.
- (7) Hazard analysis requirements are now applicable to all metal chapters.
- (8) A new chapter on performance-based design has been added.



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

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex J. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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, that exhibit combustion characteristics of alkali metals, aluminum, magnesium, tantalum, titanium, or zirconium 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, including scrap, that do not exhibit combustion characteristics of alkali metals, aluminum, magnesium, niobium, tantalum, titanium, or zirconium are subject to the requirements of Chapter 14.

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

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

1.1.7 This standard shall apply to laboratories that handle, use, or store more than 0.23 kg ($\frac{1}{2}$ lb) of alkali metals or 0.907 kg (2 lb) aggregate of other combustible metals, excluding alkali metals.

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

1.1.9* If the quantity of a combustible metal listed in Table 1.1.9 is exceeded in an occupancy, the requirements of this document shall apply.

Table 1.1.9 Applicability Thresholds by Occupancy

Occupancy Class (as defined in NFPA 5000)	Threshold Quantity (kg)	Threshold Quantity (lb)
Assembly	0.454	1
Educational	0.907	2
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	0
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 document shall be considered necessary to provide a reasonable level of protection from loss of life and property from fire and explosion.

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

1.3.3 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 15 and 16 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*, 2012 edition.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2010 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2010 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2012 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*, 2009 edition.

NFPA 54, *National Fuel Gas Code*, 2012 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2007 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2008 edition.

NFPA 70®, *National Electrical Code®*, 2011 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2010 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2011 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®*, 2012 edition.

NFPA 220, *Standard on Types of Building Construction*, 2012 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2012 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 2008 edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*, 2011 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*, 2006 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*, 2011 edition.

NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, 2008 edition.

NFPA 2113, *Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, 2012 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2012 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*, 2011.

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

ASTM E 1226, *Standard Test Method for Explosibility of Dust Clouds*, 2010.

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: Model Regulations — Manual of Tests and Criteria, 13th edition.

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*, 1991, Butterworth-Heinemann Ltd Oxford, UK.

Explosibility of Metal Powders, Report of Investigations (RI) 6516, date 1964, BuMines, US Dept. of Interior, DC.

GESTIS-DUST-EX, 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*, 2007 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2008 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*, 2006 edition.

NFPA 921, *Guide for Fire and Explosion Investigations*, 2011 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2012 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 shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

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 3.3.31.3.

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, 2007]

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, 2006]

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, 2008]

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, 2012]

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.

3.3.27* 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, 2006]

3.3.28* 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.

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

3.3.29.1 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.

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

3.3.30.1 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.

3.3.31 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.

3.3.31.1* Aluminum Flake Powder. See 3.3.31.3.

3.3.31.2 Aluminum Granular Powder. See 3.3.31.3.

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

3.3.31.4* 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.

3.3.31.5 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.

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

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

3.3.33 Pyrophoric Material. See 3.3.23.2.

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

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

3.3.35.1* Magnesium Ribbon. Magnesium metal that is less than 3.2 mm (1/8 in.) in two dimensions or less than 1.3 mm (1/16 in.) in single dimension, also considered a powder for the purposes of this standard.

3.3.36 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 E 176, 2010 Modified]

3.3.37 Spark-Resistant Material. See 3.3.23.3.

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

3.3.39 Spontaneous Heating. Process whereby a material increases in temperature without drawing heat from its surroundings. [921, 2008]

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

3.3.41 Tantalum Powder. See 3.3.31.5.

3.3.42 Tantalum Ultrafines. (Reserved)

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

3.3.44 Titanium Fines. (Reserved)

3.3.45 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 4.2 or in Section 4.3 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.

4.1.6 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 Determination of Combustibility.

4.2.1* 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.

4.2.2 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

4.2.3 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 smolder-

ing, the test material shall be considered to be in a noncombustible form.

4.2.4* 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.

4.2.5* 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.

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

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

4.3 Determination of Explosibility.

4.3.1* The determination of explosibility of metals, metal powders, metal dusts, and alloys of these materials shall be determined by using the flow chart in Figure 4.3.1.

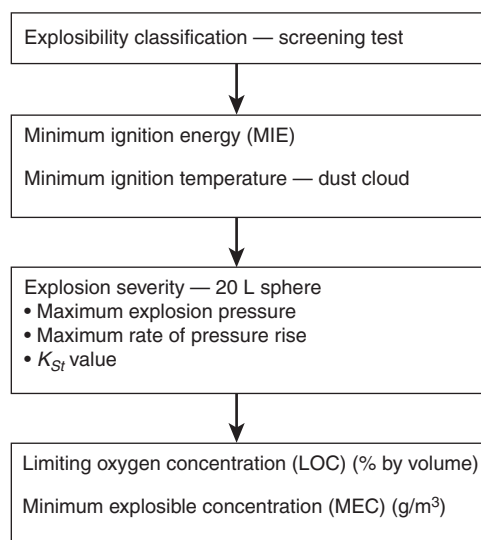


FIGURE 4.3.1 Determination of Explosibility.

4.3.2* 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.

4.3.3* 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.

4.3.4* The explosibility classification screening tests shall be conducted in accordance with ASTM E 1226, *Standard Test Method for Explosibility of Dust Clouds*.

4.4 Risk Evaluation. Where a risk evaluation (see Annex I) is required by the AHJ, the following data shall be determined:



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

Chapter 5 Determination of Dust Explosion Hazard Areas and Flash-Fire Hazard Areas

5.1 Dust Explosion and Flash-Fire Hazard Areas.

5.1.1 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, Chapters 7 through 14, and Chapter 15.

5.1.2 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.

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

5.2.1 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.

5.2.2 Use of Segregation.

5.2.2.1 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.

5.2.2.2 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*.

5.2.2.3 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.

5.2.3 Use of Separation.

5.2.3.1* 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

5.2.3.2 Where separation is used to limit the dust flash-fire hazard area, in no case shall the required separation distance determined in 5.2.3.1 be less than 9 m (30 ft).

5.2.3.3 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.

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

5.2.3.5 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 Performance-Based Design Option

6.1 General Requirements.

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

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

6.1.3 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*.

6.1.3.1* 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.

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

6.1.4* 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.

6.1.5 Sources of Data.

6.1.5.1 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.

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

6.2 Design Objectives.

6.2.1 Life Safety.

6.2.1.1 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.

6.2.1.2 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.

6.2.2 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.

6.2.3* 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.

6.2.4 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.

6.2.4.1* 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.

6.2.4.2 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.

6.3 Performance Criteria. A system and facility design shall be deemed to meet the objectives specified in Section 6.2 if its performance meets the criteria in 6.3.1 through 6.3.5.

6.3.1 Life Safety.

6.3.1.1 The life safety objectives of 6.2.1 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.

6.3.1.2 The life safety objectives of 6.2.1 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.

6.3.1.3 The life safety objectives of 6.2.1 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.

6.3.2 Structural Integrity. The structural integrity objective of 6.2.2 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.

6.3.3 Mission Continuity. The mission continuity objectives of 6.2.3 shall be achieved when damage to equipment and the facility has been limited to a level of damage acceptable to the owner/operator.

6.3.4 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.

6.3.5 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

6.4* Design Scenarios.

6.4.1 Fire Scenarios.

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

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

6.4.1.3 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.

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

6.4.1.5 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.

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

6.4.1.7 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.

6.4.2 Explosion Scenarios.

6.4.2.1 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.



6.4.2.2 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.

6.4.2.3 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.

6.4.2.4 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.

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

6.5 Evaluation of Proposed Design.

6.5.1* General. A proposed design's performance shall be assessed relative to each performance objective in Section 6.2 and each applicable scenario in Section 6.4, with the assessment conducted through the use of appropriate calculation methods acceptable to the authority having jurisdiction.

6.5.2 The design professional shall establish numerical performance criteria for each of the objectives in Section 6.2.

6.5.3 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.

6.6 Retained Prescriptive Requirements. (Reserved)

Chapter 7 Alkali Metals

7.1* General Provisions.

7.1.1 Retroactivity. The requirements of 7.1.2 through 7.1.4 shall apply to new and existing facilities.

7.1.2 Housekeeping.

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

7.1.3 Personal Protective Equipment (PPE).

7.1.3.1* PPE for Handling Solid Alkali Metals.

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

7.1.3.1.2 Personnel shall wear gloves while handling solid alkali metals.

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

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

7.1.3.2* PPE for Handling Molten Alkali Metals.

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

7.1.3.2.2 While handling molten alkali metals, personnel shall wear safety glasses and face shields.

7.1.3.2.3 Gloves shall be worn and shall be loose fitting, easily removable, and compatible with the hazards of molten alkali metals.

7.1.3.2.4 All clothing shall be loose fitting, easily removable, flame resistant, and compatible with the hazards of molten alkali metals.

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

7.1.3.2.6 Protective footwear shall be appropriate for the hazards of molten alkali metals.

7.1.4 Reactivity.

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

7.1.4.2 Eutectic Reactions. (Reserved)

7.1.5* Management of Change.

7.1.5.1 The requirements of 7.1.5.2 through 7.1.5.5 shall apply to new and existing facilities and processes.

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

7.1.5.3 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

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

7.1.5.5 Design documentation shall be updated to incorporate the change.

7.1.6 Alternative Methodologies. (Reserved)

7.1.7 Test Results. (Reserved)

7.1.8 Other.

7.2* Facility Design Requirements.

7.2.1 Building Construction.

7.2.1.1 Section 7.2 shall apply to buildings or portions of buildings that are dedicated to the handling, processing, or storage of solid or molten alkali metal.

7.2.1.2 Noncombustible Materials.

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

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

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

7.2.1.4* Roof decks shall be watertight.

7.2.1.5 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*.

7.2.1.6* 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.

7.2.1.7* Floor drains shall not be permitted.

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

7.2.1.8.1 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.

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

7.2.1.9 Separation from Water.

7.2.1.9.1* 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.

7.2.1.9.1.1 Water pipes required for safety operations shall be permitted.

7.2.1.9.1.2 Piping permitted by 7.2.1.9.1.1 shall be equipped with an emergency shutoff that is identified and located outside the area.

7.2.1.9.1.3 Piping permitted by 7.2.1.9.1.1 shall be constructed of steel.

7.2.1.9.2 A sprinkler system(s) deemed appropriate in accordance with 15.3.2 shall be permitted.

7.2.1.9.3 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.

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

7.2.1.10* Ventilation.

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

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

7.2.1.11 NFPA Hazard Identification Markings.

7.2.1.11.1 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.

7.2.1.11.2 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*.

7.2.2 Fire Protection.

7.2.2.1 Fire Protection. Fire protection shall be established in accordance with Chapter 15.

7.2.2.2* 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 15.

7.2.3 Electrical Classification. (Reserved)

7.2.4 Dust Collection. (Reserved)

7.2.5 Hazard Analysis.

7.2.5.1* 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 or explosion hazards.

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

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

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

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

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

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

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

7.3 Primary Metal Production.

7.3.1 Reduction. (Reserved)

7.3.2 Melting and Casting.

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

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

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

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

7.3.2.4 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.

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

7.3.2.6 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.

7.3.3 Refining. (Reserved)

7.4 Powder Production. (Reserved)

7.5 End Users of Powder. (Reserved)

7.6 Processing and Handling.

7.6.1 Machinery and Operations.

7.6.1.1* 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.

7.6.1.2 Moisture Protection.

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

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

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

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

7.6.1.3 Machining and Operations. (Reserved)

7.6.2 Flake and Paste. (Reserved)

7.6.3 Plasma Spray Operations. (Reserved)

7.6.4 Transfer Operations.

7.6.4.1 General Precautions.

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

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

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

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

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

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

7.6.4.1.6* 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.

7.6.5 Processing Recycled Material. (Reserved)

7.7 Machining, Fabrication, and Finishing.

7.7.1 Hot Work Operations.

7.7.1.1* No open flames, electric or gas cutting or welding operations or equipment, grinding, or other spark-producing operations or equipment shall be permitted in any section of the building where alkali metals are present unless approved hot-work procedures are followed by qualified personnel.

7.7.2 Chip Processing. (Reserved)

7.7.3 Dust Collection. (Reserved)

7.8 Storage and Handling.

7.8.1* Storage of Product.

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

7.8.1.2 Storage of Solid or Molten Alkali Metals.

7.8.1.2.1 General Precautions.

7.8.1.2.1.1* 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.

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

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

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

7.8.1.3 Solid Alkali Metals Storage.

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

7.8.1.3.2 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.

7.8.1.3.3 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.

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

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

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

7.8.1.3.4.3 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.

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

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

7.8.1.4 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.

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

7.8.2.1 NFPA Hazard Identification Markings.

7.8.2.1.1 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.

7.8.2.1.2 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*.

7.8.3 Recycling.

7.8.4 Chip Processing. (Reserved)

7.9* Fire and Explosion Protection.

7.9.1 Fire and explosion protection shall be in accordance with Chapter 15.

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

7.9.2 Housekeeping.

7.9.2.1 Dust Control. (Reserved)

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

7.9.3 Control of Ignition Sources.

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

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

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

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

7.9.3.1.4 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.

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

7.9.4* Hot Work Operations.

7.9.4.1 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 7.9.4.

7.9.4.2 Hot-work permits shall be required in areas that contain combustible metals or combustible metal powders, fines, dust, or sponge.

7.9.4.3 Open flames, cutting or welding operations, 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.

7.9.4.4 All hot-work areas that require a permit shall be thoroughly cleaned of combustible metals or exposed combustible metal powders, fines, dust, or sponge before hot work is performed.

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

7.9.5 Control of Combustible Materials.

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

7.9.5.1.1 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).

7.9.5.1.2 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*.

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

7.9.5.2 Ordinary Combustible Storage.

7.9.5.2.1 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.

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

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

7.9.5.3.1 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.

7.9.5.3.2 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.

7.9.6 Inspection, Maintenance, and Training. (Reserved)

7.10 Other. (Reserved)

Chapter 8 Aluminum

8.1 General Provisions.

8.1.1 Retroactivity. The requirements of 8.1.2 through 8.1.4 shall apply to new and existing facilities where aluminum dusts, pastes, and/or powders are produced or handled.

8.1.1.1 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.

8.1.2 Housekeeping.

8.1.2.1 Cleanup Procedures for Fugitive Dust Accumulations.

8.1.2.1.1* Fugitive dust shall not be allowed to accumulate.

8.1.2.1.2 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 8.1.2.3

8.1.2.2 Cleanup of Spilled Aluminum Powder.

8.1.2.2.1 Spills shall be removed at once, using conductive scoops and soft bristle brushes having natural fiber bristles. Scoops shall be nonsparking unless otherwise authorized for the specific application.

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

8.1.2.3* Vacuum Cleaning Systems.

8.1.2.3.1 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.

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

8.1.2.3.3* Due to the inherent hazards associated with the use of fixed and portable vacuum cleaning systems for finely divided combustible aluminum dust, special engineering consideration shall be given to the design, installation, maintenance, and use of such systems.

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

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

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

8.1.2.3.5.1 Assembled components shall be conductive, and bonded where necessary.

8.1.2.3.5.2 Periodic tests for continuity shall be performed.

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

8.1.2.4 Compressed Air Cleaning Requirements. Compressed air blowdown shall not be permitted, except only in certain areas that are otherwise impossible to clean by vacuuming or other means.

8.1.2.4.1 Where permitted, compressed air blowdown shall be performed under carefully controlled conditions, with all potential ignition sources prohibited in or near the area and with all equipment shut down.

8.1.2.4.2 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.

8.1.2.5 Water-Cleaning Requirements. 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.

8.1.2.6 Cleaning Frequency.

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

8.1.2.6.2 Regular, periodic cleaning of buildings and machinery, with all machinery idle and power off, shall be carried out as frequently as conditions warrant.

8.1.2.6.3 Regular, periodic cleaning of fugitive metal dust from buildings and machinery shall be carried out as frequently as conditions warrant.

8.1.2.6.4 Fugitive metal dust shall be removed to a designated storage or disposal area.

8.1.3* Personal Protective Equipment (PPE).

8.1.3.1 Outer clothing shall be clean, flame retardant, and non-static generating where combustible aluminum dust is present, and shall be designed to be easily removable.

8.1.3.1.1 Tightly woven, smooth fabrics treated with a flame-retardant chemical and from which dust can readily be brushed shall be used if necessary.

8.1.3.1.2 Wool, silk, or synthetic fabrics that can accumulate high static electric charges shall not be used.

8.1.3.2 Work clothing shall be designed to minimize the accumulations of combustible aluminum dust (e.g., trousers shall not have cuffs).

8.1.3.3* Safety shoes shall be static-dissipating, where necessary, shall have no exposed metal, and shall be appropriate for the type of operation taking place.

8.1.3.4* Clothing Fires.

8.1.3.4.1 Emergency procedures for handling clothing fires shall be established.

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

8.1.4 Reactivity.

8.1.4.1 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.

8.1.4.2 Contact with Water.

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

8.1.4.3 Thermite Reaction.

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

8.1.4.4 Eutectic Reactions. (Reserved)

8.1.5* Management of Change.

8.1.5.1 The requirements of 8.1.5.2 through 8.1.5.5 shall apply to new and existing facilities and processes.

8.1.5.2 Written procedures shall be established and implemented to manage a proposed change to process materials, technology, equipment, procedures, and facilities.

8.1.5.3 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

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

8.1.5.5 Design documentation shall be updated to incorporate the change.

8.2 Facility Design Requirements.

8.2.1 Building Construction.

8.2.1.1 Location of Aluminum Powder Production Plants.

8.2.1.1.1 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.

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

8.2.1.2 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.

8.2.1.3 The buildings specified in 8.2.1.2 shall be designed so that all internal surfaces are readily accessible, to facilitate cleaning.

8.2.1.4 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.

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

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

8.2.1.7 The requirements of 8.2.1.6 shall also apply to elevated platforms, balconies, floors, and gratings.

8.2.1.8 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.

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

8.2.1.10 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.

8.2.1.11 Roof decks and basements shall be watertight.

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

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

8.2.1.14 Door and Window Construction.

8.2.1.15 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*.

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

8.2.1.17 Enclosed Passageways.

8.2.1.17.1* 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*.

8.2.1.17.2 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*.

8.2.1.18 Grounding and Lightning Protection.

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

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



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

8.2.1.19 Heating and Cooling of Aluminum Powder-Production Buildings.

8.2.1.19.1 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.

8.2.1.19.2 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.

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

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

8.2.1.19.5 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.

8.2.1.19.6 The requirements of 8.2.1.19.1 through 8.2.1.19.5 shall not apply to areas where aluminum metal is melted.

8.2.1.20 Electrical Power and Control.

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

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

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

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

8.2.1.20.5 All manufacturing buildings shall be provided with emergency lighting systems in accordance with Section 7.9 of NFPA 101, *Life Safety Code*.

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

8.2.1.20.7* Electrical equipment and components shall be inspected and cleaned at least once each year or more frequently if conditions warrant.

8.2.1.20.8 The accumulation of aluminum powder inside electrical equipment and components shall be mitigated.

8.2.2 Fire Protection.

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

8.2.2.1.1* 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.

8.2.2.1.2 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.

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

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

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

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

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

8.2.2.2.2 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."

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

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

8.2.2.2.3.2 Halogenated extinguishing agents shall not be used.

8.2.2.2.4* Solvent-Wetted Powders.

8.2.2.2.4.1 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.

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

8.2.2.2.5 Carbon Dioxide Use.

8.2.2.2.5.1* 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.

8.2.2.2.5.2 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.

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

8.2.2.3 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.

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

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

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

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

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

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

8.2.2.4 Automatic Sprinkler Protection.

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

8.2.2.4.1.1* 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.

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

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

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

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

8.2.2.5 Fire Fighting.

8.2.2.5.1 Incipient Fire Fighting. Facilities handling finely divided aluminum shall develop a response plan for fighting fires, in accordance with Chapter 15.

8.2.3 Electrical Classification.

8.2.3.1* In local areas of a plant where a hazardous quantity of 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*.

8.2.3.2 Offices and similar areas within the aluminum powder–manufacturing building that are segregated and free from aluminum dust shall not be classified.

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

8.2.4 Dust Collection.

8.2.4.1 Dust collection for aluminum powder production operations shall follow the requirements of 8.4.6.

8.2.4.2 Dust collection for machining, fabrication, and finishing operations shall follow the requirements of 8.7.3.

8.2.5 Hazard Analysis.

8.2.5.1* 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 or explosion hazards.

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

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

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

8.2.5.5 Written records shall be maintained of all hazard analyses.

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

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

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

8.3 Primary Metal Production.

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

8.3.2 Melting and Casting. (Reserved)

8.3.3 Refining. (Reserved)

8.4 Aluminum Powder Production.

8.4.1 Handling and Conveying of Aluminum Powder.

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

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

8.4.1.3 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.

8.4.1.4 Each container for aluminum powders shall be conductive and covered while in storage or in transit.

8.4.1.5 When aluminum powders are being charged to or discharged from machines, the containers shall be bonded to the grounded machine.

8.4.1.6 When aluminum powder is being transferred between containers, the containers shall be bonded and at least one of the containers shall be grounded.

8.4.2 Portable Containers.

8.4.2.1 In-plant transport of aluminum powders shall be done in covered conductive containers as described in 8.4.1.4.

8.4.3 Ductwork for Pneumatic Conveying Systems. Conveyor ducts shall be fabricated of nonferrous spark-resistant metal or spark-resistant stainless steel.

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

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

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



8.4.3.4 A minimum conveying velocity of 1372 m/min (4500 ft/min) 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.

8.4.3.5* If the conveying gas is air, the aluminum-to-air ratio throughout the conveying system shall be held below the minimum explosible concentration (MEC) of the combustible aluminum dust at normal operating conditions.

8.4.3.6* Deflagration venting such as rupture diaphragms shall be provided on ductwork.

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

8.4.3.6.2 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.

8.4.3.7 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 to withstand a suddenly applied gauge pressure of at least 690 kPa (100 psi).

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

8.4.4 Conveying Using an Inert Medium.

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

8.4.4.2* The inert gas used shall be based on such gases as argon, carbon dioxide, helium, nitrogen, or flue gas and shall have a limiting oxygen concentration (LOC) determined by test to be appropriate to the inert gas except that, where the aluminum powder is never exposed to air, the oxygen content shall be permitted to be zero.

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

8.4.4.4 The inert gas stream shall be continuously monitored for oxygen content and shall be arranged to sound an alarm if the oxygen content is not within the prescribed range.

8.4.4.5 A minimum conveying velocity of 1372 m/min (4500 ft/min) 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.

8.4.4.6 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.

8.4.5 Fan and Blower Construction and Arrangement.

8.4.5.1* Blades and housings of fans used to move air or inert gas in conveying ducts shall be constructed of conductive, nonsparking metal such as bronze, nonmagnetic stainless steel, or aluminum.

8.4.5.2 The design of the fan or blower shall not allow the transported aluminum powder to pass through the fan before entering the final collector, unless the aluminum powder-conveying system is inerted.

8.4.5.3 Personnel shall not be permitted within 15 m (50 ft) of the fan or blower while it is operating, except as provided in 8.4.5.3.2 and 9.4.9.2.2.

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

8.4.5.3.2 If personnel approach the fan or blower while it is operating, such as for a pressure test, 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 aluminum powder cut off.

8.4.5.4* 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.

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

8.4.5.5.1 Bearings shall be equipped with temperature-indicating devices.

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

8.4.5.6 Fans or blowers shall be electrically interlocked with powder-producing machinery so that the machines are shut down if the fan stops.

8.4.6 Powder Collection.

8.4.6.1* Collectors.

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

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

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

8.4.6.1.3 Collectors shall be constructed of metal to allow dissipation of static electricity.

8.4.6.1.4 Ductwork shall comply with the provisions of 8.4.3.

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

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

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

8.4.6.1.7.1 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.

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

8.4.6.1.8 Repairs.

8.4.6.1.8.1 Where repairs on dry-dust collectors are necessary, the collectors shall be emptied and residual accumulations of dust thoroughly removed. (See 8.1.2.2 and 8.9.4.)

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

8.4.6.2 High-Temperature Warning.

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

8.4.6.2.2 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.

8.4.6.2.3 The devices specified in 8.4.6.2.2 shall give audible and visual alarms at normally attended locations.

8.4.6.3* Collector Filter Medium. Collector filter medium made from synthetic fabrics that accumulate static electric charges shall not be used.

8.5 End Users of Powder.

8.5.1 Aluminum Powder Handling and Use.

8.5.1.1 Scope. The provisions of Section 8.5 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.

8.5.1.2 Storage. Dry aluminum powder and aluminum paste shall be stored in accordance with the provisions of 8.8.1.

8.5.1.3* Handling. The requirements of Section 8.5 shall apply to both regular and “nondusting” grades of aluminum powder, as well as to aluminum paste.

8.5.1.4 Where aluminum powder or paste is used or handled, good housekeeping practices shall be maintained in accordance with 8.1.2.

8.5.1.5 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.

8.5.1.6 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 8.2.3.1.

8.6 Processing.

8.6.1 Machining and Operations.

8.6.1.1 Requirements for Machinery.

8.6.1.2 All combustible aluminum dust-producing machines and conveyors shall be designed, constructed, and operated so that fugitive dust is minimized.

8.6.1.3 All machinery and equipment shall be installed in accordance with NFPA 70, *National Electrical Code*.

8.6.1.4* All machinery shall be bonded and grounded to minimize accumulation of static electric charge.

8.6.1.5 Bearings.

8.6.1.5.1* Ball or roller bearings shall be sealed against dust.

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

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

8.6.1.7 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.

8.6.1.8 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.

8.6.2 Flake and Paste.

8.6.2.1 Machinery and Operations.

8.6.2.1.1* Wet Milling of Aluminum Powder. The requirements of 8.6.2.1.1.1 through 8.6.2.1.1.6 shall not apply to machining and rolling operations.

8.6.2.1.1.1* 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.

8.6.2.1.1.2* 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.

8.6.2.1.1.3 The dew point of the atmospheres in 8.6.2.1.1.1 and 8.6.2.1.1.2 shall be maintained below the point where condensation occurs.

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

8.6.2.1.1.5* 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.

8.6.2.1.1.6 Solvent or slurry pumps shall be installed with controls that ensure that a flow exists and that the pumps run with safe operating temperatures.

8.6.2.2 Electrical Equipment.

8.6.2.2.1 All electrical wiring and equipment shall conform to the provisions of NFPA 70, *National Electrical Code*.

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

8.6.2.2.3* Wet solvent milling areas or other areas where combustible or flammable liquids are present shall be classified where applicable, in accordance with Article 500 of NFPA 70, *National Electrical Code*, with the exception of control equip-



ment meeting the requirements of NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*.

8.6.3 Plasma Spray Operations.

8.6.3.1 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 medium in the collector.

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

8.6.3.3 In local areas of a plant where a hazardous quantity of 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*.

8.6.4 Transfer Operations.

8.6.4.1* 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.

8.6.4.2 Prevention of Fugitive Dust Accumulations. See 8.1.2.

8.6.5 Processing Recycled Material. The requirements of Chapter 16 shall apply to processes handling recycled aluminum, which is in a combustible form.

8.7* Machining, Fabrication, and Finishing.

8.7.1 Hot Work Operations.

8.7.1.1 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*.

8.7.1.2 General Precautions.

8.7.1.2.1 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.

8.7.1.2.2 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.

8.7.1.3 Electrical Equipment.

8.7.1.3.1 All electrical wiring and equipment shall conform to the provisions of *NFPA 70, National Electrical Code*.

8.7.2 Chip Processing.

8.7.2.1 Machining and Sawing Operations.

8.7.2.2* Cutting tools shall be of proper design and shall be kept sharp for satisfactory work with aluminum.

8.7.2.3* Sawing, grinding, and cutting equipment shall be grounded.

8.7.2.4 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.

8.7.2.5 Coolant.

8.7.2.5.1 Nonflammable coolants shall be used for wet grinding, cutting, or sawing operations.

8.7.2.5.2 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.

8.7.3* Dust Collection.

8.7.3.1* Machines that produce fine particles of aluminum 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.

8.7.3.2 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.

8.7.3.3* 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.

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

8.7.3.5* Dry-type dust collectors shall be located outside of buildings.

8.7.3.5.1* Individual machines with portable dust collection capability 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 8.7.3.5.1.1 through 8.7.3.5.1.4.

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

8.7.3.5.1.2 Personal protective clothing shall comply with 8.1.3.

8.7.3.5.1.3 The collector shall be designed to dissipate static electricity.

8.7.3.5.1.4 Collector retention capacity shall be limited to 0.45 kg (1 lb).

8.7.3.5.2* Dry-type collectors shall be provided with barriers or other means for protection of personnel.

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

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

8.7.3.6* Dust collection systems shall be dedicated to the collection of aluminum or aluminum alloy dust only.

8.7.3.6.1 Grinders, buffers, and associated equipment with dust collectors utilized for processing aluminum shall be provided with a placard that reads as follows:

WARNING: Aluminum Metal Only — Fire or Explosion Can Result with Other Metals.

8.7.3.6.2 If the combustible aluminum dust collection system is to be used for other materials, the system shall be disassembled and thoroughly cleaned of all incompatible materials prior to and after its use.

8.7.3.7* Bonding and Grounding.

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

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

8.7.3.8 Electrostatic collectors shall not be used.

8.7.3.9* Dust-collecting filter medium shall be designed to be conductive so as to dissipate static electric charges.

8.7.3.10 Dry-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.

8.7.3.11 The accumulation or condensation of water at any point in the dry-dust collection system shall be prevented.

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

8.7.3.12.1 Extreme care shall be taken in removing dust from the collectors, to avoid creating dust clouds.

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

8.7.3.13* Dry Collectors.

8.7.3.13.1 Dry collectors used for combustible aluminum dust shall be provided with deflagration vents.

8.7.3.13.2 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.

8.7.3.13.3 Material removed from the dry-type dust 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, shall be recycled or disposed of in accordance with local, state, and federal regulations.

8.7.3.14 Where repairs on dry-dust collectors are necessary, the collectors shall be emptied and residual accumulations of dust thoroughly removed (*see 8.1.2 and 8.9.4*). Ductwork leading into the collector shall be disconnected and blanked off before repair work is permitted to be started.

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

8.7.3.16 The dust collector shall be arranged so that contact between dust particles and parts moving at high speeds is prevented. The blower for drawing the dust-laden air into the collector shall be located on the clean air side of the collector.

8.7.3.17 Recycling of exhaust air from dry-dust collectors into buildings shall be prohibited.

8.7.3.18 All electrical wiring and equipment shall conform to the provisions of *NFPA 70, National Electrical Code*.

8.7.3.19 Dust Collection Ducts and Ductwork.

8.7.3.19.1 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*.

8.7.3.19.2 Ducts shall be designed to maintain a velocity of not less than 1372 m/min (4500 ft/min) 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).

8.7.3.19.3* Ducts shall be designed to handle a volumetric flow rate that maintains dust loading safely below the MEC.

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

8.7.3.19.5 Duct Construction.

8.7.3.19.5.1 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.

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

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

8.7.3.19.5.4 Additional branch ducts shall not be added to an existing system without redesign of the system.

8.7.3.19.5.5 Branch ducts shall not be disconnected.

8.7.3.19.5.6 Unused portions of the system shall be blanked off without means being provided to maintain required airflow.

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

8.7.3.20 Reserved.**8.7.3.21 Wet-Type Dust Collectors.**

8.7.3.21.1* The exhaust vent shall terminate to a safe location outside the building and shall be securely fastened except as provided in 8.7.3.21.1.1.

8.7.3.21.1.1 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 safety 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. (*See 8.2.2.1.1 and 8.1.5*.)

8.7.3.21.1.2 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.

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

8.7.3.21.3 Arrangement of Wet-Type Dust Collector Components.

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

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

8.7.3.21.3.3* 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.

8.7.3.21.3.4* Collector Sump Venting.

(A) The sump of water wet-type dust collectors shall be ventilated at all times.

(B) Vents shall remain open and unobstructed when the machine is shut down.

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

8.7.3.21.3.5* Power Supply.

(A)* 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.

(B) A time delay switch or equivalent device shall be provided on the dust-producing equipment to prevent the starting of its motor drive until the collector is in complete operation.

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

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

(B)* Covered, vented metal containers shall be used to transport the collected sludge for disposal.

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

(D) 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 aluminum) in a volume ratio of five parts inert material to one part metal dust.

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

(F) Smoking or open flames shall be prohibited in the disposal area and throughout the disposal process.

8.8 Storage and Handling.

8.8.1 Storage of Aluminum Powder. When aluminum powder is stored in sealed containers, the procedures of 8.8.1.1 through 8.8.1.7 shall apply.

8.8.1.1 Containers from which a portion of powder has been removed shall be carefully covered and resealed.

8.8.1.2 Containers shall be kept free of contact with water or moisture.

8.8.1.3 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.

8.8.1.4* Aluminum powder shall be segregated from incompatible materials and combustible materials.

8.8.1.5 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.

8.8.1.5.1 Stacked storage shall be arranged to ensure stability.

8.8.1.5.2 Aisles shall be provided for maneuverability of material-handling equipment, for ready accessibility, and to facilitate incipient fire-fighting operations.

8.8.1.6 Leakage or condensation from roof, floor, walls, drains, steam, water lines, or radiators shall be avoided.

8.8.1.7 Smoking and open flames shall be prohibited in areas where aluminum powder is stored.

8.8.1.8 Powered industrial trucks used for on-site transportation 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 8.2.3.1.

8.8.2 Scrap Handling, Storage, and Disposal. (Reserved)

8.8.3 Recycling.

8.8.3.1 Where a recycling facility handles aluminum in a combustible form, the requirements of Chapter 16 shall apply.

8.8.4 Chip Processing. (Reserved)

8.9 Fire and Explosion Protection.

8.9.1 Scope. Section 8.9 shall apply to new and existing facilities where combustible aluminum dusts, pastes, and powders are present.

8.9.1.1 Fire and explosion protection shall be in accordance with Chapter 15.

8.9.2 Housekeeping.

8.9.2.1 Dust Control. Refer to 8.1.2.

8.9.3 Control of Ignition Sources.

8.9.3.1 No smoking, open flames, electric or gas cutting or welding equipment, or spark-producing operations shall be permitted in the areas where wetted sludge is produced or handled, including the disposal area.

8.9.3.2 Cutting, welding, or spark-producing operations shall be permitted only in the areas where all machinery is shut down and where the area is thoroughly cleaned and inspected to ensure the removal of all accumulations of combustible aluminum dust.

8.9.3.3 Lockout/tagout procedures shall be followed for the shutdown of machinery.

8.9.3.4 Smoking materials, matches, and lighters shall not be carried or used by employees or visitors on the premises adjacent to or within any building in which combustible aluminum dust is present.

8.9.3.5* 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.

8.9.3.6 Nonsparking tools shall be used to make repairs or adjustments on or around any machinery or apparatus where combustible aluminum dust is present.

8.9.3.7 Dressing of grinding wheels shall not be conducted when the airflow across the grinding wheel is entering a combustible aluminum dust collection system.

8.9.3.8 Spark-producing operations shall be separated from any cleaning equipment using flammable or combustible solvents and shall comply with NFPA 30, *Flammable and Combustible Liquids Code*.

8.9.3.9 Cleaning Tools.

8.9.3.9.1 Brooms and brushes used for cleaning shall have natural fiber bristles.

8.9.3.9.2 Synthetic bristles shall not be used.

8.9.3.9.3 Scoops, dustpans, and so forth used for collecting sweepings shall be made of nonsparking, conductive material.

8.9.3.10 Dry aluminum sweepings shall not be returned to the main process stream for processing.

8.9.3.11 Compressed Air Fittings. To prevent potential explosions caused by inadvertently using compressed air in place of inert gas, fittings used on compressed air and inert gas-line outlets shall not be interchangeable.

8.9.4 Hot Work Operations.

8.9.4.1 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*.

8.9.5 Control of Combustible Materials.

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

8.9.5.1.1 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).

8.9.5.1.2 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*.

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

8.9.5.2 Ordinary Combustible Storage.

8.9.5.2.1 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.

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

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

8.9.5.3.1 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.

8.9.5.3.2 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.

8.9.6 Inspection, Maintenance, and Training.

8.9.6.1 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.

8.9.6.1.1 The inspection shall be conducted at least quarterly but shall be permitted to be done more often.

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

8.9.6.2* 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.

8.9.6.3 Emergency Procedures.

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

8.9.6.3.2* All employees shall be trained in the emergency procedures specified in 8.9.6.3.1.

8.10 Other. (Reserved)

Chapter 9 Magnesium

9.1 General Provisions.

9.1.1 Retroactivity. The requirements of 9.1.3 through 9.1.5 shall apply to new and existing facilities where magnesium dusts, pastes, and or powders are produced or handled.

9.1.1.1 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.

9.1.2 Housekeeping.

9.1.2.1 Cleanup Procedures for Fugitive Dust Accumulations.

9.1.2.1.1* Fugitive dust shall not be allowed to accumulate.

9.1.2.1.2 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 9.1.2.2

9.1.2.1.3 Cleanup of Spilled Magnesium Powder. Preliminary cleanup of the bulk of the powder shall be accomplished by using conductive, nonsparking scoops and soft brooms as well as brushes that have natural fiber bristles.

9.1.2.1.4 Spills shall be removed at once, using conductive scoops and soft bristle brushes that have natural fiber bristles. Scoops shall be nonsparking unless otherwise authorized for the specific application.

9.1.2.1.5 Compressed-air blowdown shall not be permitted.



9.1.2.2* Vacuum Cleaning Systems.

9.1.2.2.1* 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.

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

9.1.2.2.3 Due to the inherent hazards associated with the use of fixed and portable vacuum cleaning systems for finely divided combustible magnesium dust, special engineering considerations shall be given to the design, installation, maintenance, and use of such systems.

9.1.2.2.4* Portable vacuum cleaners shall be used only if listed or approved for use with combustible magnesium dust.

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

9.1.2.2.5.1 Assembled components shall be conductive and bonded where necessary.

9.1.2.2.5.2 Periodic tests for continuity shall be performed.

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

9.1.2.3 Cleaning Frequency.

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

9.1.2.3.2 Regular, periodic cleaning of buildings and machinery, with all machinery idle and power off, shall be carried out as frequently as conditions warrant.

9.1.2.3.3 Regular, periodic cleaning of fugitive metal dust from buildings and machinery shall be carried out as frequently as conditions warrant.

9.1.2.3.4 Fugitive metal dust shall be removed to a designated storage or disposal area.

9.1.3 Personal Protective Equipment (PPE).

9.1.3.1 Operator clothing shall be flame retardant and easily removable and kept clean and dust free.

9.1.3.1.1 Clothing shall be smooth, allowing dust to be brushed off readily.

9.1.3.1.2 Clothing shall have no pockets or cuffs.

9.1.3.1.3 Wool, silk, or fuzzy outer clothing and shoes with exposed steel parts shall be prohibited.

9.1.4 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.

9.1.4.1 Thermite Reaction.

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

9.1.4.2 Eutectic Reactions. (Reserved)

9.1.5* Management of Change.

9.1.5.1 The requirements of 9.1.5.2 through 9.1.5.5 shall apply to existing facilities and processes.

9.1.5.2 Written procedures shall be established and implemented to manage a proposed change to process materials, technology, equipment, procedures, and facilities.

9.1.5.3 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
- (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

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

9.1.5.5 Design documentation shall be updated to incorporate the change.

9.1.6 Alternative Methodologies. (Reserved)

9.1.7 Test Results. (Reserved)

9.2 Facility Design Requirements.

9.2.1 Building Construction.

9.2.1.1 Location.

9.2.1.1.1 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.

9.2.1.1.2 Different production operations shall be located in separate but not adjoining buildings that are located at least 15 m (50 ft) from each other.

9.2.1.1.3 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.

9.2.1.1.4 Separate buildings shall be required where different operations such as, but not limited to, atomization, grinding, crushing, screening, blending, or packaging are performed.

9.2.1.1.5 More than one operation within the same building shall be permitted if the design provides equivalent protection.

9.2.1.1.6 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.

9.2.1.1.7 The buildings shall be designed so that all internal surfaces are readily accessible to facilitate cleaning.

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

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

9.2.1.1.10 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.

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

9.2.1.1.12 Floors shall be of a noncombustible hard surface, nonslip, and installed with a minimum number of joints in which powder can collect.

9.2.1.1.13 The requirements of 9.2.1.1.10 shall also apply to elevated platforms, balconies, floors, and gratings.

9.2.1.1.14 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.

9.2.1.1.15 Roof decks shall be watertight.

9.2.1.1.16 Doors and Windows.

9.2.1.1.16.1 All exits shall conform to NFPA 101, *Life Safety Code*.

9.2.1.1.16.2 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*.

9.2.1.1.16.3* Windows shall be held in place by friction latches and shall be installed so that they open outward.

9.2.1.1.17* Grounding of Equipment. All process equipment and all building steel shall be securely grounded by permanent ground wires to prevent accumulation of static electricity.

9.2.1.1.18 Electrical Power.

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

9.2.1.1.19 Paragraph 9.2.1.1.19 shall apply to new and existing magnesium powder production plants. (See 9.1.1.)

9.2.1.1.19.1 The intent of 9.2.1.1.19 shall be to restrict access by the general public to magnesium powder production plants and to establish adequate exits for personnel.

9.2.1.1.19.2 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.

9.2.1.1.19.3 Security measures taken shall be in accordance with NFPA 101, *Life Safety Code*.

9.2.1.1.19.4 Buildings shall be provided with emergency lighting systems in accordance with NFPA 101, *Life Safety Code*.

9.2.1.1.19.5 The emergency lighting shall be energized automatically on loss of electrical power to the buildings.

9.2.1.1.19.6 Buildings of area less than 19 m² (200 ft²) that are not normally occupied shall not be required to have emergency lighting systems.

9.2.2 Fire Protection.

9.2.3 Electrical Classification.

9.2.3.1* In local areas of a plant where a hazardous quantity of 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*.

9.2.3.2 All electrical equipment shall be inspected and cleaned periodically.

9.2.3.3 Where flashlights or electrical devices are used, they shall be listed for classified locations.

9.2.3.4* Grounding of Equipment. All equipment shall be securely grounded by permanent ground wires to prevent accumulation of static electricity.

9.2.4 Dust Collection.

9.2.4.1 Dust collection for powder production operations shall follow the requirements of 9.4.10.

9.2.4.2 Dust collection for machining, fabrication, and finishing operations shall follow the requirements of 9.7.3.

9.2.5 Hazard Analysis.

9.2.5.1* 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 or explosion hazards.

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

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

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

9.2.5.5 Written records shall be maintained of all hazard analyses.

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

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

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

9.3 Primary Metal Production. This standard shall not apply to the primary production of magnesium.

9.3.1 Reduction.

9.3.2* Melting and Casting.

9.3.2.1 Buildings used for the melting and casting of magnesium shall be noncombustible.

9.3.2.1.1 Melt rooms shall provide access to facilitate fire control.

9.3.2.1.2* Floors shall be of noncombustible construction and shall be kept clean and free of moisture and standing water.

9.3.2.2* 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.

9.3.2.3 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.

9.3.2.4* Prevention of Molten Magnesium Contact with Foreign Materials.

9.3.2.4.1 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.



9.3.2.4.2 Crucible interiors and covers shall be maintained free of iron oxide scale, which could fall into the molten metal.

9.3.2.4.3 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.

9.3.2.4.4 Melting pots and crucibles shall be inspected regularly.

9.3.2.4.5 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.

9.3.2.5 Ladles, skimmers, and sludge pans shall be thoroughly dried and preheated before contacting molten metal.

9.3.2.6 Extreme care shall be exercised in pouring magnesium castings, to avoid spillage.

9.3.2.7 All molds shall be thoroughly preheated before pouring magnesium castings.

9.3.2.8 Operators in melting and casting areas shall wear flame-resistant clothing, high foundry shoes, and face protection.

9.3.2.9 Clothing worn where molten magnesium is present shall have no exposed pockets or cuffs that could trap and retain magnesium.

9.3.3 Refining. (Reserved)

9.4 Powder Production.

9.4.1 General Precautions.

9.4.1.1 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).

9.4.1.2 Water leakage within or into any building where it can contact magnesium powder shall be prevented to avoid possible spontaneous heating and hydrogen generation.

9.4.1.3 Electrical heating of any resistance element or load to a high temperature in an area containing a dust hazard shall be prohibited.

9.4.1.4* Frictional heating shall be minimized by the use of lubrication, inspection programs, and maintenance programs and by techniques recommended by the equipment manufacturer.

9.4.2 Requirements for Machinery.

9.4.2.1 All combustible magnesium dust-producing machines and conveyors shall be designed, constructed, and operated so that fugitive dust is minimized.

9.4.2.2* All machinery shall be bonded and grounded to minimize the accumulation of static electric charge.

9.4.2.2.1 The requirement of 9.4.2.2 shall apply to stamp mortars, mills, fans, and conveyors in all areas where dust is produced or handled.

9.4.2.2.2 Static-conductive belts shall be used on belt-driven equipment.

9.4.2.3* Only grounded and bonded bearings, properly sealed against dust, shall be used.

9.4.2.4 Internal machine clearances shall be maintained to prevent internal rubbing or jamming.

9.4.2.5 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.

9.4.3 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.

9.4.4 Charging and Discharging.

9.4.4.1 All magnesium powder containers not used for shipping into or out of the plant shall be made of metal.

9.4.4.2 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.

9.4.5 Packaging and Storage.

9.4.5.1 Magnesium powder shall be stored in steel drums or other closed conductive containers.

9.4.5.2 The containers shall be tightly sealed and stored in a dry location until ready for shipment or repacking.

9.4.6 In-Plant Conveying of Magnesium Powder.

9.4.6.1 Containers.

9.4.6.1.1* In-plant transfer of powders shall be done in covered conductive containers, as described in Section 9.4.

9.4.6.1.2 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 9.2.3.1.

9.4.6.1.3 All wheeled containers, hand trucks, and lift trucks shall be grounded.

9.4.7 Pneumatic Conveying.

9.4.7.1 If the conveying gas is air, the magnesium dust-to-air ratio throughout the conveying system shall be held safely below the MEC of the magnesium dust at normal operating conditions. (See 9.2.4 and Annex C.)

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

9.4.7.3 The inert gas used shall be based on such gases as argon (Ar), carbon dioxide (CO₂), helium (He), nitrogen (N), or flue gas and shall have a limiting oxidant concentration (LOC) determined by test to be appropriate to the inerting gas.

9.4.7.4 The conveying gas shall have a dew point such that no free moisture can condense or accumulate at any point in the system.

9.4.7.5* A minimum conveying velocity of 1078 m/min (3500 ft/min) 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 an unscheduled system stoppage.

9.4.8 Ductwork for Conveying Systems.

9.4.8.1* Deflagration venting by the use of means such as rupture diaphragms shall be provided on ductwork.

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

9.4.8.1.2 Ductwork provided with explosion isolation systems identified in NFPA 69, *Standard on Explosion Prevention Systems*, shall be designed to prevent propagation of a deflagration into another part of the process.

9.4.8.2* Wherever damage to other property or injury to personnel can result from the rupture of the ductwork, and where explosion relief vents cannot provide sufficient pressure relief, the ductwork shall be designed to withstand a sudden internal gauge pressure of 872 kPa (125 psi).

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

9.4.8.4 Conveyor ducts shall be constructed of conductive material.

9.4.8.5 Nonconductive duct liners shall not be used.

9.4.8.6* Ducts shall be electrically bonded and grounded to minimize the accumulation of static electric charge. (See 9.4.2.2.)

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

9.4.9 Fan Construction and Arrangement.

9.4.9.1* Blades and housings of fans used to move air or inert gas in conveying ducts shall be constructed of conductive, nonsparking metal such as bronze, nonmagnetic stainless steel, or aluminum.

9.4.9.2 Personnel shall not be permitted within 15 m (50 ft) of the fan while it is operating, except as permitted in 9.4.9.2.2.

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

9.4.9.2.2 If personnel must approach the fan while it is operating, such as for a pressure test, it shall be done under the direct supervision of a competent technical person, with the knowledge and approval of operating management, and with the flow of magnesium stopped.

9.4.9.2.3 Where the aluminum powder-conveying system is inerted, personnel shall be permitted to be closer than 15 m (50 ft).

9.4.9.3 Fans shall be located outside all buildings and located so that the entrance of dust from the fan exhaust into any building is minimized.

9.4.9.4 Fans shall be electrically interlocked with dust-producing machinery so that the machines shut down if the fans stop.

9.4.10 Dust Collectors.

9.4.10.1 Dry-dust collectors shall be located outside, in a safe location, and shall be provided with barriers or other means for protection of personnel. (See A.8.7.3.5.2.)

9.4.10.2 The area around the collector shall be posted with the following sign:

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

9.4.10.3 Ductwork shall comply with the provisions of 9.4.8.

9.4.10.4* The entire dust collection system, including the dust collector, shall be constructed of conductive material and shall be completely bonded and grounded to minimize the accumulation of static electric charge.

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

9.4.10.5.1 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.

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

9.4.10.6 Repairs.

9.4.10.6.1 Where repairs to dry-dust collectors are necessary, the collectors shall be emptied and residual accumulations of dust thoroughly removed. (See 9.8.1.)

9.4.10.6.2 Ductwork leading into the collector shall be disconnected and blanked off before repair work is started.

9.5 End Users of Powder. (Reserved)

9.6 Processing.

9.6.1 Machinery and Operations. (Reserved)

9.6.2 Flake and Paste. (Reserved)

9.6.3 Plasma Spray Operations. (Reserved)

9.6.4 Transfer Operations. (Reserved)

9.6.5 Processing Recycled Material. The requirements of Chapter 16 shall apply to processes handling recycled magnesium, which is in a combustible form.

9.7 Machining, Fabrication, and Finishing.

9.7.1 Hot Work Operations.

9.7.1.1 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*.

9.7.1.2* No open flames, electric or gas cutting or welding, or other spark-producing operations shall be permitted in the section of the building where magnesium dust is produced or handled while dust-producing equipment is in operation.

9.7.1.3 In areas where the type of work specified in 9.7.7 is done, all machinery shall be shut down, and the area shall be thoroughly cleaned to remove all accumulations of magnesium dust.

9.7.1.4 All internal sections of grinding equipment, ducts, and dust collectors shall be completely free of moist or dry magnesium dust, and any hydrogen shall be flushed out.

9.7.1.5 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*.

9.7.2 Chip Processing.

9.7.2.1* Magnesium Chips or Powder.

9.7.2.2 Periodic cleaning of magnesium chips from buildings and machinery shall be carried out as frequently as conditions warrant.



9.7.2.3 Chips shall be removed to a safe storage or disposal area.

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

9.7.2.5 Smoking shall not be permitted in areas where ignitable magnesium chips are present.

9.7.2.5.1 Areas in which ignitable magnesium chips are present shall be posted with "No Smoking" signs.

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

9.7.3 Dust Collection.

9.7.3.1 Hoods.

9.7.3.1.1 Dust shall be collected by means of suitable hoods or enclosures at each operation.

9.7.3.1.2 Hoods and enclosures shall be connected either to a wet-type collector or to a cyclone collector and blower located outdoors.

9.7.3.1.3 The dust-collection system shall be designed and installed so that the dust is collected upstream of the fan.

9.7.3.1.4 The use of dry media-type collectors shall be prohibited.

9.7.3.2 Wet-Type Dust Collectors.

9.7.3.2.1* Where wet-type dust collectors are used, the unit shall be designed so that the dust collected is converted to sludge without contact, in the dry state, with any high-speed moving parts.

9.7.3.2.2* Wet-type dust collectors shall be restricted to a dust loading of no more than 175 grains/m³ (5 grains/ft³) of inlet air on standard configuration collectors.

9.7.3.2.3 Wet-type dust collectors shall be designed such that the hydrogen being generated from the magnesium contacting the water is vented at all times.

9.7.3.2.4 Means of venting to avoid accumulation of hydrogen shall be maintained. Each chamber of the collector shall be vented to dissipate the hydrogen.

9.7.3.2.5 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.

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

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

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

9.7.3.2.9 Downdraft bench configuration collectors shall maintain no less than 90 m/min (300 ft/min) average work-surface capture velocity at each work station, with work-surface capture velocity determined as a function of nominal work surface area.

9.7.3.2.10* Each wet-type dust collector shall be dedicated to the collection of magnesium or magnesium alloy only.

9.7.3.2.11 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 safety to both personnel and property in the particular installation, with regard to particulate matter in the cleaned air and accumulations of particulate matter and hydrogen in the work area.

9.7.3.2.12 The use of additional dry-filter media downstream of a wet collector shall not be permitted.

9.7.3.2.13 Ducts shall have no unused capped connections to the main trunk line where magnesium dust can accumulate.

9.7.3.2.14* 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 activate visual and audible alarms at the equipment it serves and at an area that is occupied whenever the equipment is in operation.

9.7.3.2.15 A time-delay switch or equivalent device shall be provided on the dust-producing equipment to prevent starting of its motor drive until the dust collector is in complete operation.

9.7.3.3 Cyclone Dust Collectors.

9.7.3.3.1 Hoods and enclosures shall be connected to a high-efficiency cyclone(s) and blower located outdoors.

9.7.3.3.2 The cyclone exhaust shall terminate in a safe, outdoor location.

9.7.3.3.3 Discharge air from cyclones shall not be returned into buildings.

9.7.3.3.4 All components of a dust collection system shall be made of conductive materials and shall be watertight.

9.7.3.3.5 The minimum length of the duct from the dust-producing operation(s) to the cyclone shall be 4.7 m (15 ft).

9.7.3.3.6 Explosion venting shall be permitted to be installed on dry-type dust collection systems.

9.7.3.4 Ductwork.

9.7.3.4.1 The discharge duct for all dust collection equipment shall terminate at a safe outdoor location except where permitted by 9.7.3.2.11.

9.7.3.4.2 Recycling of air from any dust collector into buildings shall be prohibited.

9.7.3.4.3 The ductwork and fan system shall be designed such that the concentration of magnesium dust in the system is less than 25 percent of the MEC.

9.7.3.4.4 In systems that involve multiple machines connected to one dust collector, the concentration limit and velocity requirement shall be met throughout the entire system.

9.7.3.4.5 All components of the dust collection system shall be of conductive material.

9.7.3.4.6 Connecting ducts or suction tubes between points of collection and dust collectors shall be completely bonded and grounded.

9.7.3.4.7 Ducts and tubes shall be as short as possible, with no unnecessary bends.

9.7.3.4.8 Ducts shall be fabricated and installed in accordance with NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*.

9.7.4* Machining.

9.7.4.1 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.

9.7.4.1.1 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.

9.7.4.1.2 Cutting tools shall be kept sharp and ground with sufficient rake clearance to minimize rubbing on the end and sides of the tool.

9.7.4.2* 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.

9.7.4.3 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.

9.7.4.3.1 Side relief shall be 5 degrees.

9.7.4.3.2 End relief shall be from 10 degrees to 20 degrees.

9.7.4.4 If lubrication is needed, as in tapping or extremely fine grooving, a high-flash point lubricant shall be used.

9.7.4.4.1 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.

9.7.4.4.2 Special formulated coolant fluids (water-oil emulsions) that specifically inhibit the formation of hydrogen gas shall be permitted.

9.7.4.5 Where compressed air is used as a coolant, special precautions shall be taken to keep the air dry.

9.7.4.6 All machines shall be provided with a pan or tray to catch chips or turnings.

9.7.4.6.1 The pan or tray shall be installed such that it can be readily withdrawn from the machine in case of fire.

9.7.4.6.2 The pan shall be readily accessible for chip removal and for application of extinguishing agent to control a fire.

9.7.4.6.3 During magnesium-machining operations, chips shall be removed from the point of generation by continuous or batch removal.

9.7.4.6.3.1 Accumulation of chips at the point of generation shall not exceed 1.4 kg (3 lb) dry weight.

9.7.4.6.3.2 All chips shall be stored in covered noncombustible containers and removed to a storage area in accordance with 9.8.1.

9.7.4.6.4 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.

9.7.5 Cleaning.

9.7.5.1 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.

9.7.5.2 Cleaning shall be done using soft brushes and conductive, nonsparking scoops and containers.

9.7.5.3* Vacuum cleaners shall not be used unless they are specifically listed for use with magnesium powder or dusts.

9.7.5.4 Machinery and equipment described in 9.4.2 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.

9.7.6* Grinding Wheels.

9.7.6.1 Wheels used for grinding magnesium castings shall be relocated for dressing.

9.7.6.2 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.

9.7.6.3 Dust collection equipment shall not have filters or other obstructions that will allow the accumulation of magnesium dust.

9.7.7 Drawing, Spinning, and Stamping.

9.7.7.1 Reliable means to prevent overheating shall be provided where magnesium is heated for drawing or spinning.

9.7.7.2 Clippings and trimmings shall be collected at frequent intervals and placed in clean, dry steel or other noncombustible containers.

9.7.7.3 Fine particles shall be handled according to the requirements of 9.4.

9.7.8* Heat Treating.

9.7.8.1 A standard procedure for checking the uniformity of temperatures at various points within heat-treating furnaces shall be established.

9.7.8.2 Furnaces shall be checked prior to use and at regular intervals during use to identify undesirable hot spots.

9.7.8.3* Gas- or oil-fired furnaces shall be provided with combustion safety controls.

9.7.8.4 All furnaces shall have two sets of temperature controls operating independently.

9.7.8.4.1 One set of temperature controls shall maintain the desired operating temperature.

9.7.8.4.2* 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.

9.7.8.5 Magnesium parts to be put in a heat-treating furnace shall be free of magnesium turnings, chips, and swarf.

9.7.8.6 Combustible spacers on pallets shall not be used in a heat-treating furnace.

9.7.8.7* Aluminum parts, sheets, or separators shall not be included in a furnace load of magnesium.

9.7.8.8 There shall be strict adherence to the heat-treating temperature cycle recommended by the alloy manufacturer.

9.7.8.9* Molten salt baths containing nitrates or nitrites shall not be used for heat treating magnesium alloys.

9.7.8.10* 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.



9.7.8.11* Furnaces used to heat magnesium or magnesium alloys shall be inspected and cleaned as necessary to remove any accumulation of loose iron oxide scale.

9.8 Storage and Handling.

9.8.1 Storage of Magnesium Solids.

9.8.1.1* Storage of Pigs, Ingots, and Billets.

9.8.1.1.1 The size of piles of magnesium pigs, ingots, and billets shall be limited.

9.8.1.1.1.1 Minimum aisle widths shall be based on the height of the pile per 9.8.1.1.2.4.

9.8.1.1.1.2 The pile height shall not exceed 7.1 m (20 ft).

9.8.1.1.2 Yard (Outdoor) Storage.

9.8.1.1.2.1 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.

9.8.1.1.2.2 Combustible flooring or supports shall not be used under piles of ingots.

9.8.1.1.2.3 The quantity of magnesium stored in any pile shall be kept to a minimum.

(A) In no case, other than under the conditions of 9.8.1.1.2.3(B), 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.

9.8.1.1.2.4 Aisle width shall be at least one-half the height of the piles and shall be at least 3.1 m (10 ft).

9.8.1.1.2.5 Readily combustible material shall not be stored within a distance of 7.7 m (25 ft) from any pile of magnesium ingots.

9.8.1.1.2.6 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 combustible material or buildings are exposed or where the adjacent occupancy can provide fire exposure to the magnesium.

9.8.1.1.3* Indoor Storage.

9.8.1.1.3.1 Indoor storage shall be in buildings of noncombustible construction.

9.8.1.1.3.2 Floors shall be well drained to prevent accumulations of water in puddles.

9.8.1.1.3.3 Supports and pallets used under piles of magnesium ingots shall be noncombustible.

9.8.1.1.3.4 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 9.8.1.1.3.4(B), 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.

9.8.1.1.3.5 Aisle widths shall comply with 9.8.1.1.2.4.

9.8.1.1.3.6 Combustible material shall not be stored within a distance of 7.7 m (25 ft) from any pile of magnesium pigs, ingots, and billets.

9.8.1.2 Storage of Heavy Castings.

9.8.1.2.1 Except under the conditions of 9.8.1.2.2, buildings used for the storage of heavy magnesium castings shall be of noncombustible construction.

9.8.1.2.2 Storage shall be permitted in buildings of combustible construction if the buildings are fully protected by an automatic sprinkler system.

9.8.1.2.3* Floors shall be of noncombustible construction and shall be well drained to prevent accumulations of water in puddles.

9.8.1.2.4 All magnesium castings shall be clean and free of chips or fine particles of magnesium when being stored.

9.8.1.2.5 Storage Piles.

9.8.1.2.5.1 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).

9.8.1.2.5.2 Aisles shall be maintained to allow inspection and effective use of fire protection equipment.

9.8.1.2.6 Aisle width shall be at least one-half the height of the piles and shall be at least 3.1 m (10 ft).

9.8.1.2.7* Automatic sprinkler protection shall be permitted to be installed in magnesium storage buildings where combustible cartons, crates, or other packing materials are present.

9.8.1.3 Storage of Light Castings.

9.8.1.3.1 Building Construction.

9.8.1.3.1.1 Except under the conditions of 9.8.1.3.1.2, light magnesium castings shall be stored in noncombustible buildings and shall be segregated from other storage by 7.7 m (25 ft).

9.8.1.3.1.2 Storage of light castings shall be permitted in buildings of combustible construction if the buildings are fully protected by an automatic sprinkler system. (See 9.8.1.3.5.)

9.8.1.3.2 Piles of stored light magnesium castings, either in cartons or crates or without packing, shall be limited in size to 28 m³ (1000 ft³).

9.8.1.3.3 Light castings shall be segregated from other combustible materials and shall be kept away from flames or sources of heat capable of causing ignition.

9.8.1.3.4 Aisle widths shall be at least one-half the height of the piles and shall be at least 3.1 m (10 ft).

9.8.1.3.5* Automatic sprinkler protection shall be permitted to be installed in magnesium storage buildings where combustible cartons, crates, or packing materials are present.

9.8.1.4 Storage in Racks or Bins.

9.8.1.4.1 Racks shall be permitted to be extended along walls in optional lengths.

9.8.1.4.2 Aisle spaces in front of racks shall be equal to the height of the racks.

9.8.1.4.3 All aisle spaces shall be kept clear.

9.8.1.4.4 Combustible rubbish, spare crates, and separators shall not be allowed to accumulate within the rack space.

9.8.1.4.5 Separators and metal sheets shall not be stacked on edge and leaned against racks, because they will prevent heat from a small fire from activating automatic sprinklers and will act as shields against sprinkler discharge.

9.8.1.5 Storage of Scrap Magnesium.

9.8.1.5.1 Paragraph 9.8.1.5 shall apply to the storage of scrap magnesium in the form of solids, chips, turnings, swarf, or other fine particles.

9.8.1.5.2 Buildings used for the indoor storage of magnesium scrap shall be of noncombustible construction.

9.8.1.5.3 Dry magnesium scraps shall be kept well separated from other combustible materials.

9.8.1.5.3.1 Scraps shall be kept in covered steel or other noncombustible containers and shall be kept in such manner or locations that they will not become wet.

9.8.1.5.3.2 Outside storage of magnesium fines shall be permitted if such storage is separated from buildings or personnel and great care is exercised to prevent the fines from becoming wet.

9.8.1.5.4* Wet magnesium scrap (chips, fines, swarf, or sludge) shall be kept under water in a covered and vented steel container at an outside location.

9.8.1.5.5 Storage of dry scrap in quantities greater than 1.4 m³ (50 ft³) [six 208 L drums (six 55 gal drums)] shall be kept separate from other occupancies by fire-resistive construction without window openings or by an open space of at least 15 m (50 ft), and such buildings shall be well ventilated to avoid the accumulation of hydrogen in the event that the scrap becomes wet.

9.8.1.5.6 Solid magnesium scrap, such as clippings and castings, shall be stored in noncombustible bins or containers, pending salvage.

9.8.1.5.7 Oily rags, packing materials, and similar combustibles shall not be permitted in storage bins or areas that store solid magnesium scrap.

9.8.1.5.8 The use of automatic sprinklers in magnesium scrap storage buildings or areas shall be prohibited.

9.8.1.6 Storage of Magnesium Powder.

9.8.1.6.1 Buildings used to store magnesium powder shall be of noncombustible, single-story construction.

9.8.1.6.2 The use of automatic sprinklers in magnesium powder storage buildings shall be strictly prohibited.

9.8.1.6.3 Magnesium powder shall be kept well separated from other combustible or reactive metals.

9.8.1.6.4 Magnesium powder shall be stored in closed steel drums or other closed noncombustible containers, and the containers shall be stored in dry locations.

9.8.1.6.5 Magnesium powder storage areas shall be kept dry and shall be checked for water leakage.

9.8.1.6.6* In local areas of a plant where a hazardous quantity of 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*.

9.8.1.6.7* Where magnesium powder in drums is stacked for storage, the maximum height shall not exceed 5.5 m (18 ft).

9.8.1.6.7.1 Storage shall be stacked in a manner that ensures stability.

9.8.1.6.7.2 Under no circumstances shall containers be allowed to topple over.

9.8.1.7 Storage of Other Magnesium Products.

9.8.1.7.1* Paragraph 9.8.1.7 shall apply to the storage of parts and components in warehouses, wholesale facilities, factories, and retail establishments in which magnesium makes up 50 percent or more of the article's composition on a volumetric basis or where the magnesium-containing assemblies as packaged or stored exhibit the burning characteristics of magnesium.

9.8.1.7.2 Storage in quantities greater than 1.4 m³ (50 ft³) shall be separated from storage of other materials that are either combustible or are contained in combustible containers by aisles with a minimum width equal to the height of the piles of magnesium products.

9.8.1.7.3 Magnesium products stored in quantities greater than 28 m³ (1000 ft³) shall be separated into piles, each not larger than 28 m³ (1000 ft³), with the minimum aisle width equal to the height of the piles but in no case less than 3.1 m (10 ft).

9.8.1.7.4* The storage area shall be protected by automatic sprinklers in any of the following situations:

- (1) Where storage in quantities greater than 28 m³ (1000 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

9.8.2 Scrap Handling, Storage, and Disposal. (Reserved)

9.8.3 Recycling.

9.8.3.1 The requirements of Chapter 16 shall apply to processes handling recycled magnesium, which is in a combustible form.

9.8.4 Chip Processing. (Reserved)

9.9 Fire and Explosion Prevention. The provisions of Section 9.9 shall apply to all new and existing magnesium production processing, handling, and storage operations.

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

9.9.1.1 Fire and explosion protection shall be in accordance with Chapter 15.



9.9.2* Housekeeping.

9.9.2.1 Dust Control. See 9.1.2 for housekeeping and 9.2.4 for dust collection.

9.9.2.2* All containers used to receive molten magnesium shall be cleaned and dried thoroughly before use.

9.9.2.3 Good housekeeping practices shall be maintained.

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

9.9.2.5 Supplies of materials in magnesium-processing areas shall be limited to those amounts necessary for normal operation.

9.9.2.6 Periodic cleaning of magnesium chips or powder from buildings and machinery shall be carried out as frequently as conditions warrant.

9.9.2.7 Magnesium chips or powder shall be removed to a safe storage or disposal area.

9.9.3 Control of Ignition Sources.

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

9.9.3.2 Smoking shall not be permitted in areas where ignitable magnesium chips are present or where ignitable magnesium powder is present.

9.9.3.2.1 Areas in which ignitable magnesium chips are present or where ignitable magnesium powder is present shall be posted with "No Smoking" signs.

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

9.9.3.3 All electrical equipment and wiring in magnesium production, processing, handling, and storage facilities shall comply with *NFPA 70, National Electrical Code*.

9.9.3.4 Where tools and utensils are used in areas handling magnesium powder, consideration shall be given to the risks associated with generating impact sparks and static electricity.

9.9.3.5 Nonsparking tools shall be used for making repairs or adjustments around grinding wheels, hoods, or collector units where magnesium dust is present.

9.9.3.6* Processing equipment used in magnesium operations shall be electrically bonded and grounded properly to prevent accumulations of static electricity.

9.9.3.7 Where magnesium 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.

9.9.4* Hot Work.

9.9.4.1 Hot work operations shall be in accordance with Chapter 15.

9.9.4.2 Hot work permits shall be required in designated areas that contain exposed magnesium chips, powder, or sponge.

9.9.4.3 All hot work areas that require a permit shall be thoroughly cleaned of magnesium chips, powder, or sponge before hot work is performed.

9.9.5 Control of Combustible Materials.

9.9.5.1 Ordinary combustible materials, such as paper, wood, cartons, and packing material, shall not be stored or allowed to accumulate in magnesium-processing areas.

9.9.5.2 The requirement of 9.9.5.1 shall not apply where ordinary combustible materials are necessary for the process and are stored in designated areas.

9.9.5.3* Ordinary combustible materials shall not be discarded in containers used for the collection of magnesium sponge, chips, or powder, with the exception of floor sweepings from magnesium operations, which shall be permitted to contain small amounts of ordinary combustible materials.

9.9.6 Inspection, Maintenance, and Training.

9.9.6.1 Periodic inspections shall be conducted, as frequently as conditions warrant, to detect the accumulation of excessive magnesium chips or powder on any portions of buildings or machinery not regularly cleaned during daily operations.

9.9.6.2 Records of the inspections specified in 9.9.6.1 shall be kept.

9.10 Other. (Reserved)

Chapter 10 Niobium

10.1 General Provisions.

10.1.1 Retroactivity. The requirements of 10.1.2 through 10.1.4 shall apply to new and existing facilities.

10.1.1.1 In niobium 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; or frictional heating or other energy sources.

10.1.2 Housekeeping.

10.1.2.1 Cleanup Procedures for Fugitive Dust Accumulations.

10.1.2.1.1* Fugitive dust shall not be allowed to accumulate.

10.1.2.1.2 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 10.1.2.3

10.1.2.2 Cleanup of Spilled Niobium Powder.

10.1.2.2.1 Spills shall be removed at once, using conductive scoops and soft bristle brushes with natural fiber bristles. Scoops shall be nonsparking unless otherwise authorized for the specific application.

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

10.1.2.3* Vacuum Cleaning Systems.

10.1.2.3.1 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.

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

10.1.2.3.3* Due to the inherent hazards associated with the use of fixed and portable vacuum cleaning systems for finely divided combustible niobium dust, special engineering consideration shall be given to the design, installation, maintenance, and use of such systems.

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

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

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

10.1.2.3.5.1 Assembled components shall be conductive and bonded where necessary.

10.1.2.3.5.2 Periodic tests for continuity shall be performed.

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

10.1.2.4 Compressed Air Cleaning Requirements. Compressed air blowdown shall not be permitted, only except in certain areas that are otherwise impossible to clean by vacuuming or other means and, where permitted, shall be performed under carefully controlled conditions with all potential ignition sources prohibited in or near the area and with all equipment shut down.

10.1.2.4.1 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.

10.1.2.5 Cleaning Frequency.

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

10.1.2.5.2 Regular, periodic cleaning of buildings and machinery, with all machinery idle and powered off, shall be carried out as frequently as conditions warrant.

10.1.2.5.3 Regular, periodic cleaning of fugitive metal dust from buildings and machinery shall be carried out as frequently as conditions warrant.

10.1.2.5.4 Fugitive metal dust shall be removed to a designated storage or disposal area.

10.1.3 Personal Protective Equipment (PPE).

10.1.3.1 Outer clothing shall be clean, flame retardant, and non-static generating where combustible niobium dust is present and shall be designed to be easily removable.

10.1.3.1.1 Tightly woven, smooth fabrics treated with a flame-retardant chemical and from which dust can readily be brushed shall be used if necessary.

10.1.3.1.2 Wool, silk, or synthetic fabrics that can accumulate high static electric charges shall not be used.

10.1.3.2 Work clothing shall be designed to minimize the accumulations of combustible niobium dust (e.g., trousers shall not have cuffs).

10.1.3.3* Safety shoes shall be static-dissipating, where necessary, shall have no exposed metal, and shall be appropriate for the type of operation taking place.

10.1.3.4* Clothing Fires.

10.1.3.4.1 Emergency procedures for handling clothing fires shall be established.

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

10.1.4 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.

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

10.1.4.2 Eutectic Reactions. (Reserved)

10.1.5 Management of Change.

10.1.5.1 The requirements of 10.1.5.2 through 10.1.5.5 shall apply to existing facilities and processes.

10.1.5.2 Written procedures shall be established and implemented to manage a proposed change to process materials, technology, equipment, procedures, and facilities.

10.1.5.3 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
- (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

10.1.5.4 Implementation of the management-of-change procedures shall not be required for replacements-in-kind.

10.1.5.5* Design documentation shall be updated to incorporate the change.

10.1.6 Alternative Methodologies. (Reserved)

10.1.7 Test Results. (Reserved)

10.1.8 Other. (Reserved)

10.2 Facility Design Requirements.

10.2.1 Building Construction.

10.2.1.1 Buildings for the storage, handling, processing, or use of niobium in a combustible form shall be constructed of noncombustible materials.



10.2.1.2 All buildings shall be of Type I or Type II construction, as defined in NFPA 220, *Standard on Types of Building Construction*.

10.2.1.3 Floors in niobium facilities shall be made of non-combustible materials.

10.2.1.3.1* A hazards analysis shall be completed to determine where static-dissipative flooring or static-dissipative floor mats shall be required in niobium powder-manufacturing facilities storing, handling, processing, or using niobium in a combustible form.

10.2.1.3.2 The hazards analysis shall specifically consider the combustibility and specific character of the materials being handled in the facility.

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

10.2.1.5 Roof decks shall be watertight.

10.2.1.6 Drying Room Construction.

10.2.1.6.1 Drying rooms shall be of Type I construction as defined by NFPA 220, *Standard on Types of Building Construction*.

10.2.1.6.2 Drying rooms shall be segregated as far as is practical from other operations.

10.2.1.6.3 A hazards analysis shall be performed to determine whether deflagration venting is needed in drying rooms.

10.2.1.6.4 A hazards analysis shall be performed to determine the proper type of drying used for the specific niobium powders being handled as well as the specific parameters used for drying.

10.2.1.6.5 Interior walls erected for the purpose of limiting fire spread shall have a minimum 1-hour fire resistance rating and shall be designed in accordance with NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*.

10.2.1.6.6 Openings in fire walls and fire barrier walls shall be protected in accordance with NFPA 80, *Standard for Fire Doors and Other Opening Protectives*.

10.2.1.6.7 All penetrations of floors, walls, ceilings, or partitions shall be dusttight, and where structural assemblies have a fire resistance rating, the seal shall maintain that rating.

10.2.1.6.8 Sealing of penetrations shall not be required when the penetrated barrier is provided for reasons other than to limit the migration of dusts or to control the spread of fire or explosion.

10.2.1.6.9* Water pipes or pipes that can contain water for uses other than process or production support (e.g., sprinkler piping, domestic water pipes, roof drains, and waste pipes) shall be permitted where a hazards analysis is performed by a person who is knowledgeable in the hazards of niobium and is acceptable to the authority having jurisdiction.

10.2.1.7 Grounding of Equipment.

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

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

10.2.1.7.3* A periodic monitoring and testing schedule acceptable to the authority having jurisdiction shall be established to ensure that the effectiveness of grounding and bonding of fixed and mobile equipment has not failed or deteriorated over time and use.

10.2.1.8 Electrical Power.

10.2.1.8.1* All electrical equipment and wiring shall be installed in accordance with NFPA 70, *National Electrical Code*, and NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*.

10.2.1.8.2 An inspection schedule acceptable to the authority having jurisdiction shall be established to ensure that existing enclosures for electrical equipment not purged or pressurized are effective in preventing accumulation of niobium dust within the electrical enclosures.

10.2.1.8.3* In local areas of a plant where a hazardous quantity of 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*.

10.2.1.8.4* All hazardous (classified) areas identified in accordance with 10.2.1.8.3 shall be documented, and such documentation shall be maintained on file for the life of the facility.

10.2.1.9 Explosion Mitigation/Venting.

10.2.1.9.1 Fittings used on compressed air, water, nitrogen, and inert gas-line outlets shall be distinguishable, to prevent potential explosions caused by inadvertent use of the wrong material.

10.2.1.9.2* Where a room or building contains a dust explosion hazard external to protected equipment, such areas shall be evaluated for the application of deflagration venting.

10.2.1.9.3* Vent closures shall be directed toward a personnel-restricted area, and the vent closure shall be restrained to minimize the missile hazard to personnel and equipment.

10.2.1.9.4* Relief valves shall not be vented to a dust hazard area.

10.2.1.9.5 Equipment shall be located or arranged in a manner that minimizes combustible dust accumulations on surfaces.

10.2.2 Fire Protection.

10.2.2.1 Extinguishing Agents and Application Techniques for Use in Combustible Niobium Dusts.

10.2.2.2 Fire Extinguishers. (Reserved)

10.2.2.3 Automatic Sprinkler Protection. (Reserved)

10.2.2.4 Fire Fighting.

10.2.2.4.1 Incipient Fire Fighting. Facilities handling finely divided aluminum shall develop a response plan for fighting fires in accordance with Chapter 15.

10.2.3 Electrical Classification.

10.2.3.1* In local areas of a plant where a hazardous quantity of 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*.

10.2.3.2 Offices and similar areas within the niobium powder-manufacturing building that are segregated and free from niobium dust shall not be classified.

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

10.2.4 Dust Collection.

10.2.4.1 In-Plant Conveying of Niobium Powder.

10.2.4.1.1 Power Shutoff. All conveyors shall be equipped with a device that shuts off the power to the drive motor and sounds an alarm in the event the conveyor plugs.

10.2.4.1.2 Feed to the conveyor shall be stopped or diverted.

10.2.4.2 Enclosed Mechanical Conveyors.

10.2.4.2.1 Housings for enclosed conveyors (e.g., screw conveyors and drag conveyors) shall be of metal construction and shall be designed to prevent escape of niobium powders.

10.2.4.2.2 Coverings on cleanout, inspection, and other openings shall be closed and fastened.

10.2.4.2.3 Screw conveyors and bucket elevators that agitate the niobium being transported shall be enclosed in dusttight casings and shall be equipped with explosion prevention or protection methods in accordance with 10.4.5.

10.2.4.3 Pneumatic Conveying.

10.2.4.3.1 Ducts shall be designed to handle a volumetric flow rate that maintains dust loading safely below the MEC.

10.2.4.3.2 Pneumatic systems shall be designed in accordance with NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*.

10.2.4.3.3* The conveying gas shall have a dew point such that no free moisture can condense or accumulate at any point in the system.

10.2.4.3.4 Ductwork for conveying systems shall be constructed according to 10.2.4.3.4.1 through 10.2.4.3.4.7.

10.2.4.3.4.1 Nonconductive duct or duct liners shall not be used.

10.2.4.3.4.2 Ducts shall be electrically bonded and grounded.

10.2.4.3.4.3 Deflagration venting (e.g., rupture diaphragms) shall be provided on ductwork.

10.2.4.3.4.4 Deflagration vents shall relieve to a location outside the building.

10.2.4.3.4.5* The design of deflagration venting shall be in accordance with good engineering practice.

10.2.4.3.4.6 Wherever damage to other property or injury to personnel can result from the rupture of the ductwork, and where explosion-relief vents cannot provide pressure relief, the ductwork shall be designed to withstand a sudden internal gauge pressure of 862 kPa (125 psi).

10.2.4.3.4.7 Ductwork located so that no damage to property or injury to personnel can result from its bursting shall be permitted to be of light construction so as to intentionally fail, thereby acting as an auxiliary explosion vent for the system.

10.2.4.4 Fans shall be installed in accordance with the air-moving device requirements of NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*.

10.2.4.4.1 Blades and housings of fans used to move air, argon, or helium in conveying ducts shall be constructed of con-

ductive, nonsparking metal, such as bronze, nonmagnetic stainless steel, or aluminum.

10.2.4.4.2 Fan motors shall be located outside the duct airstream.

10.2.5 Hazard Analysis.

10.2.5.1* 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 or explosion hazards.

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

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

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

10.2.5.5 Written records shall be maintained of all hazard analyses.

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

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

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

10.3 Primary Metal Production

10.3.1 Reduction. (Reserved)

10.3.2 Melting and Casting. (Reserved)

10.3.3 Refining. (Reserved)

10.3.4* Explosion Prevention.

10.3.4.1* Sealed vessels shall be designed and maintained to prevent water from entering the reaction chamber.

10.3.4.2 Sealed vessels shall be permitted to be water cooled and shall be designed to prevent water from entering the vessel.

10.3.4.2.1* Water-cooled furnaces shall have the crucible and its water jacket located in a protective noncombustible enclosure that provides a means of isolation to protect personnel and to minimize damage to adjacent structures and equipment if an explosion occurs.

10.3.4.2.2 The fill used for furnace containment shall be designed to minimize the potential for the material to slough into the furnace cavity after an explosion.

10.3.5 Upper Chamber of the Furnace.

10.3.5.1* The upper chamber of the furnace shall be provided with a pressure-relieving device to aid in relieving pressure if water enters the furnace.

10.3.5.2 Means shall be provided to prevent the influx of air through the pressure-relief port.

10.3.5.3 Large low-pressure ports shall not be used.

10.3.5.4* A clearance shall be maintained at all times between the electrode and the crucible wall to minimize arcing to the crucible wall.



10.3.5.5* The furnace shall be equipped with a device that continuously senses pressure within the furnace.

10.3.5.5.1 The device shall automatically interrupt power to the melting heat source in the event of an unexpected sharp rise in pressure.

10.3.5.5.2 The furnace shall be equipped with the following:

- (1) Waterflow, temperature, and pressure sensors on all cooling systems
- (2) Arc voltage recorders and melting power recorders
- (3) Electrode position indicators
- (4) Furnace pressure sensors and recorders
- (5) Set point alarms on critical process systems to warn of abnormal conditions

10.3.5.5.3 Furnaces shall comply with NFPA 86, *Standard for Ovens and Furnaces*.

10.3.5.6* Water-cooled crucibles shall be inspected to ensure that minimum wall thicknesses are maintained to prevent a breach of the crucible wall.

10.3.6* Water Supply.

10.3.6.1 The water supply to crucibles shall be monitored continuously by a system that automatically interrupts power to the melting heat source upon a drop in water pressure or waterflow.

10.3.6.2 An emergency source of cooling water shall be provided and shall be actuated automatically by flow interlock in the event of interruption of the primary cooling water.

10.3.6.3 Equipment construction shall mitigate the potential for ignition of the niobium powder.

10.3.6.4 All electrically operated or controlled processing equipment shall be installed in accordance with *NFPA 70, National Electrical Code*.

10.3.6.5 Control consoles for water-cooled melting and casting operations shall be located remote from melting areas and outside of furnace enclosures.

10.3.6.6 Backup methods or systems shall be provided to allow for the orderly shutdown of critical processes in the case of primary system failure.

10.3.7 Casting.

10.3.7.1 Water Supply.

10.3.7.1.1 The water supply to crucibles shall be monitored continuously by a system that automatically interrupts power to the melting heat source upon a drop in water pressure or waterflow.

10.3.7.1.2 An emergency source of cooling water shall be provided and shall be actuated automatically by flow interlock in the event of interruption of the primary cooling water.

10.3.7.2* Molds.

10.3.7.2.1 Molds for niobium casting shall be made of material that is compatible with molten niobium.

10.3.7.2.2 Molds shall be dried thoroughly and shall be stored to prevent accumulation of moisture in the molds.

10.3.7.2.3 Because mold breaks are inevitable, the casting chamber shall be cooled or shall be large enough to serve as a heat sink, or both, to provide the protection necessary in the event of a spill.

10.3.7.2.4* Control consoles for water-cooled melting and casting operations shall be located remote from melting areas and outside of furnace enclosures.

10.3.7.3* Residue.

10.3.7.3.1 Residue from casting furnaces shall be passivated, placed in covered metal containers that allow for hydrogen gas venting, and moved to a designated storage or disposal area.

10.3.7.3.2 The containers specified in 10.3.7.3.1 shall be stored so that any hydrogen gas generated vents freely.

10.3.8 Personnel Safety Precautions.

10.3.8.1 Molten niobium shall be contained in closed systems that prevent its unintentional contact with air or reactive materials.

10.3.8.2 Personnel involved in niobium melting operations with the potential for exposure to molten niobium shall wear appropriate PPE.

10.3.8.3 Niobium metal shall be handled only by trained personnel who are knowledgeable of the hazards associated with niobium.

10.3.9* Machining Operations and Fabrication Operations.

10.3.9.1* Equipment shall be designed, constructed, installed, and operated to mitigate the potential for accumulation and ignition of niobium.

10.3.9.2 All electrically operated or controlled processing equipment shall be installed in accordance with *NFPA 70, National Electrical Code*.

10.3.9.3 All machines shall be provided with a pan or tray to catch chips or turnings.

10.3.9.3.1 The pan or tray shall be installed so that it is accessible for chip, turning, or compacted niobium powder removal and for application of an extinguishing agent to control a fire.

10.3.9.3.2 The pan construction shall be sufficient to minimize the potential for burn-through.

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

10.3.9.3.4* Cutting tools shall be designed for use with niobium and shall be kept sharp.

10.3.9.3.5* Forge presses, heavy grinders, and other milling equipment operated by hydraulic systems shall use a fluid with a flash point greater than 93°C (200°F).

10.3.9.3.6* Flammable or combustible liquids shall be handled in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.

10.3.9.3.7 Noncombustible coolants shall be used for wet grinding, cutting, and sawing operations.

10.3.9.3.8 The coolant shall be filtered on a continuous basis, and the collected solids shall not be permitted to accumulate in quantities greater than 19 L (5 gal).

10.3.9.3.9 The collected solids shall be moved to a designated storage or disposal area.

10.3.9.3.10 Crushed lathe turnings, raw turnings, and chips shall be collected in covered metal containers and removed daily to a designated storage or disposal area.

10.3.9.3.11 Where fully dense forms of niobium metal are conditioned via grinding or sanding operations, consideration shall be given to ensure that the residual dusts produced are handled in a safe fashion.

10.3.9.3.12 A hazards analysis shall be conducted to ensure that these operations do not contribute to fugitive dust accumulation.

10.3.9.3.13 If dust collection is used for grinding and sanding applications, take-up hoods shall be designed to minimize the accumulation of dust.

10.3.10 Hot Work. Refer to 10.9.4.

10.4 Niobium Powder Production for Primary Producers.

10.4.1 Equipment shall be designed, constructed, installed, and operated to mitigate the potential for ignition of the niobium.

10.4.2* Only niobium powder for immediate use shall be present in handling areas.

10.4.2.1 Daily supplies of niobium powder shall be allowed to be stored in the production area.

10.4.2.1.1 The niobium powder shall be stored in covered containers and shall be segregated from other combustible materials.

10.4.2.1.2 The maximum capacity of the container shall be such that it can be moved by available equipment.

10.4.2.1.3 The containers shall be protected from damage.

10.4.3 Transport of dry niobium powders within manufacturing operations and storage of dry niobium powders within manufacturing areas shall be done in covered conductive containers.

10.4.4 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 10.2.3.1.

10.4.5 To minimize the risk of fire or explosion hazard in the handling of niobium powders, the equipment and process shall be designed by persons experienced and knowledgeable in the hazards of niobium powders.

10.4.6 Drying of Niobium Powder. A hazards analysis acceptable to the authority having jurisdiction shall be conducted to determine appropriate methods and parameters for drying of niobium powder based on the specific materials being handled and dried.

10.4.6.1* Water-wetted powder, when air dried at atmospheric pressure, shall be at a temperature not exceeding 80°C (176°F).

10.4.6.2 Powders wetted with fluids other than water, when dried in air, shall be dried at a temperature governed by the characteristics of the fluid but not exceeding 80°C (176°F).

10.4.6.3* When drying niobium powders under controlled atmospheric conditions (e.g., vacuum or inert atmosphere) and the temperature exceeds 80°C (176°F), the niobium shall be cooled to less than 80°C (176°F) prior to exposure to air.

10.4.6.4 Drying air that contacts material that is being processed shall not be recycled to rooms, processes, or buildings.

10.4.6.5 Dry inert gas atmosphere shall be permitted to be recycled to the drying process if passed through a filter, a dust collector, or equivalent means of dust removal capable of removing 95 percent of the suspended particulate.

10.4.7* Dryers.

10.4.7.1 Dryers shall be constructed of noncombustible materials.

10.4.7.2 Interior surfaces of dryers shall be designed so that accumulations of material are minimized and cleaning is facilitated.

10.4.7.3* Products of combustion, as a result of a collector fire, shall be considered when designing wet collector installations.

10.4.7.4 Wet collectors posing a significant fire and evacuation risk shall have their exhaust air conveyed directly to the exterior of the building.

10.4.7.5 Explosion protection shall be provided as specified in 10.4.5.

10.4.7.6* Operating controls shall be designed, constructed, installed, and monitored so that required conditions of safety for operation of the heating system, the dryer, and the ventilation equipment are maintained.

10.4.7.7 Heated dryers shall have operating controls configured to maintain the temperature of the drying chamber within the prescribed limits.

10.4.7.8 Excess temperature-limit controls required in 10.4.7.6 shall initiate an automatic shutdown that performs at least the following functions:

- (1) Sounds an alarm at a constantly attended location to prompt emergency response
- (2) Shuts off the fuel or heat source to the dryer
- (3) Stops the flow of product into the dryer and stops or diverts the flow out of the dryer
- (4) Stops all airflow into the dryer
- (5)*Maintains purge flow of inert gas
- (6) Maintains coolant flow, if so equipped

10.4.8 An emergency stop shall be provided that will enable manual initiation of the automatic shutdown required by 10.4.7.8.

10.4.9 Heated dryers and their auxiliary equipment shall be equipped with separate excess temperature-limit controls arranged to supervise the following:

- (1) Heated air or inert gas supply to the drying chamber
- (2) Airstream or inert gas stream representative of the discharge of the drying chamber

10.4.10 All automatic shutdowns required by 10.4.8 shall require manual reset before the dryer can be returned to operation.

10.4.11 If the niobium powder being dried has been determined, via test requirements in Chapter 4 of this standard, to be combustible, only dryers specifically determined by their manufacturers to be safe for drying combustible materials shall be allowed to be used.

10.4.12 Powder Production.

10.4.12.1* Where niobium powder is present, good housekeeping practices shall be maintained.



10.4.12.2 A hazards analysis acceptable to the authority having jurisdiction shall be conducted to determine that powder-handling practices are suitable for the specific powders being used.

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

10.4.12.4* Scoops, shovels, and scrapers used in the handling of dry niobium powder shall be electrically conductive and shall be bonded or grounded.

10.4.12.5 Hand tools used in handling dry niobium powder shall be made of spark-resistant materials.

10.4.12.6 Care shall be exercised to avoid the presence of an isolated conductor in the vicinity of niobium powder being handled.

10.4.12.7* The use of humidifiers in facilities where dry niobium powder is handled shall be considered.

10.4.12.8 Sintering furnaces that handle niobium parts that are fabricated from powder shall be installed and operated in accordance with NFPA 86, *Standard for Ovens and Furnaces*.

10.4.12.9 Niobium powder or dust shall not be allowed to accumulate in the furnace or near the heating elements.

10.4.12.10 Furnaces shall be operated with inert atmospheres, such as helium or argon, or under vacuum.

10.4.13 Electrical Installations.

10.4.13.1* All niobium powder production, drying, and packaging areas shall be evaluated for fire and explosion hazards associated with the operation and shall be provided with approved electrical equipment suitable for the location.

10.4.13.2 The electrical equipment shall be installed in accordance with the requirements of Article 500 of NFPA 70, *National Electrical Code*.

10.4.13.3 Where dry niobium powders are charged to or discharged from equipment, the containers shall be bonded or grounded.

10.4.13.4 Only conductive containers shall be used for the processing of niobium powders.

10.4.13.5 When dry niobium powder is transferred between containers, the containers shall be bonded and grounded.

10.4.14 Explosion Prevention and Protection.

10.4.14.1* Explosion Risk Evaluation and Explosion Suppression Design. A documented risk evaluation acceptable to the authority having jurisdiction shall be conducted to determine the level of explosion protection to be provided for the process. The risk evaluation shall take into account the specific nature and properties of the niobium being handled.

10.4.14.2 Where explosion protection is required per 10.4.14.1, one or more of the following methods shall be used:

- (1) Equipment designed to contain the anticipated explosion pressure
- (2)*Correctly designed explosion venting
- (3)*Explosion suppression system meeting the requirements of NFPA 69, *Standard on Explosion Prevention Systems*
- (4) Inert gas used to reduce the oxygen content within the equipment to below the level prescribed by NFPA 69, *Standard on Explosion Prevention Systems*

(5)*Inert gas used to reduce the oxygen content within the equipment to below 50 percent of the LOC for the specific form of the material being processed

(6) Oxidant concentration reduction in accordance with NFPA 69, *Standard on Explosion Prevention Systems*

10.4.14.3 If the method specified in 10.4.14.2(5) is used, test data for the specific dust and dilution combinations shall be provided and shall be acceptable to the authority having jurisdiction.

10.4.14.4 Recirculating comfort air shall be permitted to be returned to the work area where tests conducted by an approved testing organization prove that the collector's efficiency is great enough to provide both personnel and property safety in the particular installation.

10.4.14.5 With regard to particulate matter in the cleaned air and accumulations of particulate matter and hydrogen in the work area, systems shall be periodically inspected and maintained to ensure correct operation.

10.4.15* Inerting. A supply of argon or helium as an inerting agent shall be provided on site at all times for blanketing and purging equipment.

10.4.16 Electrical Equipment. All electrical wiring and equipment shall comply with Article 500 of NFPA 70, *National Electrical Code*.

10.4.17 Personnel Safety Precautions.

10.4.17.1* Personnel handling niobium powder shall wear static-dissipative footwear and flame-resistant clothing that are designed to minimize the accumulation of niobium powder. Static-dissipative footwear in conjunction with static-dissipative flooring and flame-resistant clothing shall be used unless a hazards analysis shows that the footwear in conjunction with static-dissipative flooring and flame-resistant clothing is not required.

10.4.17.2 Personnel handling niobium powder who wear gloves shall wear gloves made from conductive materials, unless other chemicals or hazardous materials in use require alternative materials of construction to provide protection.

10.4.17.3 Backup methods or systems shall be provided to allow for the orderly shutdown of critical processes in case of primary system failure.

10.4.17.4* Niobium powder shall be handled only by trained personnel who are knowledgeable of the hazards associated with niobium powder.

10.4.17.5 Access to niobium powder-handling areas by unauthorized personnel shall not be permitted.

10.5 End Users of Niobium Powder.

10.5.1 Equipment shall be constructed to mitigate the potential for ignition of niobium powder.

10.5.2* All electrical wiring and equipment shall be installed in accordance with NFPA 70, *National Electrical Code*, and all components of equipment shall be electrically bonded and grounded.

10.5.3 A hazards analysis shall be performed for areas where niobium powder is present to determine risk factors and applicable controls.

10.5.4 Where the hazards analysis shows that controls are required to manage the risk of static generation, and static-dissipative flooring or static-dissipative floor mats are required,

personnel shall wear static-dissipative footwear or equivalent grounding devices.

10.5.5* Where static-dissipative flooring or static-dissipative floor mats are required, personnel shall wear flame-resistant clothing designed to minimize the accumulation of niobium powder.

10.5.6* Spark-resistant tools shall be used.

10.5.7 Backup methods or systems shall be provided to allow for the orderly shutdown of critical processes in the case of primary system failure.

10.5.8* Niobium Powder Storage.

10.5.8.1 Niobium powder-handling areas or niobium powder-processing areas shall not be used for primary storage of niobium.

10.5.8.1.1 Primary storage of ordinary combustible materials and flammable and combustible liquids shall be prohibited in niobium-processing areas.

10.5.8.2 Stacked Storage.

10.5.8.2.1 Where niobium powder is stored in sealed containers, stacked storage shall be arranged to ensure stability.

10.5.8.2.2 Aisles shall be provided for maneuverability of material-handling equipment, for accessibility, and to facilitate fire-fighting operations.

10.5.8.3 Dry Niobium Powder Handling.

10.5.8.3.1 Precautions shall be taken to prevent spills or dispersions that produce niobium dust clouds.

10.5.8.3.2 Sintering furnaces that handle compacted niobium powder shall be installed and operated in accordance with NFPA 86, *Standard for Ovens and Furnaces*.

10.5.8.3.2.1 Niobium powder or dust shall not be allowed to accumulate in the furnace or near the heating elements.

10.5.8.3.2.2 Furnaces shall be operated with inert atmospheres of argon or helium or under vacuum.

10.5.8.4 Wet Niobium Powder Handling. Water-wetted powder, when air dried at atmospheric pressure, shall be at a temperature not exceeding 80°C (176°F).

10.5.8.4.1 Powders wetted with fluids other than water, when dried in air, shall be dried at a temperature governed by the characteristics of the fluid but not exceeding 80°C (176°F).

10.5.8.4.2 When drying niobium powders under controlled atmospheric conditions (for example, vacuum or inert atmosphere) and the temperature exceeds 80°C (176°F), the niobium shall be cooled to less than 80°C (176°F) prior to exposure to air.

10.5.8.5 Heat Treatment and Passivation.

10.5.8.5.1 General.

10.5.8.5.1.1 Equipment shall be designed, constructed, installed, and operated to mitigate the potential for accumulation and ignition of niobium.

10.5.8.5.1.2 Fuel supply lines to gas-fired furnaces or other gas-fired equipment shall be installed and maintained in accordance with NFPA 54, *National Fuel Gas Code*.

10.5.8.5.1.3 Furnaces shall comply with NFPA 86, *Standard for Ovens and Furnaces*.

10.5.8.5.2 Electrical Installations. The electrical equipment shall be installed in accordance with the requirements of NFPA 70, *National Electrical Code*.

10.5.8.6 Personnel Safety Precautions.

10.5.8.6.1 Niobium metal shall be handled only by trained personnel who are knowledgeable of the hazards associated with niobium.

10.5.8.6.2 Access to niobium-handling areas by unauthorized personnel shall not be permitted.

10.5.8.6.3 Backup methods or systems shall be provided to allow for the orderly shutdown of critical processes in the case of primary system failure.

10.5.8.7 Niobium Powder Heat Treatment and Sintering.

10.5.8.7.1 After niobium powder furnacing, the niobium powder shall be passivated prior to exposure to air atmosphere.

10.5.8.7.2 Furnaced niobium powder shall be cooled to 50°C (122°F) or less prior to starting passivation.

10.5.8.7.3 Furnaced niobium powder shall be monitored during passivation to ensure that uncontrolled oxidation, resulting in unacceptable temperature increase of the niobium, does not occur.

10.5.8.8* Heat Treatment and Sintering of Niobium Compacts.

10.5.8.8.1 Sintered niobium compacts shall be cooled to 50°C (122°F) or less prior to removal from the furnace.

10.5.8.8.2 Sintered niobium compacts shall be isolated from other combustible materials until their temperature has stabilized below 50°C (122°F).

10.5.8.9 Safety Precautions.

10.5.8.9.1 If the furnace primary cooling source fails, an alternative system shall provide cooling for the furnace for any required cooldown time period.

10.5.8.9.2 The alternative cooling system specified in 10.5.8.9.1 shall be activated automatically on failure of the main cooling source and shall be interlocked to prevent operation of the furnace.

10.6 Processing and Handling.

10.6.1 Machinery and Operations. (Reserved)

10.6.2 Flake and Paste. (Reserved)

10.6.3 Plasma Spray Operations. (Reserved)

10.6.4 Transfer Operations. (Reserved)

10.6.5 Processing Recycled Material. (Reserved)

10.7 Machining, Fabrication, and Finishing.

10.7.1 Hot Work Operations. See 10.9.4.

10.7.2 Chip Processing. (Reserved)

10.7.3 Dust Collection.

10.7.3.1 Dust-Producing Operations.

10.7.3.1.1 Machines that produce fine particles of niobium 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.

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

10.7.3.1.1.2 Dust shall be collected by means of suitable hoods or enclosures at each operation.

10.7.3.1.2* 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 are as straight as possible

10.7.3.1.3 Dust collection systems handling niobium shall be provided with explosion protection as required under 10.4.5.

10.7.3.2 Dust-Collecting Ducts and Ductwork.

10.7.3.2.1 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*.

10.7.3.2.2 Ducts shall be designed to maintain a velocity of not less than 1372 m/min (4500 ft/min) to ensure the transport of both coarse and fine particles and to ensure re-entrainment if, for any reason, the particles fall out before delivery to the collector (e.g., in the event of a power failure).

10.7.3.2.3 Ducts shall be designed to handle a volumetric flow rate that maintains dust loading safely below the MEC.

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

10.7.3.2.5 The discharge duct for all dust collection equipment shall terminate at a safe outdoor location except where permitted by 10.7.3.3.2.

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

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

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

10.7.3.2.6.3 Additional branch ducts shall not be added to an existing system without redesign of the system.

10.7.3.2.6.4 Branch ducts shall not be disconnected, and unused portions of the system shall not be blanked off, without provision of means to maintain required airflow.

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

10.7.3.3* Wet-Type Dust Collectors.

10.7.3.3.1 The exhaust vent shall terminate outside the building and shall be fastened securely.

10.7.3.3.2 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 safety 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.

10.7.3.3.3 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.

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

10.7.3.3.5 The dust collector shall be arranged so as to prevent contact between dust particles and parts moving at high speed.

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

10.7.3.3.7* The dust collector shall be arranged so that the dust-laden air stream shall be thoroughly scrubbed by the liquid to achieve the desired efficiency.

10.7.3.3.8 The use of additional dry-filter media downstream of a wet collector shall not be permitted.

10.7.3.4 Collector Sump Venting. The sump of water wet-type dust collectors shall be ventilated at all times.

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

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

10.7.3.4.3* 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 activate visual and audible alarms at the equipment it serves and at an area that is occupied whenever the equipment is in operation.

10.7.3.4.4 A time delay switch or equivalent device shall be provided on the dust-producing equipment to prevent starting of its motor drive until the collector is in complete operation.

10.7.3.5* Dry-Type Dust Collectors.

10.7.3.5.1 Electrostatic and media collectors shall not be used.

10.7.3.5.2 Dry-type cyclone dust collectors shall be located outside buildings.

10.7.3.5.3 Dry dust collection systems shall be designed and maintained so that internal cleanliness is ensured.

10.7.3.5.3.1 The accumulation of material inside any area of the collector other than in the discharge containers designed for that purpose shall not be permitted.

10.7.3.5.3.2 Accumulation or condensation of water at any point in the dry dust collection system shall be prevented.

10.7.3.5.4 Dust shall be removed from the dry collectors at the end of each workday and at more frequent intervals if conditions warrant.

10.7.3.5.4.1 Extreme care shall be taken in removing dust from the collectors to avoid creating dust clouds.

10.7.3.5.4.2* The dust shall be discharged into properly bonded and grounded metal containers that shall be promptly covered to avoid the creation of airborne fugitive dust.

10.7.3.5.5* The cyclone dust collector shall be of conductive metal construction applicable for the service intended.

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

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

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

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

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

10.7.3.7 Recycling of Exhaust Air. Recycling of air from dry dust collectors into buildings shall be prohibited.

10.8 Storage and Handling.

10.8.1 Storage of Product.

10.8.1.1 Storage with Incompatible Materials. Niobium shall not be stored in an area with incompatible materials.

10.8.1.2 Scrap Storage.

10.8.1.2.1 Open storage of sheet, plate, forgings, or massive pieces of scrap shall be permitted.

10.8.1.2.2 Storage of scrap, chips, fines, and dust that are ignitable shall be isolated and segregated from other combustible materials to prevent propagation of a fire.

10.8.1.3 Powder Storage.

10.8.1.3.1* Niobium powder shall be stored in covered containers.

10.8.1.3.2 Niobium storage areas shall be free of combustible goods (other than the container used to store the niobium) and plainly marked with "No Open Flame" signs.

10.8.1.3.3 Where drums or other containers are used for storage, storage shall be limited to a height that would require no more than three movements using available equipment to move a stack.

10.8.1.3.4 Under no circumstances shall stack height exceed 3.1 m (10 ft).

10.8.1.3.5 Stacked storage shall be arranged to ensure stability.

10.8.1.3.6 Aisles shall be provided for maneuverability of material-handling equipment, for accessibility, and to facilitate fire-fighting operations.

10.8.1.4 Other Production Materials.

10.8.1.4.1 Magnesium Operations. All magnesium storage, handling, and processing operations in niobium production operations shall be in accordance with the requirements of Chapter 9.

10.8.1.4.2 Flammable and Combustible Liquids. Storage and handling of flammable and combustible liquids shall be in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.

10.8.2 Scrap Handling, Storage, and Disposal. Scrap handling, storage, and disposal shall be in accordance with Chapter 16.

10.8.3 Recycling. Recycling shall be in accordance with Chapter 16.

10.8.4 Chip Processing. (Reserved)

10.9 Fire and Explosion Protection.

10.9.1 Fire and explosion protection shall be in accordance with Chapter 15.

10.9.2* Housekeeping.

10.9.2.1 Dust Control. (Reserved)

10.9.2.2 Good housekeeping practices shall be followed so that accumulations of niobium powder are minimized.

10.9.2.3 Special attention shall be paid to niobium powder accumulations in crevices and joints between walls and floors. (See 11.9.6.1.)

10.9.3 Control of Ignition Sources.

10.9.3.1 Hot Work.

10.9.3.1.1* 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 10.9.3.1.

10.9.3.1.2 Hot-work permits shall be required in any areas that contain combustible metals or combustible metal powders, fines, dust, or sponge.

10.9.3.1.3 Open flames, cutting or welding operations, 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.

10.9.3.1.4 All hot-work areas that require a permit shall be thoroughly cleaned of combustible metals or exposed combustible metal powders, fines, dust, or sponge before hot work is performed.

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

10.9.3.2 Smoking.

10.9.3.2.1* Smoking shall not be permitted in areas where combustible metal, sponge, chips, or powder is present.

10.9.3.2.2 Smoking shall be permitted only in designated areas.

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

10.9.3.2.4 Matches and lighters shall be prohibited in no-smoking areas.

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

10.9.3.3 Spark-Resistant Tools.

10.9.3.3.1 Where tools and utensils are used in areas handling combustible metals, powders, fines, or dusts, consideration shall be given to the risks associated with impact sparks and static electricity.



10.9.3.3.2* Tools used in the handling of combustible metal powders, dusts, or fines shall be electrically conductive and shall be made of spark-resistant materials.

10.9.3.3.3 Spark-resistant tools shall be used when repairs or adjustments are made on or around any machinery or apparatus where combustible metal dusts, fines, or powders are present and cannot be removed.

10.9.4* Hot Work Operations. Hot work, exclusive of process activities, shall not be permitted in areas where combustible forms of niobium are present until exposed equipment has been cleaned thoroughly.

10.9.5 Control of Combustible Material.

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

10.9.5.1.1 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).

10.9.5.1.2 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*.

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

10.9.5.2 Ordinary Combustible Storage.

10.9.5.2.1 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.

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

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

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

10.9.5.3.2 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.

10.9.6 Inspection, Maintenance, and Testing. (Reserved)

10.10 Other. (Reserved)

Chapter 11 Tantalum

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 where tantalum dusts, pastes, and/or powders are produced or handled.

11.1.1.1 In tantalum powder-handling or -manufacturing buildings and in the operation of powder-conveying systems, pre-

cautions 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.

11.1.2 Housekeeping.

11.1.2.1 Cleanup Procedures for Fugitive Dust Accumulations.

11.1.2.1.1* Fugitive dust shall not be allowed to accumulate.

11.1.2.1.2 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 11.1.2.3

11.1.2.1.3 Special attention shall be paid to tantalum powder accumulations in crevices and joints between walls and floors. (See 11.9.6.1.)

11.1.2.2 Cleanup of Spilled Tantalum Powder.

11.1.2.2.1 Spills shall be removed at once, using conductive scoops and soft bristle brushes having natural fiber bristles. Scoops shall be nonsparking unless otherwise authorized for the specific application.

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

11.1.2.3* Vacuum Cleaning Systems.

11.1.2.3.1 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.

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

11.1.2.3.3* Due to the inherent hazards associated with the use of fixed and portable vacuum cleaning systems for finely divided combustible aluminum dust, special engineering consideration shall be given to the design, installation, maintenance, and use of such systems.

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

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

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

11.1.2.3.5.1 Assembled components shall be conductive and bonded where necessary.

11.1.2.3.5.2 Periodic tests for continuity shall be performed.

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

11.1.2.4 Compressed Air Cleaning Requirements. Compressed air blowdown shall not be permitted, only except in certain areas that are otherwise impossible to clean by vacuuming or other means and, where permitted, shall be performed under carefully controlled conditions with all potential ignition sources prohibited in or near the area and with all equipment shut down.

11.1.2.4.1 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.

11.1.2.5 Water Cleaning Requirements. 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.

11.1.2.6 Cleaning Frequency.

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

11.1.2.6.2 Regular, periodic cleaning of buildings and machinery, with all machinery idle and powered off, shall be carried out as frequently as conditions warrant.

11.1.2.6.3 Regular, periodic cleaning of fugitive metal dust from buildings and machinery shall be carried out as frequently as conditions warrant.

11.1.2.6.4 Fugitive metal dust shall be removed to a designated storage or disposal area.

11.1.3 Personal Protective Equipment (PPE).

11.1.3.1 Tantalum metal shall be handled only by trained personnel who are knowledgeable of the hazards associated with tantalum.

11.1.3.2 Personnel involved in tantalum-melting operations shall wear flame-resistant clothing.

11.1.3.2.1 Outer clothing shall be clean, flame retardant, and non-static generating where combustible tantalum dust is present, and shall be designed to be easily removable.

11.1.3.2.1.1 Tightly woven, smooth fabrics treated with a flame-retardant chemical and from which dust can readily be brushed shall be used if necessary.

11.1.3.2.1.2 Wool, silk, or synthetic fabrics that can accumulate high static electric charges shall not be used.

11.1.3.2.2 Work clothing shall be designed to minimize the accumulations of combustible tantalum dust (e.g., trousers shall not have cuffs).

11.1.3.3* Safety shoes shall be static-dissipating, where necessary; shall have no exposed metal; and shall be appropriate for the type of operation taking place.

11.1.3.4* Clothing Fires.

11.1.3.4.1 Emergency procedures for handling clothing fires shall be established.

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

11.1.4 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.

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.

11.1.5.1 The requirements of 11.1.5.2 through 11.1.5.5 shall apply to existing facilities and processes.

11.1.5.2 Written procedures shall be established and implemented to manage a proposed change to process materials, technology, equipment, procedures, and facilities.

11.1.5.3 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
- (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

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

11.1.5.5 Design documentation shall be updated to incorporate the change.

11.1.6 Alternative Methodologies. (Reserved)

11.1.7 Test Results. (Reserved)

11.1.8 Other. (Reserved)

11.2 Facility Design Requirements.

11.2.1 Building Construction.

11.2.1.1 Buildings for the storage, handling, processing, or use of tantalum in a combustible form shall be constructed of noncombustible materials.

11.2.1.2 All buildings shall be of Type I or Type II construction, as defined in NFPA 220, *Standard on Types of Building Construction*.

11.2.1.3 Where local, state, and national building codes require modifications, such modifications shall be permitted for conformance to these codes.

