

NFPA®

484

**Standard for
Combustible Metals**

2019



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NFPA® 484

Standard for

Combustible Metals

2019 Edition

This edition of NFPA 484, *Standard for Combustible Metals*, was prepared by the Technical Committee on Combustible Metals and Metal Dusts and released by the Correlating Committee on Combustible Dusts. It was issued by the Standards Council on May 4, 2018, with an effective date of May 24, 2018, and supersedes all previous editions.

This document has been amended by one or more Tentative Interim Amendments (TIAs) and/or Errata. See “Codes & Standards” at www.nfpa.org for more information.

This edition of NFPA 484 was approved as an American National Standard on May 24, 2018.

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 requirements, including processing, storage, handling, dust collection, housekeeping, and fire protection, for all combustible metals.

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

The 2009 edition of NFPA 484 contained the following changes:

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

The 2012 edition of NFPA 484 contained the following changes:

- (1) A unified format was applied for chapter-to-chapter consistency for the individual combustible metals in the document.
- (2) New definitions were added for dust explosion and dust flash-fire hazard area and a number of particular forms, including metal dust, fines, superfines, ultrafines, flakes, paste, and ribbon. A definition for screening test was added. The committee clarified when the standard would apply rather than when the standard would not apply. New information was included in Chapter 16 to clarify the testing and classification of potentially combustible metals.
- (3) Management of change requirements was added to chapters where it had not been previously identified as a requirement.

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

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

The 2019 edition of NFPA 484 is a complete reorganization of the document. Many of the changes were made to align the document with NFPA 652, the new *Standard on the Fundamental of Combustible Dust*. A new Chapter 7 was added on Dust Hazard Analysis. Chapter 4, General, was added to include material on objectives and compliance options to align with NFPA 652. Chapter 4 now includes requirements on Management of Change and Personnel Protective Equipment. New chapters are added to the document on Nanometals (Chapter 12) and Additive Manufacturing (Chapter 13) to reflect emerging technologies and issues in the metals industry. Chapter 11, Powder and Dust Collection and Centralized Vacuum Systems, is completely rewritten to provide clarity for the users. Chapter 15, Legacy Metals, consolidates the common requirements for aluminum, magnesium, niobium, tantalum, titanium, zirconium, and hafnium into a single location. Note that material that is specific to one of these metals remains in the metal-specific chapters.

In addition to the above changes, definitions in Chapter 3 are reviewed and updated to correlate with those in NFPA 652, the fundamentals document. Where requirements in the code are retroactive, statements indicate this clearly to the user. Material is added to the scope in Chapter 1 to clarify the application of the standard to mixtures of metals and other combustible nonmetal dusts. Changes in Chapter 8 clarify and strengthen the requirements regarding static electricity. Changes are also made to the requirements for electrical area classification, referring to *NFPA 70*[®], *National Electrical Code*[®], but clarify that the committee does not agree with the definition of combustible dust found in *NFPA 70*. The committee also clarifies that the zone classification system is not to be used for metal dusts.

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

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

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NFPA 484

Standard for

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

Chapter 1 Administration

1.1* Scope. This standard provides requirements for 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 5 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 provides requirements for operations where metal or metal alloys are subjected to processing or finishing operations that produce combustible powder or dust.

N 1.1.2.2* This standard shall apply to the storage or use of ignitable fibers/flyings, specifically with regard to fire hazards.

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

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

Δ 1.1.4 Metals, metal alloy parts, and those materials and mixtures, including scrap, not covered by a specific metal chapter, are subject to the requirements of Chapter 16.

1.1.5 Materials submitted for recycling or waste disposal shall be subject to the requirements of Chapter 17.

1.1.6* This standard provides requirements for mixtures that contain metals exhibiting combustion characteristics of metals covered by this standard. (See 5.1.4 for additional information on testing and characterization.)

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

Δ 1.1.6.2* Metal-containing mixtures that also contain combustible nonmetal dusts shall be permitted to be excluded from this standard and protected according to NFPA 652 and NFPA 654 or another NFPA industry- or commodity-specific standard, if by testing it is established that the mixture meets all of the following criteria:

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

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

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

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

N 1.1.9.1 Applicability thresholds for storage in laboratories shall follow the appropriate occupancy classification as designated by NFPA 45 and threshold quantities per Table 1.1.11.

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

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

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.

Table 1.1.11 Applicability Thresholds by Occupancy

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

1.3 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 Conflicts.

1.4.1 Where a requirement specified in this industry-specific standard differs from a requirement specified in NFPA 652, the requirement in this standard shall be permitted to be used instead.

1.4.2 Where a requirement specified in this standard specifically prohibits a requirement specified in NFPA 652, the prohibition in this standard shall be applied.

1.5 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.

1.5.1 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.

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

1.5.3 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.

1.5.4 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.

1.6 Units and Formulas.

1.6.1 SI Units. Metric units of measurement in this standard shall be in accordance with the modernized metric system known as the International System of Units (SI).

1.6.2* Primary and Equivalent Values. If a value for a measurement as given in this standard is followed by an equivalent value in other units, the first stated value shall be regarded as the requirement.

1.6.3 Conversion Procedure. SI units shall be converted by multiplying the quantity by the conversion factor and then rounding the result to the appropriate number of significant digits.

1.7 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*, 2018 edition.

NFPA 2, *Hydrogen Technologies Code*, 2016 edition.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2018 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2018 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, 2018 edition.

NFPA 34, *Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*, 2018 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 2015 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2019 edition.

NFPA 54, *National Fuel Gas Code*, 2018 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition.

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

NFPA 70®, *National Electrical Code®*, 2017 edition.

NFPA 77, *Recommended Practice on Static Electricity*, 2019 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2019 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2019 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*, 2015 edition.

NFPA 101®, *Life Safety Code*®, 2018 edition.

NFPA 220, *Standard on Types of Building Construction*, 2018 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2018 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 2017 edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*, 2018 edition.

NFPA 600, *Standard on Facility Fire Brigades*, 2015 edition.

NFPA 652, *Standard on the Fundamentals of Combustible Dust*, 2019 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2017 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2017 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2017 edition.

NFPA 1081, *Standard for Industrial Fire Brigade Member Professional Qualifications*, 2018 edition.

NFPA 2112, *Standard on Flame-Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire*, 2018 edition.

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

NFPA 5000®, *Building Construction and Safety Code*®, 2018 edition.

2.3 Other Publications.

▲ **2.3.1 ASME Publications.** ASME International, Two Park Avenue, New York, NY 10016-5990.

ASME B31.3, *Process Piping*, 2016.

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

ASTM E11, *Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves*, 2017.

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 2016a.

ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*, 2012a.

ASTM E2019, *Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air*, 2003, reapproved 2013.

ASTM F1002, *Standard Performance Specification for Protective Clothing and Materials for Use by Workers Exposed to Specific Molten Substances and Related Thermal Hazards*, 2015.

■ **2.3.3 ISA Publications.** International Society of Automation, 67 T. W. Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709.

ISA 84.00.01, *Functional Safety: Application of Safety Instrumented Systems for the Process Industry Sector*, 2004.

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

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

▲ 2.3.5 Other Publications.

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

▲ 2.4 References for Extracts in Mandatory Sections.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2019 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition.

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

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*, 2015 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2018 edition.

NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 2021 edition.

NFPA 652, *Standard on the Fundamentals of Combustible Dust*, 2019 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2017 edition.

NFPA 921, *Guide for Fire and Explosion Investigations*, 2017 edition.

NFPA 1250, *Recommended Practice in Fire and Emergency Service Organization Risk Management*, 2015 edition.

NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018 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. An NFPA Standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase “standards development process” or “standards development activities,” the term “standards” includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

N 3.3.1* Air-Material Separator (AMS). A device designed to separate the conveying air from the material being conveyed. [654, 2017]

N 3.3.1.1 Enclosureless AMS. An air-material separator designed to separate the conveying air from the material being conveyed where the filter media are not enclosed or in a container. [652, 2019]

N 3.3.2* Air-Moving Device (AMD). A power-driven fan, blower, or other device that establishes an airflow by moving a given volume of air or gas per unit time. [652, 2019]

3.3.3 Alkali Metals. See 3.3.45.1.

3.3.4 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.

3.3.5 Aluminum Powder. See 3.3.56.3.

N 3.3.6 Bonding. For the purpose of controlling static electric hazards, the process of connecting two or more conductive objects by means of a conductor so that they are at the same electrical potential but not necessarily at the same potential as the earth. [652, 2019]

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

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

N 3.3.8* Centralized Vacuum Cleaning System. A fixed-pipe system utilizing variable-volume negative-pressure (i.e., vacuum) air flows from remotely located hose connection stations to allow the removal of dust accumulations from surfa-

ces and conveying those dusts to an air-material separator (AMS). [652, 2019]

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

N 3.3.10* Combustible Dust. A finely divided combustible particulate solid, including combustible fibers/flyings, that presents a flash-fire hazard or explosion hazard when suspended in air or the process-specific oxidizing medium over a range of concentrations. [652, 2019]

N 3.3.11* Combustible Fibers/Flyings. Fibers/flyings, where any dimension is greater than 500 µm in nominal size, which can form an explosible mixture when suspended in air at standard atmospheric pressure and temperature. [499, 2021]

3.3.12 Combustible Metal. See 3.3.45.2.

Δ 3.3.12.1* Combustible Metal Dust. A combustible particulate metal, including combustible fibers/flyings, that presents a fire or explosion hazard when suspended in air or the process-specific oxidizing medium over a range of concentrations.

3.3.12.2 Combustible Metal Particulate. See 3.3.12.1, Combustible Metal Dust.

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

N 3.3.13* Combustible Particulate Solid. Any solid material composed of distinct particles or pieces, regardless of size, shape, or chemical composition, that, when processed, stored, or handled in the facility, has the potential to produce a combustible dust. [652, 2019]

N 3.3.14 Compartment. A subdivision of an enclosure. [652, 2019]

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

3.3.16 Deflagration. Propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium. [68, 2018]

3.3.17 Deflagration Hazard Area.

3.3.17.1 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.

3.3.17.2 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.

N 3.3.18 Detachment. A hazard management strategy in which the hazard is located in a separate building or an outside area, removed from other structures to be protected by a distance as required by this standard. [654, 2017]

3.3.19 Dryer. A piece of processing equipment using temperature or pressure change to reduce the moisture or volatile content of the material being handled. [654, 2017]

3.3.20 Duct. Pipes, tubes, or other enclosures used for the purpose of pneumatically conveying materials. [91, 2015]

▲ **3.3.21 Dust.** See 3.3.12.1, Combustible Metal Dust.

N **3.3.21.1* Dust Collection System.** A combination of equipment designed to capture, contain, and pneumatically convey fugitive dust to an air-material separator (AMS) in order to remove the dust from the process equipment or surrounding area. [652, 2019]

N **3.3.21.1.1 Dry-Type Dust Collector.** A device that does not use liquid to separate the material being conveyed from the conveying medium, such as cyclones or media collectors.

N **3.3.21.1.2 Wet-Type Dust Collector.** A device that uses liquid to separate the material being conveyed from the conveying medium.

N **3.3.21.2 Dust Deflagration Hazard.** A condition that presents the potential for harm or damage to people, property, or the environment due to the combustion of a sufficient quantity of combustible dust suspended in air or another oxidizing medium. [652, 2019]

N **3.3.21.3 Dust Explosion Hazard.** A dust deflagration hazard in an enclosure that is capable of bursting or rupturing the enclosure due to the development of internal pressure from the deflagration. [652, 2019]

N **3.3.21.4* Dust Hazards Analysis (DHA).** A systematic review to identify and evaluate the potential fire, flash fire, or explosion hazards associated with the presence of one or more combustible particulate solids in a process or facility. [652, 2019]

▲ **3.3.22 Eutectic Reaction. (Reserved)**

N **3.3.23* Explosible.** Capable of propagating a deflagration when dispersed in air or the process-specific oxidizing media. [652, 2019].

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

3.3.25 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.

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

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

N **3.3.26 Fire Hazard.** Any situation, process, material, or condition that, on the basis of applicable data, can cause a fire or provide a ready fuel supply to augment the spread or intensity of a fire and poses a threat to life or property. [652, 2019]

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

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

N **3.3.29* Flash Fire.** A deflagration that spreads through a combustible dust, gas, or vapor cloud without the production of damaging pressure.

N **3.3.30 Fuel Object.** A combustible object or mass of particulate that can serve as a source of fuel for a fire or deflagration; sometimes referred to as a *fuel package*. [652, 2019]

N **3.3.31 Fugitive Dusts.** Dust that escapes from equipment and containers. [652, 2019]

3.3.32 Fugitive Material. See 3.3.42.1.

N **3.3.33 Grounding.** The process of bonding one or more conductive objects to the ground so that all objects are at zero electrical potential; also referred to as *earthing*. [652, 2019]

3.3.34 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.

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

▲ **3.3.36 Hot Work.** Work involving burning, welding, or a similar operation that is capable of initiating fires or explosions. [51B, 2019]

N **3.3.37* Hybrid Mixture.** An explosible heterogeneous mixture, comprising gas with suspended solid or liquid particulates, in which the total flammable gas concentration is ≥ 10 percent of the lower flammable limit (LFL) and the total suspended particulate concentration is ≥ 10 percent of the minimum explosible concentration (MEC). [68, 2018]

N **3.3.38* Ignitable Fibers/Flyings.** Fibers/flyings where any dimension is greater than 500 μm in nominal size, which are not likely to be in suspension in quantities to produce an explosible mixture, but could produce an ignitable layer fire hazard. [499, 2021]

3.3.39* 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.

N **3.3.40* Industry- or Commodity-Specific Standard.** An NFPA code or standard whose intent as documented within its purpose or scope is to address fire and explosion hazards of a combustible particulate solid. [652, 2019]

N **3.3.41 Limiting Oxidant Concentration (LOC).** The concentration of oxidant in a fuel-oxidant-diluent mixture below which a deflagration cannot occur under specified conditions. [69, 2014]

3.3.42 Material.

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

▲ **3.3.42.2* Pyrophoric Material.** A material that ignites upon exposure to air at or below 54.4°C (130°F).

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

3.3.43 Media Collector. An air-material separator (AMS) that uses filter bags or cartridges for air/gas flow and dust separation.

3.3.44* Mesh Size. The dimensions of a mesh that are specified in ASTM E11, *Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves*.

3.3.45* 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.

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

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

N 3.3.45.3* Legacy Metals. The metals aluminum, magnesium, niobium, tantalum, titanium, zirconium, and hafnium.

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

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

3.3.46* 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, 2017]

N 3.3.47* Minimum Ignition Energy (MIE). The lowest capacitive spark energy capable of igniting the most ignition-sensitive concentration of a flammable vapor–air mixture or a combustible dust–air mixture as determined by a standard test procedure. [654, 2017]

3.3.48 Mixtures. (Reserved)

N 3.3.49* Nanometal Powder. Any metal powder produced with a characteristic size smaller than 500 nanometers (0.5 µm), which can include powders where only a fraction of the material produced is less than 500 nanometers (0.5 µm). (See also Section 12.2.2.)

3.3.50* 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.

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

3.3.51.1 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.

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

3.3.52.1 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.

N 3.3.53* Pneumatic Conveying System. An equipment system that transfers a controlled flow of solid particulate material from one location to another using air or other gases as the conveying medium, and that is comprised of the following components: a material feeding device; an enclosed ductwork, piping, or tubing network; an air–material separator; and an air-moving device. [652, 2019]

N 3.3.54 Portable AMS (Dust Collector). A portable machine designed to collect airborne dust produced from a dust-generating operation.

N 3.3.55 Portable Vacuum Cleaner. A portable machine for collecting settled fugitive dust from floors and other surfaces.

3.3.56 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.

3.3.56.1* Aluminum Flake Powder. See 3.3.56.3, Aluminum Powder.

3.3.56.2 Aluminum Granular Powder. See 3.3.56.3, Aluminum Powder.

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

3.3.56.4* 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 5.

3.3.56.5 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.

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

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

3.3.58 Pyrophoric Material. See 3.3.42.2.

N 3.3.59 Qualified Person. A person who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by knowledge, training, and experience, has demonstrated the ability to deal with problems related to the subject matter, the work, or the project. [1451, 2018]

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

3.3.61 Replacement-in-Kind. A replacement that satisfies the design specifications of the replaced item. [652, 2019]

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

3.3.62.1* Magnesium Ribbon. Magnesium metal that is less than 3.2 mm ($\frac{1}{8}$ in.) in two dimensions or less than 1.3 mm ($\frac{1}{20}$ in.) in single dimension, also considered a powder for the purpose of this standard.

N 3.3.63* Risk Assessment. An assessment of the likelihood, vulnerability, and magnitude of the incidents that could result from exposure to hazards. [1250, 2015]

3.3.64 Screening Test. For the purposes of this standard, a test performed to determine whether a material or mixture exhibits fire-, explosion-, or water-reactivity-related characteristics.

N 3.3.65 Segregation. A hazard management strategy in which a physical barrier is established between the hazard area and an area to be protected. [654, 2017]

N 3.3.66 Separation. A hazard management strategy achieved by the establishment of a distance as required by the standard between the combustible particulate solid process and other operations that are in the same room. [654, 2017]

N 3.3.67 Spark. A moving particle of solid material that emits radiant energy due to either its temperature or the process of combustion on its surface. [654, 2017]

3.3.68 Spark-Resistant Material. See 3.3.42.3.

3.3.69* Sponge. A porous metal product obtained by processing metal ore prior to being melted.

3.3.70 Spontaneous Heating. Process whereby a material increases in temperature without drawing heat from its surroundings. [921, 2017]

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

3.3.72 Tantalum Powder. See 3.3.56.5.

3.3.73 Tantalum Ultrafines. (Reserved)

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

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

3.3.76 Titanium Fines. (Reserved)

N 3.3.77 Wall.

N 3.3.77.1 Fire Barrier Wall. A wall, other than a fire wall, having a fire resistance rating. [221, 2018]

N 3.3.77.2 Fire Wall. A wall separating buildings or subdividing a building to prevent the spread of fire and having a fire resistance rating and structural stability. [221, 2018]

3.3.78 Zirconium Fines. (Reserved)

Chapter 4 General

N 4.1 Retroactivity. Sections 4.3 through 4.6 shall apply retroactively.

N 4.2 Owner's Obligation. The facility owner/operator shall be responsible for ensuring that the facility and the systems handling combustible particulate solids are designed, installed, and maintained in accordance with the requirements of this standard and NFPA 652.

N 4.3 Objectives.

N 4.3.1 The design of the facility, processes, and equipment shall be intended to meet the following objectives:

- (1) Life safety
- (2) Structural integrity
- (3) Mission continuity
- (4) Mitigation of fire spread, explosions, or consequential releases of hazardous materials

N 4.3.1.1 The objectives stated in 4.3.1 shall be interpreted as intended outcomes of this standard and not as prescriptive requirements.

N 4.3.1.2 The objectives stated in Section 4.3 shall be deemed to be met when, consistent with 4.3.1 and the provisions in Sections 1.4 and 1.5, both of the following are met:

- (1) The facility, processes, and equipment are designed, constructed, and maintained in accordance with the prescriptive criteria set forth in this standard.
- (2) The management systems set forth in this standard are implemented.

N 4.3.1.3 Where a performance-based alternative design is used, it shall be documented to meet the same objectives as the prescriptive design it replaces in accordance with Chapter 6.

N 4.3.2* Life Safety. The life safety objective shall be deemed to have been met when, consistent with 4.3.1, the provisions in Sections 1.4 and 1.5 and the following are met:

- (1) The facility, combustible particulate processes, and human element programs are 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 consequential release of hazardous materials for the time needed to evacuate, relocate, or take refuge.
- (2) The structure is located, designed, constructed, and maintained to minimize the propagation of fire, explosion, or the consequential release of hazardous materials to adjacent properties and to avoid injury to the public.

N 4.3.3 Structural Integrity. The structural integrity objective shall be deemed to have been met when, consistent with 4.3.1, the provisions in Sections 1.4 and 1.5 are met, and the facility is designed, constructed, and equipped to maintain its structural integrity in spite of the effects of fire, explosion, or the consequential release of hazardous materials for the time necessary to evacuate, relocate, or defend in place occupants not in the immediate proximity of the ignition.

N 4.3.4* Mission Continuity. The mission continuity objective shall be deemed to have been met when, consistent with 4.3.1, the provisions in Sections 1.4 and 1.5 are met, and the facility, processes, equipment, and human element program are 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.

N 4.3.5* Mitigation of Fire Spread, Explosions, and Consequential Release of Hazardous Materials. The mitigation of fire spread and explosions shall be deemed to have been met when, consistent with 4.3.1, the provisions in Sections 1.4 and 1.5 and the following are met:

- (1)* The facility and processes are designed to prevent fires, explosions, or consequential 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.
- (2)* The structure is designed, constructed, and maintained to prevent fire or explosions from causing failure of load-bearing structural members, propagating into adjacent interior compartments, and/or incapacitating fire-protective and emergency life safety systems in adjacent compartments.
- (3) The structure is located, designed, constructed, equipped, and maintained to prevent the propagation of fire or explosion to or from adjacent storage or structures.

N 4.3.6 Where a dust fire, deflagration, or explosion hazard exists within a process system, the hazards shall be managed in accordance with this standard.

N 4.3.7 Where a dust fire, deflagration, or explosion hazard exists within a facility compartment, the effects of the fire, deflagration, or explosion shall be managed in accordance with this standard.

N 4.3.8* Compliance Options. The objectives in 4.3.1 shall be achieved by either of the following means:

- (1) A prescriptive approach in accordance with Chapter 5 and Chapters 7 through 17, as applicable
- (2) A performance-based approach in accordance with Chapter 6

4.4* Management of Change.

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

4.4.2 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

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

4.4.4 Design documentation shall be updated to incorporate the change.

4.5 Hazard Analysis.

4.5.1* 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, explosion, and reactivity hazards.

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

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

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

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

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

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

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

4.6* Personal Protective Equipment (PPE).

4.6.1 PPE Hazard Analysis.

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

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

4.6.2 Primary PPE for Molten Metals.

4.6.2.1 Primary PPE for molten metals shall include all of the items described in paragraphs 4.6.2.2 to 4.6.2.5.

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

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

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

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

4.6.3 Primary PPE for Dust Flash Fires.

- △ 4.6.3.1* Primary PPE for dust flash fires shall include flame-resistant garments in accordance with the workplace hazard assessment required by NFPA 2113.

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

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

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

4.6.3.4.1 Trousers or coveralls shall cover the tops of footwear.

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

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

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

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

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

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

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

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

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

- △ 4.6.4.5.1* Proper protective clothing, respiratory protection, and adequate eye protection shall be used by all responding fire-fighting personnel assigned to a combustible metal fire equipped to the requirements of NFPA 600 or NFPA 1081.

4.7 Dust Explosion and Flash-Fire Hazard Areas.

4.7.1 Those portions of the process and facility where deflagration venting is not currently required and a dust explosion hazard or flash-fire hazard exists shall be evaluated to determine appropriate protection levels from the effects of these hazards in accordance with this section and the fire protection and building construction sections in each metal chapter — Chapter 14 through 16 — and Chapter 8.

4.7.2 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.

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

4.8.1 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.

4.8.2 Use of Segregation.

4.8.2.1 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.

- △ 4.8.2.2 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.

4.8.2.3 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.

4.8.3 Use of Separation.

4.8.3.1* 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

4.8.3.2 Where separation is used to limit the dust flash-fire hazard area, in no case shall the required separation distance determined in 4.8.3.1 be less than 11 m (35 ft).

4.8.3.3 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.

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

4.8.3.5 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.

N 4.9* Organometallic Materials. (Reserved)

Chapter 5 Determination of the Combustibility or Explosibility of a Metal, Metal Powder, or Metal Dust

5.1* Overview. The screening test in Section 5.3 and in Section 5.4 shall be conducted to determine if a metal is in combustible or explosible form.

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

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

5.1.3 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.

5.1.4 Application of This Document.

5.1.4.1 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. (See 1.1.6 for additional information.)

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

5.1.4.3 Wherever the documentation necessary for compliance with 5.1.2 and 5.1.3 is lacking, the requirements of this document shall apply.

5.1.5* 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.

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

5.1.6 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.

5.2* Basic Material Characterization.

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

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

5.3 Determination of Combustibility.

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

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

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

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

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

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

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

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

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

5.4 Determination of Explosibility.

5.4.1* The explosibility of metals, metal powders, metal dusts, and alloys of these materials shall be determined by using the flow chart in Figure 5.4.1.

5.4.1.1* If the material is determined to be explosible, some or all of the standard test methods in Figure 5.4.1 shall be performed as needed by the hazard analysis as described in Section 4.5. If a sample either ignites during ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*, screening testing prior to ignition source energizing, or results in a positive classification, it shall be considered to be explosible.

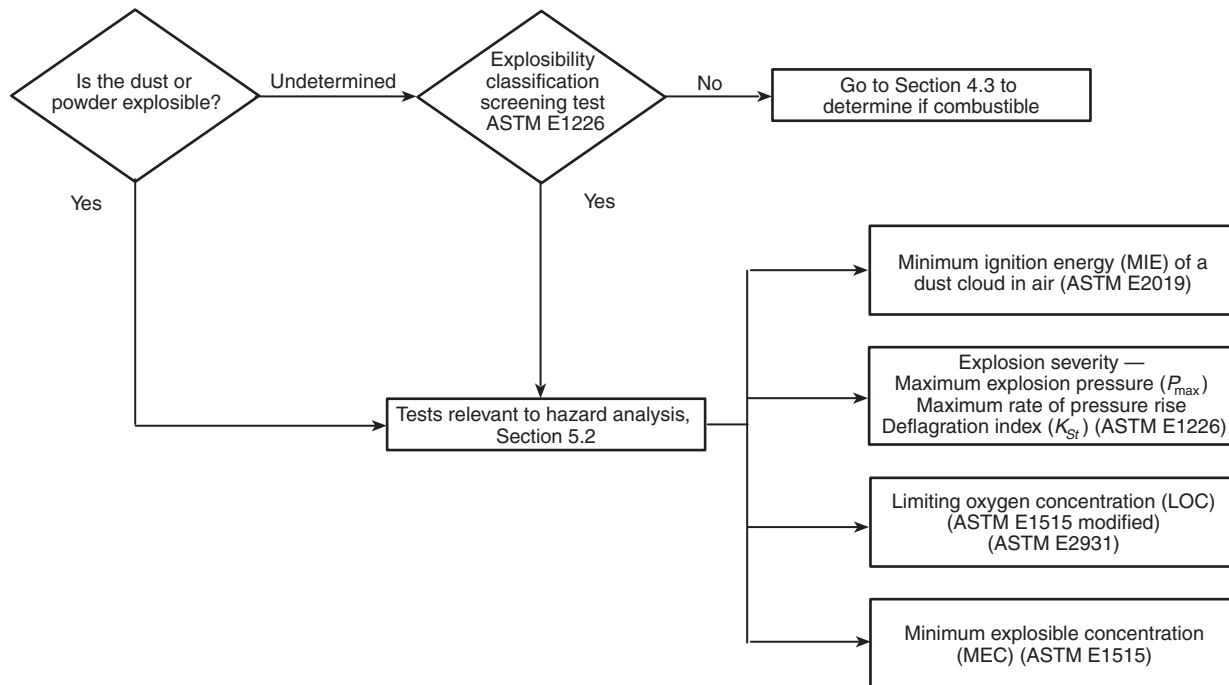
5.4.1.2 Additional tests chosen shall be those relevant to hazard analysis of the intended explosion protection techniques and flash-fire hazards anticipated for the process.

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

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

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

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



▲ FIGURE 5.4.1 Determination of Explosibility.

5.5 Use of Test Data for Hazard Analysis.

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

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

5.6* Determination of Flash Fire Potential. (Reserved)

▲ **5.7 Risk Evaluation.** Where a risk evaluation (*see Annex I*) is required by the AHJ, material property data and material handling and processing conditions shall be reviewed to determine the likelihood and consequences of a metal powder or dust ignition. It shall be permitted to make qualitative determinations of likelihood and consequences, providing at least some of the following property data are included in the determinations:

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

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

- (1) The prescriptive provisions in accordance with Chapter 5 and Chapters 7 through 17
- (2) The performance-based provisions in accordance with Chapter 6

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.

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 **consequential** 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 **consequential** 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 **consequential** 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 **consequential** 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 Consequential 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.

Δ 6.6 Retained Prescriptive Requirements. Portions of a facility designed in accordance with this chapter as an alternative for particular prescriptive requirements shall meet all other relevant prescriptive requirements in this standard.

N Chapter 7 Hazard Analysis

N 7.1* General.

N 7.1.1* Retroactivity. The requirements of Chapter 7 shall apply retroactively.

N 7.1.2 Solid metal in a combustible form shall meet the requirements of Section 5.2.

N 7.1.3 Combustible metal dusts shall meet the requirements of Section 7.2.

N 7.1.4 Molten combustible metals shall meet the requirements of Section 7.3.

N 7.1.5 The design of the fire and explosion safety provisions shall be based on a hazard analysis of the facility, the process, and the associated fire and explosion hazards.

N 7.2 Dust Hazard Analysis (DHA).

N 7.2.1 Responsibility. The owner/operator of a facility where materials that have been determined to be combustible or explosible in accordance with Chapter 5 are present in an enclosure shall be responsible to ensure a DHA is completed in accordance with the requirements of this chapter. [652:7.1.1]

N 7.2.1.1 For existing processes and facility compartments that are undergoing modification, the owner/operator shall complete a DHA.

N 7.2.1.2 New or altered operations, equipment, or facilities shall be reviewed for potential hazards prior to operation.

N 7.2.1.3* The design of the fire and explosion safety provisions shall be based on a hazard analysis of the facility, the process, and the associated fire and explosion hazards.

N 7.2.1.4 The DHA shall be reviewed and updated at least every five years.

N 7.2.2 Criteria.

N 7.2.2.1* Overview. The DHA shall evaluate the fire, deflagration, reactivity, and explosion hazards and provide recommendations to manage the hazards in accordance with Section 4.3. [652:7.2.1]

N 7.2.2.2* Qualifications. The DHA shall be performed or led by a qualified person. [652:7.2.2]

N 7.2.2.2.1 The DHA shall be signed off, prior to operation, by a cognizant authority at the facility.

N 7.2.2.3 Documentation. The results of the DHA review shall be documented, including any necessary action items requiring change to the process materials, physical process, process operations, or facilities associated with the process. [652:7.2.3]

N 7.2.2.3.1 The results of the hazard analysis shall be maintained for the life of the process.

N 7.2.3 Methodology.

N 7.2.3.1 General. The DHA shall include the following:

- (1) Identification and evaluation of the process or facility areas where fire, flash fire, and explosion hazards exist

(2) Where such a hazard exists, identification and evaluation of specific fire and deflagration scenarios shall include the following:

- (a) Identification of safe operating ranges
- (b)* Identification of the safeguards that are in place to manage fire, deflagration, and explosion events
- (c) Recommendation of additional safeguards where warranted, including a plan for implementation

[652:7.3.1]

N 7.2.3.1.1 Recommendations from the DHA shall be tracked to completion.

N 7.2.3.2 Material Evaluation. The DHA shall be based on data obtained in accordance with Chapter 5 for material that is representative of the dust present.

N 7.2.3.3 Process Systems.

N 7.2.3.3.1* Each part of the process system where combustible metal dust is present, or where combustible metal particulate solids could cause combustible metal dust to be present, shall be evaluated, and the evaluation shall address the following:

- (1) Potential intended and unintended combustible metal dust transport between parts of the process system
- (2) Potential fugitive combustible metal dust emissions into a building or building compartments, including powder and fugitive material as defined by this document
- (3) Potential deflagration propagation between parts of the process system
- (4) Reactivity of the combustible metal

N 7.2.3.3.2 Each part of the process that contains a combustible metal particulate solid and that can potentially include both of the following conditions shall be considered a fire hazard and shall be documented as such:

- (1) Oxidizing atmosphere
- (2) Credible ignition source

N 7.2.3.3.3* Each part of the process that contains a sufficient quantity of combustible metal dust to propagate a deflagration and that can potentially include all the following conditions shall be considered a dust deflagration hazard and shall be documented as such:

- (1) Oxidizing atmosphere
- (2) Credible ignition source
- (3) Credible suspension mechanism

N 7.2.3.4 Building or Building Compartments.

N 7.2.3.4.1 Each building or building compartment where combustible metal dust is present shall be evaluated.

N 7.2.3.4.1.1 Where multiple buildings or building compartments present essentially the same hazard, a single evaluation shall be permitted to be conducted as representative of all similar buildings or building compartments. [652:7.3.4.1.1]

N 7.2.3.4.1.2 The evaluation shall address potential combustible metal dust migration between buildings or building compartments.

N 7.2.3.4.1.3 The evaluation shall address potential deflagration propagation between buildings or building compartments. [652:7.3.4.1.3]

N 7.2.3.4.2* Each building or building compartment that contains a combustible metal particulate solid and that can

potentially include both of the following conditions shall be considered a fire hazard and shall be documented as such:

- (1) Oxidizing atmosphere
- (2) Credible ignition source

N 7.2.3.4.2.1 The evaluation of dust deflagration hazard in a building or building compartment shall include a comparison of actual or intended dust accumulation to the threshold housekeeping dust accumulation that would present a potential for flash-fire exposure to personnel or compartment failure due to explosive overpressure. [652:7.3.4.2.1]

N 7.2.3.4.2.2 Threshold housekeeping dust accumulation levels and nonroutine dust accumulation levels (e.g., from a process upset) shall be in accordance with this standard.

N 7.2.3.4.3 Each building or building compartment that contains a sufficient quantity of combustible metal dust to propagate a deflagration and that can potentially include all of the following conditions shall be considered a dust deflagration hazard and shall be documented as such:

- (1) Oxidizing atmosphere
- (2) Credible ignition source
- (3) Credible suspension mechanism

[652:7.3.4.3]

N 7.3 Molten Metal Hazard Analysis.

N 7.3.1 Responsibility. The owner/operator of a facility where combustible metals are present in a molten state shall be responsible to ensure a hazard analysis is completed in accordance with the requirements of this section.

N 7.3.1.1 For existing processes and facility compartments that are undergoing modification, the owner/operator shall complete a hazard analysis.

N 7.3.1.2 New or altered operations, equipment, or facilities shall be reviewed prior to operation for potential hazards.

N 7.3.1.3 The hazard analysis shall be reviewed and updated at least every five years.

N 7.3.2 Criteria.

N 7.3.2.1 Overview. The hazard analysis shall evaluate the fire, reactivity, and explosion hazards and provide recommendations to manage the hazards in accordance with Section 4.3.

N 7.3.2.1.1 Reactivity hazards shall include potential molten metal/water interactions.

N 7.3.2.2* Qualifications. The hazard analysis shall be performed or led by a qualified person.

N 7.3.2.2.1 Hazard analyses shall be signed off, prior to operation, by a cognizant authority at the facility.

N 7.3.2.3 Documentation. The results of the hazard analysis review shall be documented, including any necessary action items requiring change to the process materials, physical process, process operations, or facilities associated with the process.

N 7.3.2.3.1 The results of the hazard analysis shall be maintained for the life of the process.

N 7.3.3 Methodology.

N 7.3.3.1 General. The hazard analysis shall include the following:

- (1) Identification and evaluation of the process or facility areas where fire, reactivity, and explosion hazards exist
- (2) Where such a hazard exists, identification and evaluation of specific fire, reactivity, and deflagration scenarios shall include the following:
 - (a) Identification of safe operating ranges
 - (b)* Identification of the safeguards that are in place to manage fire, reactivity, deflagration, and explosion events
 - (c) Recommendation of additional safeguards where warranted, including a plan for implementation

N 7.3.3.1.1 Recommendations from the hazard analysis shall be tracked to completion.

N 7.3.3.1.2 Hazard analyses shall be signed off, prior to operation, by a cognizant authority at the facility.

N 7.3.3.2 Material Evaluation.

N 7.3.3.2.1 The hazard analysis shall be based on data that is representative of the molten metal present.

N 7.3.3.3 Process Systems.

N 7.3.3.3.1* Each part of the process system where combustible metal in a molten form is present shall be evaluated, and the evaluation shall address the following:

- (1) Potential intended and unintended runout of combustible molten metal between parts of the process system
- (2) Potential runout of combustible molten metal from the process system into a building or building compartments, including potential interaction with water in the building or building compartments
- (3) Potential explosion impacts on other parts of the process system
- (4) Reactivity of the combustible molten metal

N 7.3.3.3.2 Each part of the process that contains a combustible metal in molten form and that can potentially include both of the following conditions shall be considered a fire hazard and shall be documented as such:

- (1) Oxidizing atmosphere
- (2) Combustible loading in the melting area

N 7.3.3.3.3* Each part of the process that contains a sufficient quantity of combustible molten metal to propagate a fire or explosion and that can potentially include all the following conditions shall be considered a fire or explosion hazard and shall be documented as such:

- (1) Oxidizing atmosphere
- (2) Combustible loading in the melting area
- (3) Water or other reactive materials in the melting area

N 7.3.3.4 Building or Building Compartments.

N 7.3.3.4.1 Each building or building compartment where combustible metal in a molten form is present shall be evaluated.

N 7.3.3.4.1.1 Where multiple buildings or building compartments present essentially the same hazard, a single evaluation

shall be permitted to be conducted as representative of all similar buildings or building compartments. [652:7.3.4.1.1]

N 7.3.3.4.1.2 The evaluation shall address potential combustible molten metal flow between buildings or building compartments.

N 7.3.3.4.1.3 The evaluation shall address potential fire or explosion propagation between buildings or building compartments. [652:7.3.4.1.3]

N 7.3.3.4.2 Each building or building compartment that contains a combustible molten metal and that can potentially include both of the following conditions shall be considered a fire hazard and shall be documented as such:

- (1) Oxidizing atmosphere
- (2) Combustible loading in the melting area
- (3) Water or other reactive materials in the melting area

Chapter 8 Fire Prevention, Fire Protection, and Emergency Response

N 8.1 Retroactivity. The requirements of this chapter shall apply retroactively.

8.2 Fire Prevention.**8.2.1 Inspection and Maintenance.**

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

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

- (1) Fire and explosion protection and prevention equipment in accordance with the applicable NFPA codes and standards
- (2) Dust control equipment
- (3) Housekeeping
- (4) Potential ignition sources
- (5) Electrical, process, and mechanical equipment, including process interlocks
- (6) Process changes
- (7) Continuity check on grounding and bonding systems
- (8) Resistivity testing of static-dissipative footwear and conductive floors where required
- (9) Piping systems that carry or transport combustible/flamable gases, liquids, and/or hazardous chemicals, or materials that can interact and present a hazard should a release occur, (i.e., water lines in the vicinity of molten metal).

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

8.2.1.3.1 The inspection shall be conducted at least quarterly.

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

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

8.2.2 Control of Combustible Materials.

- △ 8.2.2.1 Areas in which flammable and combustible liquids are used shall be in accordance with the requirements of NFPA 30.

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

- △ 8.2.2.1.2 Dipping and coating applications of flammable or combustible liquids shall be done in accordance with NFPA 34.

- △ 8.2.2.1.3 Spray application of flammable or combustible liquids shall be done in accordance with NFPA 33.

8.2.2.2 Ordinary Combustible Storage.

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

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

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

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

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

8.2.3* Molten Metal.

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

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

8.3 Fire Protection.

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

8.3.1.1* Automatic sprinkler protection shall not be permitted in areas where combustible metals are produced or handled unless allowed by 8.3.1.2, 8.3.1.3, and 8.3.1.4.

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

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

8.3.1.4 The special hazards associated with metals in a combustible form and in contact with water shall be considered

in the selection, design, and installation of automatic sprinkler systems.

8.3.1.5 Employee training and organizational planning shall be provided to ensure safe evacuation of the areas that contain combustible metal hazards in case of fire in accordance with 8.3.4.

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

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

8.3.2 Sprinkler Protection for Alkali Metals.

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

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

- △ 8.3.2.3 Sprinkler systems installed in accordance with NFPA 13 shall be permitted in areas where combustibles other than alkali metals create a more severe fire hazard than the alkali metals and where acceptable to an authority having jurisdiction knowledgeable of the hazards associated with alkali metals.

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

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

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

8.3.3* Extinguishing Agents and Application Techniques.

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

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

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

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

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

▲ **8.3.3.4** Portable or wheeled extinguishers listed for use on combustible-metal fires shall be provided and shall be distributed in accordance with NFPA 10.

8.3.3.5 The following agents shall not be used as extinguishing agents on a combustible-metal fires because of adverse reactions or ineffectiveness unless they are compatible with the metal and are an effective extinguishing agent (*see 8.3.3*):

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

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

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

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

8.3.3.9* Solvent-Wetted Powders. Incipient fires in solvent-wetted powders shall be handled according to [8.3.3.9.1](#) or [8.3.3.9.2](#).

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

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

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

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

8.3.3.9.2.3 The material shall be handled in covered containers.

8.3.3.10 Applications of Extinguishing Agents. Applications of extinguishing agents shall be handled according to [8.3.3.10.1](#) through [8.3.3.10.4](#).

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

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

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

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

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

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

8.3.4 Fire-Fighting Activities.

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

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

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

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

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

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

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

8.3.4.8 Processing Equipment.

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

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

8.3.4.9 Alkali Metals Fire-Fighting Procedures.

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

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

8.3.5 Fire-Fighting Organization.

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

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

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

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

8.3.5.2.1 Training shall include all possible contingencies.

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

8.4 Emergency Preparedness.

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

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

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

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

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

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

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

- (1) Water, when applied to most burning combustible metals, results in an increase in burning intensity and possible explosion.
- (2) Water applied to alkali metals not involved in the fire will result in hazardous decomposition, ignition, or explosion.
- (3) Application of carbon dioxide on combustible-metal fire adds to the intensity of the burning. Most combustible metals ignite and burn in 100 percent carbon dioxide atmospheres. (See 8.3.3.)
- (4) Dry chemical extinguishers react with alkali metals and intensify the fire.
- (5) Dry chemical extinguishers utilized on non-alkali metal fires are ineffective in controlling the metal fire but might be effective where flammable or combustible liquids are used and the metal is not yet involved in the fire. (See 8.3.3.)
- (6) Halogenated extinguishing agents used on alkali metals can result in an explosion.

- (7) Halogenated extinguishing agents will have a detrimental effect on other combustible metal fires, with the decomposition producing hazardous by-products.
- (8) A primary metal fire displays intense orange-to-white flame and can be associated with a heavy or large production of white or gray smoke.
- (9) When water is applied to non-alkali combustible metal, it can disassociate to the basic compounds, oxygen and hydrogen. Similar results occur with carbon dioxide.
- (10) When water is applied to alkali metals, hydroxides and hydrogen are generated immediately.
- (11) Fires involving combustible metals that contain moisture exhibit more intense burning characteristics than dry product.
- (12) Extreme heat can be produced. For example, burning titanium and zirconium have the potential to produce temperatures in excess of 3857°C (7000°F) and 4690°C (8500°F), respectively.
- (13) Dusts, fines, and powders of combustible metals present an explosion hazard, especially in confined spaces.
- (14) Dusts, fines, and powders of titanium and zirconium present extreme hazards; zirconium powders have ignition temperatures as low as 20°C (68°F). Static electric charges can ignite some dusts and powders of titanium and zirconium.
- (15) Zirconium and titanium powder can exhibit pyrophoric characteristics.
- (16) Turnings and chips of combustible metals can ignite and burn with intensity, especially if coated with a petroleum-based oil, with some spontaneous combustion having been observed.
- (17) With the exception of alkali metals, the larger the product, the smaller the likelihood of ignition. Bars, ingots, heavy castings, and thick plates and sheets are virtually impossible to ignite and, in most cases, self-extinguish when the heat source is removed.
- (18) The sponge product of most combustible metals burns at a slower rate but still produces tremendous heat.
- (19) Burning combustible metals can extract moisture from concrete and similar products that can intensify burning and cause spalling and explosion of the products and spewing of chunks of concrete.
- (20) Burning metal destroys asphalt and extracts moisture from rock.
- (21) Most fires involving non-alkali combustible metals usually cannot be extinguished, and unless they are placed in an inert atmosphere of argon or helium, they can only be controlled.
- (22) Fires involving large quantities of metals should be allowed to cool for at least 24 hours prior to being disturbed to prevent re-ignition.
- (23) Fires will oxidize most metals and provide a protective covering limiting open burning.
- (24) Alkali metal fires can be extinguished with the suitable extinguishing agents correctly applied. (See 8.3.3.)
- (25) Combustible metal fines and powders that are stored and contain moisture can produce hydrogen gas.
- (26) Combustible metal fines and dusts that are reduced (not oxidized) and that come into contact with other metal oxides can result in thermite reactions.

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

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

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

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

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

8.4.7* Clothing Fires.

8.4.7.1 Emergency procedures for handling clothing fires shall be established.

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

8.5* Emergency Response.

8.5.1 The following list of actions to be performed as well as information regarding the hazards of combustible metals shall be provided to emergency responders for the safe handling of combustible metal fires:

- (1)* Perform a size-up, evaluation, and identification of metals involved in the fire.
- (2) Ensure control of utilities (e.g., water, gases, power, etc.) to affected areas.
- (3) Review safety data sheets (SDSs) for the involved products, and if available, contact those familiar with the product and hazards.

- (4) Evaluate whether the fire can be isolated safely and allowed to burn out.
- (5) Determine whether uninvolved product and exposures — other than alkali metals — can be protected by hose streams, after an adequate review has been completed to ensure any runoff from hose streams does not come into contact with burning or molten combustible metal.
- (6) Do not apply water to alkali metals in either a fire or nonfire situation.
- (7) Use an inert blanket, such as argon, helium, or nitrogen, if the fire is burning in a closed container, such as a dust collection system, to control the fire where an adequate delivery system is available and personnel safety is considered.
- (8) Evaluate the potential for explosion.
- (9) Use extreme caution with fires involving combustible-metal powders, dusts, and fines because of the possibility of explosions, especially if the product becomes airborne and there is an available ignition source.
- (10) Evaluate the control and shutdown of both domestic and fire protection water systems to prevent unintended contact of water with burning or molten combustible metal.
- (11) Use extinguishing agents that are compatible with the hazards present. (See 8.3.3.)
- (12) Use extinguishing agents for containment of small and incipient fires. (See 8.3.3.)
- (13)* Use extreme caution with fires involving large quantities of product within structures.
- (14) Most fires involving combustible metals cannot be extinguished in a manner other than by providing an inert atmosphere of argon or helium — and nitrogen for alkali metals or iron — if the product is dry.
- (15) Most fires can be controlled by application of argon or helium — or nitrogen for alkali metals or iron — or by the development of an oxide crust.
- (16) The temperature of the metals involved in the fire can remain extremely high and the fire can flare up again if the product is disturbed prior to complete oxidation of the product or self-extinguishment.
- (17) Water in contact with molten combustible metals will result in violent steam explosions, and can cause hydrogen explosions and reactions.
- (18) Isolate the metal as much as possible; large fires might be impossible to extinguish.
- (19) Evaluate whether there is adequate drainage to prevent the contact of water with burning metal that is not compatible for protecting exposures.
- (20) Evaluate the fire to determine whether the fire can burn itself out naturally to minimize hazards to personnel and losses to exposures.

Chapter 9 Housekeeping

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

9.2 Applicability. The requirements of this chapter shall not apply to nanometals (see Chapter 12).

9.3* Housekeeping Plan.

9.3.1 A documented housekeeping program shall be established.

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

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

9.4 Cleanup Procedures for Fugitive Dust Accumulations.

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

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

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

- (1) Conductive, nonsparking scoops and soft brooms
- (2) Brushes that have natural fiber bristles
- (3) Dedicated vacuum cleaning systems designed for handling combustible metal powders in accordance with **Section 9.6**

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

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

9.4.5.1 The cleaning shall include machinery.

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

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

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

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

9.5* Cleanup of Spilled Dust, Fine or Powder.

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

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

9.5.3 Compressed-air blowdown shall be permitted as a method for cleaning only when done in accordance with **Section 9.7**.

9.6* Vacuum Cleaning.

9.6.1 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.

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

9.6.3* Due to the inherent hazards associated with the use of **centralized** and portable vacuum cleaning systems for finely divided combustible metal dust, special engineering consideration shall be given to the design, installation, maintenance, and use of such systems. (See **Section 11.4**.)

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

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

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

Δ 9.6.6 Vacuum cleaner hose shall be conductive and nozzles or fittings shall be made of conductive, nonsparking material.

9.6.7 Assembled components shall be conductive and bonded where necessary.

9.6.8 Periodic tests for continuity shall be performed.

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

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

9.7 Compressed Air Cleaning Requirements.

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

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

- (1) Electrical equipment not suitable for Class II, **Division Group E or Zone Group IIIC** 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.

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

9.8 Water-Cleaning Requirements.

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

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

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

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

9.9 Cleaning Frequency.

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

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

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

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

9.10 General Precautions.

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

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

9.10.3 Oil spills shall be cleaned up promptly.

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

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

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

9.10.7 In aluminum powder-handling or manufacturing buildings and in the operation of powder-conveying systems,

precautions shall be taken to avoid the production of sparks from static electricity; electrical faults; impact, such as iron or steel articles on each other, on stones, or on concrete; frictional heating; or other energy sources.

Chapter 10 Control of Ignition Sources

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

10.2* Hot Work.

10.2.1 Hot work operations in facilities covered by this standard shall comply with the requirements of NFPA 51B and this section.

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

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

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

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

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

10.3 Smoking.

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

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

10.3.3 Smoking shall be permitted only in designated areas.

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

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

10.4 Spark-Resistant Tools.

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

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

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

10.5* Static Electricity.

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

Δ 10.5.1.1 Grounding and bonding of equipment shall be independent of the facility electrical system.

Δ 10.5.1.2* Where nonconductive components present a discontinuity in the electrical path, isolated conductive components shall be bonded.

Δ 10.5.2* Movable or mobile process equipment or tools of metal construction shall be bonded or grounded or both, prior to use.

10.5.3* A monitoring and testing schedule shall be established based on the requirements of Section 6.2 to ensure that the effectiveness of grounding and bonding of fixed and mobile equipment has not failed or deteriorated over time and use.

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

Δ 10.5.5 Bonding and grounding for dust collection and pneumatic conveying shall be in accordance with Chapter 11.

10.5.6* Grounding of Personnel.

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

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

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

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

10.6.1 Bearings.

10.6.1.1 Ball or roller bearings shall be sealed against dust.

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

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

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

10.6.1.5 Grounded and bonded bearings shall be used.

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

10.6.2 Fan and Blower Construction.

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

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

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

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

10.6.2.4.1 Bearings shall be equipped with temperature indicating devices.

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

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

10.6.3* Grinding Wheels.

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

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

10.7 Electrical Power and Control.

Δ 10.7.1 All electrical equipment and wiring shall be installed in accordance with *NFPA 70*.

Δ 10.7.2 All process equipment and all building steel shall be bonded and grounded in accordance with *NFPA 70*.

Δ 10.7.3 All manufacturing buildings shall be provided with emergency lighting systems in accordance with *NFPA 101*.

Δ 10.7.4 Control equipment, control rooms, and offices meeting the requirements of *NFPA 496* shall be permitted.

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

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

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

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

10.8 Electrical Area Classification.

N 10.8.1* The identification of the possible presence and extent of combustible dust hazardous (classified) locations shall be made based on the criteria in Article 500 or 506 of *NFPA 70*.

N 10.8.2 All areas designated as hazardous (classified) locations shall be documented, and such documentation shall be maintained and preserved for access at the facility.

N 10.8.3 Electrical equipment and wiring within combustible dust locations shall comply with *NFPA 70*.

10.8.4* Preventive maintenance programs for electrical equipment and wiring in combustible dust locations shall include provisions to verify that dusttight electrical enclosures are not experiencing significant dust ingress.

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

• 10.9 Powered Industrial Trucks.

Δ 10.9.1 Where used, powered industrial trucks shall be selected and maintained in accordance with *NFPA 505*.

Δ 10.9.2* Where industrial trucks, in accordance with *NFPA 505*, are not commercially available, a documented risk assessment acceptable to the authority having jurisdiction shall be permitted to be used to specify the fire and explosion prevention features for the equipment used.

10.10 Propellant-Actuated Tools.

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

10.10.2 Propellant-actuated tools shall be used in accordance with Section 10.2.

Chapter 11 Powder and Dust Collection and Centralized Vacuum Systems

N 11.1 Retroactivity. Paragraphs 11.2.4.2.2, 11.2.4.4.6, 11.2.4.4.12, 11.2.4.4.15.3, 11.2.4.5.9, and Section 11.4 shall be applied retroactively.

N 11.2* Dust Collection.

N 11.2.1* Dust collection systems for machining, fabrication, finishing, mechanical conveying, additive manufacturing, and other dust generation operations for metals in a combustible form shall comply with the requirements of this chapter.

N 11.2.2 Powder conveying and collection for combustible metal powder production operations shall follow the requirements of Section 11.5, 11.2.4.4, and 11.2.4.5 for wet and dry AMS.

N 11.2.3 General Requirements.

N 11.2.3.1 All dust collection systems shall be installed in accordance with *NFPA 91*.

N 11.2.3.2* Where used to handle combustible particulate solids, systems shall be designed by and installed under the supervision of qualified persons who are knowledgeable about these systems and their associated hazards. [652:8.3.3.1.1]

N 11.2.3.3* Where it is necessary to make changes to an existing system, all changes shall be managed in accordance with the management of change (MOC) requirements in Section 4.4.

N 11.2.3.4* The dust collection system shall be designed and maintained to ensure that the air/gas velocity used meets or exceeds the minimum required to keep the interior surfaces of all piping or ducting free of accumulations under all normal operating modes.

N 11.2.3.5 Restrictions on Collected Materials.

N 11.2.3.5.1 Dust collection systems shall not be used to collect incompatible materials or other materials that might react with the conveyed metal dusts or particles.

N 11.2.3.5.1.1 The collection of any metal other than the metal the system was designed to collect shall be prohibited.

N 11.2.3.5.1.2 If other materials are to be collected, the modified process shall first be reviewed under management of change (MOC) to ensure that the requirements of this chapter are maintained.

N 11.2.3.6 Operations.

N 11.2.3.6.1 Sequence of Operation. Dust collection systems shall be designed with the operating logic, sequencing, and timing outlined in 11.2.3.6.1.1 and 11.2.3.6.1.2.

N 11.2.3.6.1.1 Startup. Dust collection systems shall be designed such that, on startup, the system achieves and maintains design air velocity prior to the admission of material into the system.

N 11.2.3.6.1.2 Shutdown.

N (A) Dust collection systems shall be designed such that, on normal shutdown, the system maintains design air velocity until material is purged from the ducting.

N (B) The requirements of 11.2.3.6.1.2(A) shall not apply during emergency shutdown of the system, such as by activation of an emergency stop button or by activation of an automatic safety interlocking device.

N 11.2.3.6.2* At each collection point, the system shall be designed to achieve the minimum velocity required for capture, control, and containment of the dust source. [652:8.3.3.3.1]

N 11.2.3.6.3* The hood or pickup point for each dust source shall have a documented minimum air volume flow based upon the system design. [652:8.3.3.3.2]

N 11.2.3.6.4* Branch lines shall not be disconnected, and unused portions of the system shall not be blanked off without providing a means to maintain required and balanced airflow. [652:8.3.3.3.3]

N 11.2.3.6.5* The addition of branch lines shall not be made to an existing system without first confirming that the entire system will maintain the required and balanced airflow. [652:8.3.3.3.4]

N 11.2.3.6.6* All dust sources (i.e., hoods) shall be connected using only a tapered main design.

N 11.2.3.6.7* Dust collection systems that remove material from operations that generate sparks, hot material, or similar ignition sources under normal operating conditions shall utilize a wet-type AMS and shall provide deflagration isolation to

prevent propagation between interconnected equipment in accordance with NFPA 69.

N 11.2.3.6.8* The air-material separator (AMS) selected for the system shall be designed to allow for the characteristics of the combustible dust being separated from the air or gas flow. [652:8.3.3.3.6]

N 11.2.3.6.9* Air-moving devices (AMDs) shall be of appropriate type and sufficient capacity to maintain the required rate of air/gas flow in all parts of the system.

N 11.2.3.6.10* All dust collection systems for combustible metal dusts shall have the AMD located on the clean side of the AMS.

N 11.2.3.6.11* Control panels and related equipment for controlling the operation of the AMS, AMD, monitoring equipment, or a combination thereof shall be installed in a location that is safe from the effects of a deflagration in the AMS.

N 11.2.3.6.12* The dust loading (i.e., grain loading) in ductwork during normal operating conditions shall be held below the minimum explosible concentration (MEC) in accordance with the deflagration prevention by combustible concentration reduction methods in NFPA 69.

N 11.2.3.7* The dry-type AMS and upstream work stations shall include a data plate listing the type of combustible metal dust that the system is designed to collect and a visible warning label that states collecting other materials can create a fire or explosion hazard.

N 11.2.3.7.1 The data plate on the dry-type AMS shall include the following information:

- (1) The metal collected by the AMS
- (2) The maximum P_{max} and K_{st} of dust that can be collected by the AMS
- (3) The lowest value of minimum ignition energy of the dust that can be collected by the AMS
- (4) Where filter media is used, the specifications of the filters that must be used

N 11.2.4 Specific Requirements.

N 11.2.4.1* A means shall be provided to prevent condensation in the ductwork.

N 11.2.4.2* Prevention of Static Discharge.

N 11.2.4.2.1 Prevention of ignition due to static discharge shall be in accordance with Section 10.5.

N 11.2.4.2.2 Bonding and Grounding.

N 11.2.4.2.2.1 All components of dust collection systems shall be bonded and grounded independently of the electrical grounding system to minimize accumulation of static electric charge.

N 11.2.4.2.2.2 When continuous contact is interrupted, metallic jumpers shall be installed for effective bonding.

N 11.2.4.2.2.3* The owner/operator shall verify and document the continuity of the bonding and grounding of the dust collection system on at least an annual basis.

N 11.2.4.3 Ducts, Ductwork, and Flex Connections.

N 11.2.4.3.1 All ducts and ductwork shall be constructed of metal or noncombustible conductive material.

N 11.2.4.3.2* Ducting runs shall be as short as practical with minimal turns.

N 11.2.4.3.3* Where the conveying duct is exposed to weather or moisture, it shall be moisture- and weathertight.

N 11.2.4.3.4* Hose and flexible connection length shall be the minimum required to accomplish the reason for their use.

N 11.2.4.3.5* All hoses and flex connections shall be conductive, static dissipative, or otherwise properly bonded/grounded to prevent accumulation of electrostatic charges.

N 11.2.4.3.6 Grinding operations shall not be served by the same dust collection system as buffing and polishing operations.

N 11.2.4.4* Dry-Type Air-Material Separator (AMS) Requirements.

N 11.2.4.4.1* Dry-type filter media AMS shall not be used for metal dusts being collected in air with a K_{st} greater than 150 bar-m/s or for niobium, tantalum, titanium, zirconium, and hafnium unless their use is supported by a dust hazard analysis (DHA) that is acceptable to the AHJ.

N 11.2.4.4.2 Media dust collectors shall be provided with all of the following ignition prevention measures:

- (1) Where the minimum ignition energy of the dust is less than 1000 mJ, the filter media shall be static-dissipative and shall be effectively bonded to the conductive filter frame.
- (2) Accumulations on filter media shall be limited to levels below the thresholds for any oxidative self-heating ignition and any possible ignition due to exothermic reaction with humid air. These thresholds shall be determined as part of the dust collection dust hazard analysis (DHA) conducted in accordance with Chapter 7.
- (3) Accumulation levels during the operation shall be monitored across the media by pressure drop or an equivalent sensor; if the accumulation exceeds the predetermined limits, a controlled shutdown of the collector and dust generation equipment shall be implemented.
- (4) Periodic inspections and replacement of media shall be based on intervals determined by the pressure drop across the filter media or by indication of self-heating detection equipment based on moisture reactivity.

N 11.2.4.4.3* The ingress, accumulation, or condensation of water in a dry-type AMS shall be prevented.

N 11.2.4.4.4 Dry-Type AMS Limitations.

N 11.2.4.4.4.1* Electrostatic collectors shall be prohibited.

N 11.2.4.4.4.2 Enclosureless dry-type AMS shall be prohibited.

N 11.2.4.4.4.3* Self-contained, dry-type AMS, down-draft benches, and environmental control booths (e.g., buffing, grinding, and finishing booths) with integral filter media in the wall shall be prohibited.

N (A) Self-contained, dry-type AMS, down-draft benches, and environmental control booths (e.g., buffing, grinding, and finishing booths) with integral filter media in the wall shall be permitted where a DHA has been performed and less than 0.22 kg (0.5 lb) of dust less than 500 microns is collected and emptied each day.

N (B) Self-contained, dry-type AMS devices, down-draft benches, and environmental control booths (e.g., buffing, grinding, and

finishing booths) with integral filter media in the wall shall be permitted where a DHA has been performed and less than 0.22 kg (0.5 lb) of dust less than 500 microns is collected and emptied each day.

N 11.2.4.4.5* The accumulation of material inside any area of the dry-type AMS other than the discharge containers designed for that purpose and for normal operation of the AMS shall not be permitted.

N 11.2.4.4.6 Repairs.

N 11.2.4.4.6.1 Where repairs on dry-type AMS are necessary, the AMS shall be emptied and residual accumulations of dust thoroughly removed before the repairs are made.

N 11.2.4.4.6.2 Ductwork leading into the AMS shall be disconnected and blanked off before repair work shall be permitted to be started.

N 11.2.4.4.7 Cyclone Construction.

N 11.2.4.4.7.1 Cyclone dry-type AMS shall be of conductive nonsparking construction suitable for the service intended.

N 11.2.4.4.7.2 Metallic cyclone dry-type AMS shall be continuously welded with smooth internal seams.

N 11.2.4.4.8 Temperature Monitoring Requirements.

N 11.2.4.4.8.1 Dry-type AMS shall be equipped with instruments for recording the surface temperature.

N 11.2.4.4.8.2 An overheating alarm or warning device shall be included, and the limit setting shall be below the maximum service temperature of the filter media or 50°C (122°F) below the hot surface ignition temperature of the dust, whichever is lower.

N 11.2.4.4.8.3 The devices specified shall give audible and visual alarms at normally attended stations.

N 11.2.4.4.9* Removal and replacement of filter media containing combustible dust shall be performed based on a standardized procedure that addresses the hazard of the combustible dust, work methods, and personal protective equipment.

N 11.2.4.4.10 Filter Media Properties.

N 11.2.4.4.10.1* Cartridge filters shall not be used with pyrophoric metal dusts.

N 11.2.4.4.10.2 Filter media shall not be chemically reactive with the collected dust, including any contaminants carried in the dust stream with the combustible metal.

N 11.2.4.4.11 Explosion Protection.

N 11.2.4.4.11.1 Where provided, explosion protection shall be directed to a safe location away from areas where personnel are normally present.

N 11.2.4.4.11.2 Collectors shall be protected by a minimum of one of the following explosion protection methods:

- (1)* Deflagration venting in accordance with NFPA 68, which includes the following requirements:
 - (a) Where deflagration venting is used on indoor dust collectors, the vents shall be ducted to the outside and the flow resistance shall be included in the vent design.

(b)* Vent ducts shall be designed to prevent accumulation of moisture.

(2) Oxidant concentration reduction in accordance with NFPA 69, which includes the following requirements:

(a) Where oxygen monitoring is used, it shall be installed in accordance with ISA 84.00.01, *Functional Safety: Application of Safety Instrumented Systems for the Process Industry Sector*.

(b)* Where the chemical properties of the material being conveyed require a minimum concentration of oxygen to control pyrophoricity, that level of concentration shall be maintained.

(3) Deflagration pressure containment in accordance with NFPA 69

(4)* Deflagration suppression in accordance with NFPA 69, where the suppressant has been shown to be chemically compatible and effective with the material collected

(5)* Dilution with a compatible, noncombustible material to render the mixture noncombustible

(6)* Deflagration venting through a listed dust retention and flame-arresting device that has been shown to be effective with the metal being collected through independent third-party testing

N 11.2.4.4.11.3 If the method in 11.2.4.4.11.2(5) is used, test data for specific dust and diluent combinations shall be provided and shall be acceptable to the authority having jurisdiction.

N 11.2.4.4.11.4 Where an explosion hazard exists and is not protected by 11.2.4.4.11.2(2) or 11.2.4.4.11.2(5), isolation devices that have been shown to be compatible and effective with the material collected shall be provided to prevent deflagration propagation between connected equipment in accordance with NFPA 69.

N (A)* Explosion isolation shall be provided in accordance with NFPA 69 between the dust collector and upstream process.

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

N 11.2.4.4.11.5 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.

N 11.2.4.4.11.6 Where collectors are provided with deflagration vents, the area within the deflagration vent's discharge area shall be marked.

N 11.2.4.4.11.7 Signage shall be posted near the dust collector that reads, at a minimum, the following,

**CAUTION: THIS DUST COLLECTOR CAN CONTAIN
EXPLOSIBLE DUST.KEEP OUTSIDE THE MARKED AREA
WHILE EQUIPMENT IS OPERATING.**

N 11.2.4.4.11.8 Where collectors are provided with deflagration vents, vent closures shall be clearly marked with, at a minimum, the following text:

WARNING: EXPLOSION RELIEF DEVICE

N 11.2.4.4.12 Collected Material.

N 11.2.4.4.12.1 Discharge containers for collectors shall be emptied before or when 100 percent of the storage capacity of the container is attained.

N 11.2.4.4.12.2 Dust shall be removed from collectors at least once each day and at more frequent intervals if conditions warrant.

N 11.2.4.4.12.3 Material removed from the collector shall be permitted to be recycled into a process or mixed with an inert material in a volume ratio of five parts inert material to one part metal dust and, once mixed, shall be recycled or disposed of in accordance with local, state, and federal regulations.

N 11.2.4.4.12.4 Precautions shall be taken to avoid creating dust clouds when removing dust from the collectors.

N 11.2.4.4.12.5 The dust removed shall be recycled or disposed of in accordance with local, state, and federal regulations.

N 11.2.4.4.12.6 The dust shall be discharged into metal containers that shall be promptly and tightly covered to avoid the creation of airborne fugitive dust.

N 11.2.4.4.13* Requirements for the Clean Air Exhaust.

N 11.2.4.4.13.1 Recycling of exhaust air from fixed dry-type dust collectors into buildings shall not be permitted unless all of the following requirements are met:

- (1)* The material being collected has a calculated adiabatic flame temperature below 2300°C (4172°F).
- (2) Water has been shown to be an effective extinguishing agent for the material being collected.
- (3) Combustible or flammable gases or vapors are not present either in the intake or in the recycled air in concentrations above applicable industrial hygiene exposure limits or 1 percent of the LFL, whichever is lower.
- (4)* Combustible particulate solids are not present in the recycled air in concentrations above applicable industrial hygiene exposure limits or 15 mg/m³, whichever is lower.
- (5)* The oxygen concentration of the recycled air stream is between 19.5 percent and 23.5 percent by volume.
- (6) Provisions are incorporated to prevent transmission of flame and pressure effects from a deflagration in an AMS back to the facility unless a DHA indicates that those effects do not pose a threat to the facility or the occupants.
- (7) Provisions are incorporated to prevent transmission of smoke and flame from a fire in an AMS back to the facility unless a DHA indicates that those effects do not pose a threat to the facility or the occupants.
- (8) The system includes a method for detecting AMS malfunctions that would reduce collection efficiency and allow increases in the amount of combustible particulate solids returned to the building.
- (9) The building or room to which the recycled air is returned meets the housekeeping requirements of Chapter 9.
- (10) Recycled-air ducts are inspected and cleaned at least annually.

N 11.2.4.4.13.2 For materials not meeting items 11.2.4.4.13.1(1) and 11.2.4.4.13.1(2), they shall meet the following requirements prior to allowing the recirculation:

- (1) The maximum amount of metal in a combustible form accumulating in the discharge container will not exceed 4.5 kg (10 lb) of material with a maximum of 0.45 kg (1 lb) of material less than 500 microns for an aggregate of 4.95 kg (11 lb) total.
- (2) The collector annually collects a maximum of 300 lb of metal in a combustible form that is less than 500 microns.

N 11.2.4.4.14 Dry-type dust collectors shall be located outside of buildings unless permitted by 11.2.4.4.15.

N 11.2.4.4.15* Indoor Dry-Type Air-Material Separator (AMS). All portions of 11.2.4.4 on dry-type AMS requirements shall apply to indoor dry-type AMS in addition to this section.

N 11.2.4.4.15.1 A hazards analysis shall be conducted in accordance with Section 5.2 and Chapter 7 to ensure that the risk to personnel and operations is minimized for both new and existing systems.

N 11.2.4.4.15.2 The collector shall be designed to comply with all applicable requirements in this chapter.

N 11.2.4.4.15.3 The requirements for fire protection for indoor dry-type dust collection systems shall apply retroactively.

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

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

N (C) Collected material shall not be stored in the collector, but shall be continually emptied from the collector into a sealed metal container through an isolation device in accordance with NFPA 69.

N (D) The collection of materials other than iron or steel dust shall be prohibited in collectors with a dirty volume greater than 0.57 m³ (20 ft³) or an airflow greater than 2549 m³/hr (1500 ft³/min).

N (E)* Media collectors shall contain a filter break (i.e., broken-bag) detection system that automatically shuts down the collector and connected equipment if a filter break is detected.

N 11.2.4.4.15.4* The exhaust duct from the fan discharge shall exit the building using as straight and short a path as is practical.

N 11.2.4.4.15.5* The collector inlet duct, exhaust duct, and blower shall be inspected at least every 6 months to ensure that material is not accumulating.

N 11.2.4.4.15.6 The collector exhaust duct located inside the building shall use one of the following deflagration protection methods:

- (1) Deflagration pressure containment in accordance with NFPA 69
- (2)* Deflagration isolation in accordance with NFPA 69

N 11.2.4.4.15.7* If the material meets either of the following criteria, the additional requirements in 11.2.4.4.15.7(A), 11.2.4.4.15.7(B), and 11.2.4.4.15.7(C) apply:

- (1) The material is a UN Class 4.3 solid as tested using UN 4.3 water reactivity test methods.
- (2)* Water has not been shown to be an effective extinguishing agent (*see Table A.8.3.3*).

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

N (B) The collector shall contain a warning sign stating the following:

**THIS COLLECTOR CONTAINS COMBUSTIBLE METAL
DUST.DO NOT EXTINGUISH WITH WATER.**

N (C) The emergency response plan required in Section 8.5 shall include the following information to emergency responders:

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

N 11.2.4.4.15.8 Indoor dry-type dust collectors shall be permitted for metals covered by Chapter 16, meeting the following requirements:

- (1) The P_{max} is less than 8 bar-g as measured using the test method in ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*.
- (2) The K_{st} is less than 150 bar-m/s as measured using the test method in ASTM E1226.
- (3) The minimum ignition energy (MIE) is greater than 100 mJ as measured using the test method in ASTM E2019, *Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air*.
- (4) The material is not a UN Class 4.2 solid as tested using UN 4.2 self-heating test methods.
- (5) The collection of materials other than iron or steel dust is prohibited in collectors with a dirty volume greater than 0.57 m³ (20 ft³) or an airflow greater than 2549 m³/hr (1500 ft³/min).

N 11.2.4.4.15.9 Indoor dry-type dust collectors shall be permitted for metals other than those covered by Chapter 16, provided that one of following provisions are met:

- (1) The maximum amount of metal in a combustible form accumulating in the collector receptacle shall not exceed a maximum accumulation of 4.5 kg (10 lb) of material greater than 500 microns with a maximum of 0.45 kg (1 lb) of material less than 500 microns for an aggregate of 5 kg (11 lb) total.
- (2) The collector annually collects a maximum of 136 kg (300 lb) of metal in a combustible form that is less than 500 microns.

- (3) The AMS has a dirty volume less than 0.2 m³ (8 ft³) or an airflow less than 850 m³/hr (500 ft³/min) and is emptied daily.

N 11.2.4.4.16* Portable Indoor Dry-Type Air-Material Separators (AMS) (Dust Collectors).

N 11.2.4.4.16.1 Portable indoor dry-type AMS shall be used only for grinding, buffing, or sanding operations.

N 11.2.4.4.16.2 Individual machines with portable dry dust-collection capabilities shall be permitted to be used indoors when the object being processed or finished is incapable of being moved to a properly arranged fixed hood or enclosure and shall incorporate the safeguards in 11.2.4.4.16.

N 11.2.4.4.16.3 Portable indoor dry-type dust collectors shall not be connected to a permanent fixed piping system.

N 11.2.4.4.16.4 The operation of portable dry dust-collection devices shall be subject to a DHA to ensure that the risk to personnel and operations from flash fire and shrapnel is minimized.

N (A)* The portable dust collector shall not be used in an identified deflagration hazard area until appropriate housekeeping methods in Chapter 9 have been used to remove hazardous quantities of dust.

N (B) Portable dry AMS with a dirty side volume greater than 0.2 m³ (8 ft³) shall be protected against explosion in accordance with NFPA 69.

N 11.2.4.4.16.5 Personal protective clothing shall comply with Section 4.6.

N 11.2.4.4.16.6 Prior to a change in the collected materials, the portable dry-type AMS and all associated components shall be thoroughly cleaned.

N 11.2.4.4.16.7 Grounding of personnel operating portable indoor dust collectors shall comply with 10.5.6.

N 11.2.4.4.16.8 The AMS and any associated components shall be bonded and grounded to an earth ground.

N 11.2.4.4.16.9 Hazards associated with static discharge shall be mitigated in accordance with Section 10.5.

N 11.2.4.4.16.10 Hoses shall be appropriate for use and be static dissipative or conductive.

N 11.2.4.4.16.11* Hoses and nozzles shall be bonded and grounded, and a path to ground shall be verified prior to use after each movement, each new connection, or both.

N 11.2.4.4.16.12 The resistance of the path to ground shall be documented and maintained.

N 11.2.4.4.16.13* The material collected shall be limited to 2.2 kg (5 lb) and, at a minimum, emptied daily.

N 11.2.4.4.16.14 The collector shall not be used on processes generating hot embers or sparks.

N 11.2.4.4.17 Operations Generating Hot Particles.

N 11.2.4.4.17.1* Grinding, plasma spray, and other operations generating hot metal particles shall have a spark arrestor system upstream of the AMS.

N 11.2.4.4.17.2* Dust collection systems for hot metallic nanoparticles shall be inerted unless combustibility testing of nano-

particle dust samples demonstrate that the particles are not pyrophoric.

N 11.2.4.4.17.3* Ordinary combustibles shall not be allowed to enter dust collection systems using dry-type AMS collecting hot metal particles.

N 11.2.4.4.17.4 Metal temperatures at the dust collector shall be compatible with the limiting temperature of the filter media.

N 11.2.4.5* Wet-Type Air-Material Separator (AMS) Requirements.

N 11.2.4.5.1 The exhaust vent shall terminate to a safe location outside the building and shall be securely fastened except as provided in 11.2.4.5.3.

N 11.2.4.5.2 The clean air shall not be permitted to be returned to an identified deflagration hazard area.

N 11.2.4.5.3 The cleaned air shall be permitted to be returned to the indoor work area when tests conducted prove that the collector's efficiency is great enough to provide, to both personnel and property, safety in the particular installation with regard to particulate matter in the cleaned air and accumulations of particulate matter and hydrogen in the work area.

N 11.2.4.5.4 The exhaust duct shall be as short and straight as is practical and shall be designed to withstand the same explosion pressure as the wet-type dust collector.

N 11.2.4.5.5* The outlet portion of the AMS and the exhaust vent duct shall be inspected and cleaned as required to prevent buildup of deposits of combustible metal dusts on the interior surfaces.

N 11.2.4.5.6* The wet-type AMS shall meet or exceed the design efficiency of combustible dust collection at all times during normal operation.

N 11.2.4.5.7 The use of additional dry filter media either downstream or combined with a wet collector shall not be permitted.

N 11.2.4.5.7.1 Where required to meet industrial hygiene exposure, dry filter media shall be permitted to be located downstream of the wet-type collector when equipped with all of the following:

- (1) Signs posted in the area warning of the hazards associated with the use of dry filter media
- (2) A differential pressure alarm
- (3) Static dissipative or conductive filter media
- (4) A means to limit hydrogen accumulation to 10 percent of the LFL
- (5) A high-temperature alarm at the filter media limit

N 11.2.4.5.8 Operational Safeguards.

N 11.2.4.5.8.1* The power supply to the dust-producing equipment shall be interlocked with the drive motor of the exhaust blower and the liquid-level, liquid-supply rate controller of the wet-type AMS, or both, to ensure that the system will shut down the equipment it serves if improper system function is detected.

N 11.2.4.5.8.2 A time delay switch or equivalent device shall be provided on the dust-producing equipment to prevent the start of the dust-producing process until the wet-type AMS and AMD are fully operational.

N 11.2.4.5.8.3 An interlock shall be provided to prevent operation of the wet-type AMS unless water tank capacity and water supply is maintained.

N 11.2.4.5.8.4 The AMS shall be constructed of conductive materials or be static dissipative.

N 11.2.4.5.9* Disposal of Sludge from Water-Based Wet-Type Air-Material Separators.

N 11.2.4.5.9.1* All sludge removed from wet-type AMS shall be collected and transported in covered, vented metal containers and removed daily, at a minimum, to a safe outdoor storage or ventilated disposal area.

N 11.2.4.5.9.2 Sludge from wet-type AMS shall be managed prior to disposal and recycled or disposed of in accordance with applicable federal, state, and local regulations.

N 11.2.4.5.9.3 Material removed from wet-type AMS shall be permitted to be mixed with an inert material (e.g., sand or material that is nonreactive with the combustible metal) in a volume ratio of at least five parts inert material to one part metal dust.

N 11.2.4.5.9.4 Smoking or open flames shall be prohibited in the disposal area and throughout the disposal process.

N 11.2.4.5.9.5 Open storage of sludge from wet-type AMS shall be isolated and segregated from other combustible materials and metal scrap to prevent propagation of a fire.

N 11.2.4.5.9.6 Sludge level buildup in the sludge tank of the wet-type AMS shall not exceed 5 percent of the tank liquid capacity as measured by volume.

N 11.2.4.5.10* Requirements to Prevent the Buildup of Hydrogen in Water-Based Wet-Type Air-Material Separators.

N 11.2.4.5.10.1 Wet-type AMS shall be designed so that hydrogen generated from the metal contacting the water is vented at all times.

N 11.2.4.5.10.2 Vents shall remain open and unobstructed when the machine is shut down.

N 11.2.4.5.10.3 When the AMS is not in operation, ventilation shall be permitted to be provided by an independent blower or by an unimpeded vent.

N 11.2.4.5.10.4 Each chamber of the AMS shall be vented to dissipate the hydrogen.

N 11.2.4.5.10.5 Sludge shall be removed from the AMS whenever the AMS is to remain inoperative for a period of 24 hours or more.

N 11.2.4.5.11 Additional Requirements for Water-Based Wet-Type AMS.

N 11.2.4.5.11.1 Where approved, the buildup of hydrogen in portable collectors shall be permitted to be mitigated through the use of an unimpeded vent in lieu of an auxiliary blower.

N 11.2.4.5.11.2 Hydrogen vents shall remain open and unobstructed when the machine is shut down.

N 11.2.4.5.11.3 When the dust collector is not in operation, ventilation shall be permitted to be provided by an independent blower or by an unimpeded vent.

- N 11.2.4.5.11.4** Hydrogen shall be permitted to be vented indoors where the DHA documents that this activity is acceptable and considers the effects of hydrogen buildup within the building.
- N 11.2.4.5.11.5** Each chamber of the collector shall be vented to dissipate the hydrogen.
- N 11.2.4.5.12 Additional Requirements for Non-Water-Based Wet-Type AMS.**
- N 11.2.4.5.12.1** The liquid used shall be limited to nonaqueous Class IIIB or noncombustible liquids.
- N 11.2.4.5.12.2** Possible vapor generation due to metal reaction with the liquid shall be evaluated and addressed as part of the DHA required in Chapter 7.
- N 11.2.4.5.12.3** Class IIIB liquids shall be handled in accordance with NFPA 30.
- N 11.2.4.5.12.4** Pressurized transfer of liquid shall be prohibited.
- N 11.2.4.5.12.5** Formation of liquid residue in the vicinity of the operating unit shall be minimized.
- N 11.2.4.5.13 Portable Indoor Wet-Type Immersion Air-Material Separators (AMS).**
- N 11.2.4.5.13.1** Portable indoor wet-type immersion AMS shall comply with 11.2.3.5 and 11.2.4.5.10.1 through 11.2.4.5.10.5, in addition to this section.
- N 11.2.4.5.13.2** Personal protective clothing shall comply with Section 4.6.
- N 11.2.4.5.13.3** When the collector is to remain inoperative for a period of 24 hours or more, sludge shall be removed from the collector or the collector shall be permitted to be moved to an approved safe location where hydrogen venting and other hazards are sufficiently mitigated.
- N 11.2.4.5.13.4** Hoses shall be appropriate for use and be static dissipative or conductive.
- N 11.2.4.5.13.5** Hoses and nozzles shall be bonded and grounded and shall include a monitoring system to confirm appropriate bonding and grounding. A path to ground shall be verified prior to each movement, prior to each new connection, or prior to both at least daily.
- N 11.2.4.5.13.6** The maximum capacity shall not exceed 20 lb (9 kg) of sludge.
- N 11.3* Centralized Vacuum Cleaning System.**
- N 11.3.1 General Requirements.**
- N 11.3.1.1*** Where used to handle combustible metal dusts, the system shall be designed by and installed under the supervision of qualified persons who are knowledgeable about this type of system and the associated hazards.
- N 11.3.1.2*** Where it is necessary to make changes to an existing system, all changes shall be managed in accordance with the management of change (MOC) policy.
- N 11.3.1.3*** The system shall be designed and maintained to ensure that the air-and-material velocity in the tubing, piping network, or both meets or exceeds the minimum required to keep the interior surfaces free of accumulations under all normal operational modes.
- N 11.3.2* Specific Requirements for Centralized Vacuum Cleaning Systems.**
- N 11.3.2.1*** The system shall be designed to assure minimum conveying velocities at all times whether the system is used with a single or multiple simultaneous operators.
- N 11.3.2.2*** The hose length and diameter shall be sized for the application and operation.
- N 11.3.2.3*** Vacuum cleaning tools shall be constructed of metal or shall be static dissipative and provide proper grounding and bonding to the hose.
- N 11.3.2.4*** Vacuum cleaning hose shall be static dissipative or conductive and shall be grounded.
- N 11.3.2.5** Centralized vacuum cleaning systems shall be used only for removal of dust accumulations too small, too dispersed, or too inaccessible to be thoroughly cleaned by hand brushing.
- N 11.3.2.6*** The entire centralized vacuum cleaning system shall be effectively bonded and grounded to minimize the accumulation of static electrical charge.
- N 11.3.2.7*** The tubing, piping, or both used in the system shall be metal and properly grounded and bonded.
- N 11.3.2.8*** The dry or wet AMS used in the system must comply with the requirements for dust collectors found in 11.2.4.4 for dry-type AMS and 11.2.4.5 for wet-type AMS.
- N 11.3.2.9*** The method of collected material discharge from a dry-type AMS shall be designed specifically for continuous discharge and for the characteristics of the combustible metal dust vacuumed into the system.
- N 11.4* Portable Vacuum Cleaners.**
- N 11.4.1** All dry-type AMS assemblies must comply with 11.2.4.4.16.
- N 11.4.2** All wet-type AMS assemblies must comply with 11.2.4.5.11 through 11.2.4.5.13.
- N 11.4.3*** When a portable vacuum cleaner is used for other materials, the equipment shall be thoroughly cleaned prior to use and identified accordingly.
- N 11.5 Pneumatic Conveying of Powder.**
- N 11.5.1 Ductwork for Pneumatic Conveying Systems.**
- N 11.5.1.1** Conveyor ducts shall be fabricated of spark-resistant metals that are compatible with the metal being transported.
- N 11.5.1.2** Plastics or other nonconductive ducts or duct liners shall not be used.
- N 11.5.1.3*** Ducts shall be electrically bonded and grounded to minimize accumulation of static electric charge.
- N 11.5.1.4*** Where the conveying duct is exposed to weather or moisture, it shall be moisture-tight.
- N 11.5.1.5*** A minimum conveying velocity shall be maintained throughout the conveying system to prevent the accumulation of dust at any point and to pick up any dust or powder that can drop out during unscheduled system stoppages.

N 11.5.1.6* Where a deflagration hazard exists, deflagration protection such as rupture diaphragms shall be provided on ductwork.

N 11.5.1.6.1 Deflagration vents shall relieve to a safe location outside the building.

N 11.5.1.6.1.1 Where provided with deflagration vents, the area within the deflagration vent's discharge area shall be marked.

N 11.5.1.6.1.2 It shall be permissible to determine the deflagration vent discharge area using NFPA 68.

N 11.5.1.6.1.3* Where ducts are provided with deflagration vents, vent closures shall be clearly marked as follows:

WARNING: EXPLOSION RELIEF DEVICE

N 11.5.1.6.2 Deflagration venting shall not be required for ductwork provided with explosion isolation systems identified in NFPA 69 that can prevent propagation of a deflagration into other parts of the process.

N 11.5.1.7* 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 in accordance with Chapter 13 of NFPA 69.

N 11.5.1.8 If a portion of the ductwork is located so that no damage to property or injury to personnel will result from its bursting, that portion shall be permitted to be of lightweight construction to intentionally fail, thereby acting as an auxiliary explosion vent for the system.

N 11.5.2 Conveying Using an Inert Medium.

N 11.5.2.1* Inert gas-conveying systems shall be permitted if designed in accordance with NFPA 69.

N 11.5.2.2 The inert gas used shall not react with the specific metal.

N 11.5.2.3* The concentration of oxygen in the inert gas stream shall be below the limiting oxygen concentration (LOC) of the specific gas in accordance with NFPA 69.

N 11.5.2.4* A residual level of oxygen below the LOC shall be present in the inert gas stream unless the conveyed material will not be exposed to air in future handling.

N 11.5.2.5 The oxygen concentration of the inert gas stream shall be monitored in accordance with NFPA 69.

N 11.5.2.6* The inert gas shall have a dew point so that no free moisture can condense or accumulate at any point in the system.

N 11.5.2.7* If the conveying gas is inducted into the system in a relatively warm environment and the ducts and collectors are relatively cold, the ducts and collectors shall be either insulated or provided with heating so that the gas temperature does not fall below the dew point, causing condensation.

N 11.5.2.8* A minimum conveying velocity shall be maintained throughout the conveying system to prevent the accumulation of dust at any point and to pick up any dust or powder that drops out during an unscheduled system stoppage.

N 11.5.3 Fan and Blower Construction and Arrangement.

N 11.5.3.1 Fans and blowers shall be in accordance with 10.6.2.

N 11.5.3.2 Personnel shall not be permitted within 15 m (50 ft) of the fan or blower while it is operating, except under either of the following conditions:

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

N 11.5.3.3 No maintenance shall be performed on the fan until it is shut down.

N 11.5.3.4* Fans or blowers shall be located outside of all manufacturing buildings and shall be located to minimize entrance of dust into the building from the fan exhaust.

N 11.6 Powder Collection.

N 11.6.1* Collectors.

N 11.6.1.1 Dry-type collectors shall be located outside in a safe location and shall be provided with barriers or other means of protection for personnel.

N 11.6.1.2* The area around the collector shall be posted with a sign that reads as follows:

CAUTION: THIS COLLECTOR CAN CONTAIN EXPLOSIBLE DUST. KEEP OUTSIDE THE MARKED AREA WHILE EQUIPMENT IS OPERATING.

N 11.6.1.2.1 Where collectors are provided with deflagration vents, the area within the deflagration vent's discharge area shall be marked.

N 11.6.1.2.2* It shall be permissible to determine the deflagration vent discharge area using NFPA 68.

N 11.6.1.2.3 Where collectors are provided with deflagration vents, vent closures shall be clearly marked as follows:

WARNING: EXPLOSION RELIEF DEVICE

N 11.6.1.3 Collectors shall be constructed of metal that is static dissipative.

N 11.6.1.4 Ductwork shall comply with the provisions of 11.5.1.

N 11.6.1.5* The entire collection system, including the collector, shall be completely bonded and grounded to minimize accumulation of static electric charge.

N 11.6.1.6 Recycling of air from powder collectors into buildings shall be prohibited.

N 11.6.1.7* Where an explosion hazard exists, dry-type collectors shall be provided with deflagration vents.

N 11.6.1.7.1 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.

N 11.6.1.7.2 Where collectors are provided with deflagration vents, the area within the deflagration vent's discharge area shall be marked.

N 11.6.1.7.3 It shall be permissible to determine the deflagration vent discharge area using NFPA 68.

N 11.6.1.7.4 Deflagration vents shall be positioned so that a potential blast is not directed toward any combustible or frangible structure.

N 11.6.1.7.5 Vent closures shall be clearly marked as follows:

WARNING: EXPLOSION RELIEF DEVICE

N 11.6.2 Repairs.

N 11.6.2.1 Where repairs on dry-type collectors are necessary, the collectors shall be emptied and residual accumulations of dust thoroughly removed.

N 11.6.2.2* Ductwork leading into the collector shall be disconnected and isolated by blanking before repair work is permitted to be started.

N 11.6.3 High-Temperature Warning.

N 11.6.3.1 Cyclone or other dry-type collectors shall be equipped with instruments for recording the surface temperature.

N 11.6.3.2 An overheating alarm or warning device shall be included, and the limit setting shall be below the maximum service temperature of the filter medium or 50°C (122°F) below the ignition temperature of the powder cloud, whichever is lower.

N 11.6.3.3 The devices specified in 11.6.3.2 shall give audible and visual alarms at normally attended locations.

N 11.6.4* Collector Filter Media. Collector filter media made from synthetic fabrics that accumulate static electric charges shall not be used.

N Chapter 12 Nanometal Powders

N 12.1 Retroactivity. The requirements of this chapter shall apply retroactively.

N 12.2* General.

N 12.2.1 Processing, handling, and storage of nanometal powders shall follow the requirements of this chapter in addition to the fire and explosion prevention and mitigation requirements in Chapters 8 through 16.

N 12.2.2* The requirements of this chapter are applicable to mixtures of nanometal powder particles and micrometer-sized metal particles where the nanometal powder particles are greater than 0.1 percent by weight.

N 12.2.3 If testing with a specific mixture and particle size distribution shows that the explosibility characteristics are similar to the micrometer metal particles, the requirements of this chapter do not apply.

N 12.2.4* Due to the special hazards of nanometals, a DHA conducted in accordance with Chapter 7 shall include a determination of the appropriate effective fire and explosion protection measures for combustible metal nanoparticle processes and equipment.

N 12.3 Nanoparticle Production Processes.

N 12.3.1 Nanometal Production Using Exploding Electrical Wires.

N 12.3.1.1* Fire, flash fire, and explosion hazards associated with exploding electrical wire production of nanometals, as well as the energy associated with the exploding wires, shall be assessed and documented.

N 12.3.1.2* Fire and explosion protection measures for this process equipment shall be established based on the hazard analysis, other pertinent requirements of this standard, and blast wave protection for the exploding wires.

N 12.3.1.3 The power supply and electrical circuits used for exploding electrical wire production shall be in accordance with NFPA 70.

N 12.3.1.4 If an inert gas atmosphere is used in the chamber containing the exploding wires, control of the maximum allowable oxygen concentration shall be in accordance with Chapter 7 of NFPA 69.

N 12.3.1.5 If a hydrogen atmosphere is used in the chamber containing the exploding wires, the generation and use of hydrogen shall be in accordance with NFPA 2.

N 12.3.2 Nanometal Production with Plasma-Based Processes.

N 12.3.2.1* Fire and explosion hazards associated with nanometal production by recondensation after metal immersion in a plasma, as well as the potential ignitions due to exposure to plasma thermal loads and ionized and aerosol particles, shall be assessed and documented.

N 12.3.2.1.1 Fire and explosion protection measures for this process shall be established based on the hazard analysis and the other pertinent requirements of this standard.

N 12.3.2.2 The internal surfaces of plasma-generating equipment shall be inspected after each production run to check for combustible metal particulate condensation and accumulation, and shall be cleaned where such condensation and accumulation is observed.

N 12.3.2.3 Particulate cooling, capture, and encapsulation equipment shall be operated per requirements in Section 12.4.

N 12.3.3 Nanometal Synthesis by Chemical Reduction of Salt Solutions and Colloidal Dispersions.

N 12.3.3.1* Fire and explosion hazards associated with nanometal production by chemical reduction methods, as well as the chemical reactivity hazards and the flammability properties of all reactants and reaction products, shall be assessed and documented.

N 12.3.3.2 Fire and explosion protection measures for this process shall be established based on the hazard analysis and the other pertinent requirements of this standard.

N 12.3.3.3* Fire protection for solutions with flammable or combustible liquid solvents shall be in accordance with requirements of NFPA 30.

N 12.3.4 Biochemical Production of Nanometals.

N 12.3.4.1* Fire and explosion hazards associated with nanometal production by biochemical processes, as well as the biochemical reactivity and flammability hazards and possible needs for biological or microbiological containment, shall be assessed and documented.

N 12.3.4.1.1 Fire and explosion protection measures for this process shall be established based on the hazard analysis and the other pertinent requirements of this standard.

N 12.3.5* Nanoparticle Production by Thermal Spray Pyrolysis.

Fire and explosion protection measures for combustible metal nanoparticle thermal spray pyrolysis production processes and equipment shall address the hazards of the materials coated by the nanoparticles, including the potential for pyrophoric reactions of the nanoparticles and coating upon suddenly being introduced to an air atmosphere.

N 12.4 Equipment Design and Operation.

N 12.4.1* Nanometal transport in pipes, ducts, and conveyors shall use an inert gas at an oxygen concentration below the limiting oxygen concentration (LOC) in accordance with NFPA 69. The LOC shall be measured specifically for submicron particulate of the primary metal transported.

N 12.4.2 Equipment with inerting for nanometals shall use an inert gas atmosphere in accordance with NFPA 69 and a LOC based on testing with an applicable nanometal sample.

N 12.4.3 Explosion suppression and isolation systems for nanometal explosion protection shall be in accordance with NFPA 69 and shall have been demonstrated to be effective for pertinent nanometals.

N 12.4.4* Equipment containing nanometals that are intended to withstand explosion pressures shall have a pressure containment capability in accordance with NFPA 69 and a value of P_{max} determined for a nanometal similar in composition and size to the nanometal in the equipment.

N 12.4.5 Equipment and operations for application of nanometal coatings with flammable or combustible solvents shall be protected in accordance with applicable requirements in NFPA 33 or NFPA 34.

N 12.5 Housekeeping.

N 12.5.1* A documented housekeeping program shall be established based on the hazards described in the DHA for all nanometal particles and shall include special provisions for preventing personnel exposure to nanoparticles during cleaning.

N 12.5.1.1 The location and extent of potential nanoparticle deposits shall be described in the program documentation.

N 12.5.1.2 The likelihood of ignition during cleaning shall also be documented.

N 12.5.2 Personnel responsible for cleaning nanoparticle deposits shall be equipped with personal protective equipment (PPE) determined as part of the documented housekeeping program.

N Chapter 13 Additive Manufacturing

N 13.1 Retroactivity. The requirements of this chapter shall apply retroactively.

N 13.2 General Requirements.

N 13.2.1* Due to the special hazards of additive manufacturing, a dust hazards analysis (DHA) conducted per Chapter 7 shall include the need for inerting, proper personal protective equipment (PPE), and other fire and explosion protection measures during all the operations delineated in Section 13.3.

N 13.2.2 Additive manufacturing facility construction and layout, including powder storage provisions, shall meet the requirements of Chapters 14 through 16 for all applicable metals in addition to the requirements of this chapter.

N 13.2.3* Operations having more than 22.7 kg (50 lb) in the system at any one time shall meet the requirements of 13.2.4.

N 13.2.4* Provisions for Emergency Shutdown for Large Systems.

N 13.2.4.1 The system shall shut down on any of the following conditions:

- (1) Loss of purge gas
- (2) High chamber temperature 50°C (90°F) above normal operating temperature
- (3) Loss of vacuum

N 13.2.4.2 The system shall be provided with an automatic emergency shutdown device.

N 13.2.4.3* The system shall also be provided with a local and a remote manual emergency shutdown device.

N 13.2.4.3.1 Shutdown shall deactivate the affected printing operations.

N 13.2.4.3.2 Shutdown shall not deactivate the purge gas or the vacuum system of the affected system.

N 13.2.5 Shipping and Handling Containers.

N 13.2.5.1* When nonmetallic containers or liners are used for powders, the containers or liners shall be conductive or static dissipative.

N 13.2.5.2* Where the requirement of 13.2.5.1 is not met, a documented risk assessment acceptable to the authority having jurisdiction shall be permitted to be conducted to determine the alternative mitigations to be implemented.

N 13.3 Additive Manufacturing Equipment and Operations.

N 13.3.1 General.

N 13.3.1.1 All pieces of fixed equipment shall be grounded and bonded in accordance with NFPA 77.

N 13.3.1.2 Personnel involved in manually filling or emptying containers or vessels, sieving, handling open containers, or cleaning shall be grounded/bonded during such operations.

N 13.3.2 Powder Weighing Operations.

N 13.3.2.1 Powder weighing equipment shall have an installed ground connection. (See 7.4.1.3 and 10.1.1 in NFPA 77.)

- N 13.3.2.2*** Conductive powder containers shall be bonded to the weighing equipment before the transfer of metallic powder to and from the weighing equipment.
- N 13.3.2.3** All containers or hoppers used for intermediate handling of materials shall be conductive.
- N 13.3.2.4*** Where the requirement of 13.3.2.3 is not met, a documented risk assessment acceptable to the authority having jurisdiction shall be permitted to be conducted to determine the alternative mitigations to be implemented.
- N 13.3.2.5*** Control measures shall be employed to avoid the formation of suspended dust clouds during transfer of powder to and from the weighing equipment.
- N 13.3.3 Sieving Operations.**
- N 13.3.3.1** Powder sieving equipment shall have an installed ground connection.
- N 13.3.3.2*** Conductive powder containers shall be bonded to the sieving equipment before the transfer of metallic powder to and from the sieving equipment.
- N 13.3.3.3** Containers or hoppers used for sieving operations materials shall be conductive.
- N 13.3.3.4*** Where the requirement of 13.3.3.3 is not met, a documented risk assessment acceptable to the authority having jurisdiction shall be permitted to be conducted to determine the alternative mitigations to be implemented.
- N 13.3.3.5*** Control measures shall be employed to avoid the formation of suspended dust clouds during transfer of powder to and from the sieving equipment.
- N 13.3.3.6*** Precautions shall be employed to remove tramp metal before it enters the sieve.
- N 13.3.4 Powder Transport Equipment.**
- N 13.3.4.1** Bonding and grounding connections shall be verified prior to the transfer of metallic powder to and from transport equipment.
- N 13.3.4.2*** Control measures shall be employed to avoid the formation of suspended dust clouds during transfer of powder.
- N 13.3.4.3** Transport containers shall be completely enclosed and sealed during transport.
- N 13.3.5 3D Printing.**
- N 13.3.5.1 Startup.**
- N 13.3.5.1.1*** Before starting printing operations, an inert environment shall be established at a concentration below the limiting oxidant concentration (LOC) for the alloy and size distribution being processed per NFPA 69. The LOC shall be determined for the inert gas being used.
- N 13.3.5.1.2** Inerting operations shall be in accordance with 11.5.2.2 through 11.5.2.8, and the inert gas supply shall be monitored per NFPA 69.
- N 13.3.5.1.3*** Before loading combustible metal powder into the printer, the operator shall verify that the printer and dust collector is free of residual materials from previous operations with other metal alloys, unless a DHA has determined that the materials are compatible under all conditions.
- N 13.3.5.1.4** Purged enclosures shall be in accordance with NFPA 496.
- N 13.3.5.2 Powder Bed Printing.**
- N 13.3.5.2.1** An inert environment shall be maintained at a concentration below the LOC for the alloy and size distribution being processed per NFPA 69. The LOC shall be determined for the inert gas being used.
- N 13.3.5.2.2** The inert gas supply shall be monitored per NFPA 69.
- N 13.3.5.2.3** Control measures shall be employed to minimize frictional heating of the powder.
- N 13.3.5.2.4** Powder shall be transported from the bed to the build platform without forming dust clouds.
- N 13.3.5.2.5** Loose powder and dust accumulations within the printer shall be prevented using inerted dust collectors or an alternate method acceptable to the authority having jurisdiction.
- N 13.3.5.2.5.1** In addition to the requirements in NFPA 69, inerting operations shall be in accordance with 11.5.2.2 through 11.5.2.8.
- N 13.3.5.3 Powder Spray Printing.**
- N 13.3.5.3.1** An inert environment shall be maintained around the powder spray at a concentration below the LOC for the alloy and size distribution being processed per NFPA 69.
- N 13.3.5.3.2** The inert gas supply shall be designed to ensure an envelope within the spray housing and on the build platform is maintained throughout the build process.
- N 13.3.5.3.3** The inert gas supply shall be monitored per NFPA 69.
- N 13.3.5.3.4** The powder spray equipment and operations shall be in accordance with applicable provisions of NFPA 33.
- N 13.3.5.3.5** Loose powder and dust accumulations within the printer shall be minimized using inerted dust collectors or an alternate method acceptable to the authority having jurisdiction.
- N 13.3.5.3.5.1** In addition to the requirements in NFPA 69, inerting operations shall be in accordance with 11.5.2.2 through 11.5.2.8.
- N 13.3.5.4 Object Harvesting.**
- N 13.3.5.4.1*** Printed object removal shall be performed without the formation of a dust cloud.
- N 13.3.5.5 Post Processing Operation.**
- N 13.3.5.5.1*** Loose powder shall be removed from the printed object before post processing.
- N 13.3.5.5.2** Dust generated during post processing shall be captured in accordance with Chapter 11.
- N 13.3.5.6 Fire Protection Systems.**
- N 13.3.5.6.1** Fire protection systems shall be in accordance with Chapter 8.

N 13.4 Equipment and Object Cleaning.

N 13.4.1 Equipment used for cleaning shall be listed for use in a Class II, Group E atmospheres.

N 13.4.2 Grounding and bonding of equipment used for cleaning shall be in accordance with the requirements of Chapter 11.

N 13.4.3 Proper PPE, including the need for flash-fire-resistant garments, shall be in accordance with Section 4.6.

N 13.4.4* Cleaning operations shall avoid the formation of dust clouds.

N 13.4.5 Electrical classification shall be in accordance with Section 10.8.

N 13.5* Training.

N 13.5.1* Operators shall be required to receive documented equipment manufacturer-representative-provided training classes addressing the safety and proper use of all additive manufacturing and cleaning equipment as described in equipment operation manuals.

N 13.5.1.1 Operators shall receive this training prior to production assignment.

N 13.5.1.2 Where these classes are not available, the owner/operator shall develop an equivalent training program based on the current manufacturer's recommendations and knowledgeable and experienced users.

N 13.5.2 In addition to the requirements of Chapter 8, operators shall be trained in accordance with Sections 9.8 of NFPA 652.

N 13.6 Emergency Response.

N 13.6.1 Emergency response shall be in accordance with Chapter 8 in addition to the equipment manufacturer's instructions.

N 13.6.2* Signs identifying the powder composition in the printer shall be posted in a location readily visible to emergency responders.

Chapter 14 Alkali Metals

14.1* General Provisions.

14.1.1 Retroactivity. The requirements of 14.1.2 through 14.1.4 shall apply to new and existing facilities.

14.1.2 Housekeeping.

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

14.1.3 Personal Protective Equipment (PPE). In addition to the requirements of this section, PPE shall be in accordance with Section 4.6.

14.1.3.1* PPE for Handling Solid Alkali Metals.

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

14.1.3.1.2 Personnel shall wear gloves while handling solid alkali metals.

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

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

14.1.3.2* PPE for Handling Molten Alkali Metals.

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

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

14.1.4 Reactivity.

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

14.1.4.2 Eutectic Reactions. (Reserved)

14.1.5 Management of Change. Management of change shall be in accordance with Section 4.4.

14.1.6 Alternative Methodologies. (Reserved)

14.1.7 Test Results. (Reserved)

14.1.8 Other.

14.2* Facility Design Requirements.

14.2.1 Building Construction.

14.2.1.1 Section 14.2 shall apply to buildings or portions of buildings that are dedicated to the handling, processing, or storage of solid or molten alkali metal.

14.2.1.2 Noncombustible Materials.

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

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

Δ 14.2.1.3 Buildings shall comply with applicable provisions of NFPA 101.

14.2.1.4* Roof decks shall be watertight.

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

14.2.1.6* 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.

14.2.1.7* Floor drains shall not be permitted.

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

14.2.1.8.1 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.

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

14.2.1.9 Separation from Water.

14.2.1.9.1* 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.

14.2.1.9.1.1 Water pipes required for safety operations shall be permitted.

14.2.1.9.1.2 Piping permitted by **14.2.1.9.1.1** shall be equipped with an emergency shutoff that is identified and located outside the area.

14.2.1.9.1.3 Piping permitted by **14.2.1.9.1.1** shall be constructed of steel.

14.2.1.9.2 A sprinkler system(s) deemed appropriate in accordance with **8.3.2** shall be permitted.

14.2.1.9.3 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.

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

14.2.1.10* Ventilation.

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

Δ 14.2.1.10.2 Mechanical ventilation systems shall be designed and installed in accordance with *NFPA 5000*.

14.2.1.11 NFPA Hazard Identification Markings.

Δ 14.2.1.11.1 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* to make emergency responders aware of the presence of water-reactive materials within the area.

Δ 14.2.1.11.2 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*.

14.2.2 Fire Protection.

Δ 14.2.2.1 Fire Protection. Fire protection shall be established in accordance with Chapter **8**.

Δ 14.2.2.2* 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 **8**.

14.2.3 Dust Collection. (Reserved)

14.2.4 Hazard Analysis. The hazard analysis shall be in accordance with Section **4.5**.

14.3 Primary Metal Production.

14.3.1 Reduction. (Reserved)

14.3.2 Melting and Casting.

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

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

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

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

14.3.2.4 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.

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

14.3.2.6 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.

14.3.3 Refining. (Reserved)

14.4 Powder Production. (Reserved)

14.5 End Users of Powder. (Reserved)

14.6 Processing and Handling.

14.6.1 Machinery and Operations.

Δ 14.6.1.1* Where alkali metals are processed with a flammable or combustible liquid, the requirements of *NFPA 30* shall also be followed for the flammable or combustible liquids.

14.6.1.2 Moisture Protection.

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

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

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

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

14.6.1.3 Machining and Operations. (Reserved)

14.6.2 Flake and Paste. (Reserved)

14.6.3 Plasma Spray Operations. (Reserved)

14.6.4 Transfer Operations.

14.6.4.1 General Precautions.

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

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

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

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

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

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

14.6.4.1.6* 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.

14.6.5 Processing Recycled Material. (Reserved)

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

14.7.1 Hot Work Operations.

14.7.1.1 Hot work operations shall be in accordance with Section 10.2.

14.7.2 Chip Processing. (Reserved)

14.7.3 Dust Collection. (Reserved)

14.8 Storage and Handling.

14.8.1* Storage of Product.

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

14.8.1.2 Storage of Solid or Molten Alkali Metals.

14.8.1.2.1 General Precautions.

14.8.1.2.1.1* 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.

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

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

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

14.8.1.3 Solid Alkali Metals Storage.

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

14.8.1.3.2 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.

14.8.1.3.3 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.

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

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

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

14.8.1.3.4.3 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.

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

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

14.8.1.4 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.

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

14.8.2.1 NFPA Hazard Identification Markings.

▲ **14.8.2.1.1** 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 to make emergency responders aware of the presence of water-reactive materials within the area.

▲ **14.8.2.1.2** 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.

14.8.3 Recycling.

14.8.4 Chip Processing. (Reserved)

14.9* Fire and Explosion Protection.

▲ **14.9.1** Fire and explosion protection shall be in accordance with Chapter 8.

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

14.9.2 Housekeeping.

14.9.2.1 Dust Control. (Reserved)

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

14.9.3 Control of Ignition Sources.

▲ **14.9.3.1** Control of ignition sources shall be in accordance with Chapter 10.

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

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

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

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

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

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

14.9.4* Hot Work Operations.

14.9.4.1 Hot work operations shall be in accordance with Section 10.2.

14.9.5 Control of Combustible Materials.

Δ 14.9.5.1 Areas in which flammable and combustible liquids are used shall be in accordance with the requirements of NFPA 30.

14.9.5.1.1 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).

Δ 14.9.5.1.2 Dipping and coating applications of flammable or combustible liquids shall be done in accordance with NFPA 34.

Δ 14.9.5.1.3 Spray application of flammable or combustible liquids shall be done in accordance with NFPA 33.

14.9.5.2 Ordinary Combustible Storage.

14.9.5.2.1 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.

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

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

14.9.5.3.1 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.

14.9.5.3.2 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.

14.9.6 Inspection, Maintenance, and Training. (Reserved)

14.10 Other. (Reserved)

N Chapter 15 Legacy Metals

N 15.1* General.

N 15.1.1 Reactivity.

N 15.1.1.1 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.

N 15.1.1.2 Reactive molten metals shall be contained in closed systems that prevent their unintentional contact with air or reactive materials.

N 15.1.2* Contact with Water. Water leakage inside or into any building where the water can contact water reactive metals shall be prevented to avoid possible spontaneous heating.

N 15.1.3* Thermite Reactions. Caution shall be exercised in the mixing of fines or molten material with metal oxides [e.g., iron oxide (rust)].

N 15.1.4* Eutectic Reactions. It shall be the responsibility of the facility to research processing and materials for potentially dangerous reactions and eutectic compositions, which could occur in the course of their activities.

N 15.1.5 Dust Collection. Dust collection shall be in accordance with Chapter 11.

N 15.1.6 Ignition Sources. Electrical power and ignition sources shall be in accordance with Chapter 10.

N 15.1.7 Hot Work.

N 15.1.7.1 Hot work operations shall be in accordance with Section 10.2 and the requirements of this section.

N 15.1.7.2* All welding of legacy metals shall be carried out under an inert atmosphere, such as helium or argon, or under vacuum.

N 15.1.8 Fire Extinguishers. Portable fire extinguishers shall be in accordance with Chapter 8.

N 15.1.9 Fire Protection. Fire suppression systems shall be in accordance with Chapter 8.

N 15.2* Facility Design Requirements.

N 15.2.1 General.

N 15.2.1.1 Individuals or firms designing facilities and/or equipment for the processing of the specific combustible metal shall be briefed by individual(s) or firm(s) knowledgeable in the specific hazards associated with manufacturing, handling, processing, and storage of the specific combustible metal and this standard.

N 15.2.1.2 In addition to the requirements of this chapter, buildings shall comply with applicable provisions of locally adopted building and fire safety codes.

N 15.2.1.3 Where local, state, and national building codes require modifications, such modifications shall be permitted for conformance to these codes and where a hazard analysis is conducted to ensure modifications do not create a greater risk.

N 15.2.1.4 Installation of automatic sprinkler protection shall be in compliance with Chapter 8.

N 15.2.2 Dust Hazard Analysis (DHA).

N 15.2.2.1 Dust hazard analysis shall be in accordance with Chapter 7 and the requirements of this section.

N 15.2.2.2 A hazards analysis shall be performed to determine the material classification and the appropriate hazard classification (i.e., flammable solid, pyrophoric, or water reactive) based on the form or state of the material in determining the high hazard protection level of the structure based on maximum allowable quantity (MAQ) per control area requirements.

N 15.2.3 Building Location.

N 15.2.3.1 A hazards analysis shall be conducted to determine the minimum separation distance for individual buildings and operations within powder and primary production and melting plants.

N 15.2.3.1.1 Separate buildings shall be required where different operations such as, but not limited to, atomization, grinding, crushing, screening, blending, or packaging are performed.

N 15.2.3.1.2 More than one operation within the same building shall be permitted if the design provides equivalent protection.

N 15.2.3.1.3 Different production operations including drying rooms shall be located in separate but not adjoining buildings that are located at least 15 m (50 ft) from each other.

N 15.2.3.1.4 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.

N 15.2.3.1.5 Combustible metal 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 combustible metal powder production plant.

N 15.2.3.1.6 Fuel supply lines shall have an emergency shutoff valve located within easy access outside of the building.

N 15.2.3.1.7 Emergency shutoff valves shall be clearly identified.

N 15.2.4 Building Construction.

N 15.2.4.1 Buildings that contain metals in a combustible form shall be constructed in accordance with the locally adopted building code.

N 15.2.4.2 Buildings housing furnaces, boring and crushing facilities, and refining operations shall be constructed of noncombustible materials.

N 15.2.4.3 Construction of other than noncombustible materials shall be permitted if equivalent protection can be demonstrated.

N 15.2.4.4 Where local, state, and national building codes require modifications, such modifications shall be permitted for conformance to these codes.

N 15.2.4.5 Walls and ceilings shall be constructed with noncombustible insulation that has been tested in accordance with

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

N 15.2.4.6 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.

N 15.2.4.7 All penetrations of floors, walls, ceilings, or partitions where combustible dust is present shall be dusttight, and where structural assemblies have a fire resistance rating, the seal shall maintain that rating.

N 15.2.4.8 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.

N 15.2.4.9 The annulus of all pipe, conduit, and ventilation penetrations shall be sealed.

N 15.2.4.10 All walls of areas where fugitive dust can be produced shall have a smooth finish and shall be sealed to leave no interior or exterior voids where dust can infiltrate and accumulate.

N 15.2.4.10.1 The requirements of 15.2.4.10 shall also apply to elevated platforms, balconies, floors, and gratings.

N 15.2.5 Floors.

N 15.2.5.1 Floors shall be of a noncombustible hard surface, nonslip material and installed with a minimum number of joints in which powder can collect.

N 15.2.5.1.1 The requirements of 15.2.5.1 shall also apply to elevated platforms, balconies, floors, and gratings.

N 15.2.5.2 Floors in reduction, boring, and crushing buildings shall be made of noncombustible materials, such as concrete, brick, or steel plate.

N 15.2.5.3 Aisles shall be provided for maneuverability of material-handling equipment, for accessibility, and to facilitate fire-fighting operations.

N 15.2.6 Roofs.

N 15.2.6.1 Roofs of buildings that house combustible metal dust-producing operations shall be supported on girders or structural members designed to minimize surfaces on which dust can collect.

N 15.2.6.1.1* Roof decks shall be watertight.

N 15.2.7 Surfaces.

N 15.2.7.1 The buildings shall be designed so that all internal surfaces are readily accessible to facilitate cleaning.

N 15.2.7.1.1* Interior surfaces where dust accumulations can occur shall be designed and constructed (and angle greater than the angle of repose) to facilitate cleaning and to minimize combustible dust accumulation.

N 15.2.8 Protective Openings.

N 15.2.8.1 Means of egress shall be provided in compliance with NFPA 101.

N 15.2.8.2 All doors in interior fire-rated partitions shall be listed, self-closing fire doors installed in accordance with NFPA 80.

N 15.2.9 Enclosed Passageways.

N 15.2.9.1* Where buildings or process areas are interconnected by enclosed passageways, and there is a deflagration hazard, the passageways shall be designed to prevent propagation of an explosion or fire from one unit to another in accordance with NFPA 68.

N 15.2.9.2 All enclosed passageways that can be occupied and that connect with one or more processing areas shall be provided with means of egress in accordance with NFPA 101.

N 15.2.10 Heating and Cooling of Buildings.

N 15.2.10.1 Buildings shall be permitted to be heated by indirect hot-air heating systems, by bare-pipe heating systems using steam or hot water as the heat transfer medium, or by listed electric heaters.

N 15.2.10.1.1 Indirect hot air shall be permitted if the heating unit is located in a combustible metal dust-free area adjacent to the room or area where heated air is required.

N 15.2.10.1.2 Fans or blowers used to convey the heated or cooled air shall be located in a combustible metal dust-free location.

N 15.2.10.1.3 The air supply shall be taken from outside or from a location that is free of combustible metal dust.

N 15.2.10.1.4 Make-up 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 metal dust or powder.

N 15.2.10.1.5 The requirements of 15.2.10.1.1 through 15.2.10.1.4 shall not apply to areas where metal is melted.

N 15.2.11* Ventilation.

N 15.2.11.1 Where hydrogen generation occurs during the process, ventilation shall be provided for dissipation of hydrogen to the atmosphere.

N 15.2.11.2 Mechanical ventilation systems shall be designed and installed in accordance with the locally adopted building and fire code.

N 15.2.12 Explosion Mitigation/Deflagration Venting.

N 15.2.12.1* Explosion venting in accordance with NFPA 68 shall be required for all buildings or building areas where combustible metal powders or dusts are present, unless a hazard analysis has been performed that shows that explosion venting is not required.

N 15.2.12.2 In accordance with NFPA 68, deflagration 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.

N 15.2.12.3* Relief valves shall not be vented to a dust hazard area.

N 15.2.12.4 Equipment shall be located or arranged in a manner that minimizes combustible dust accumulations on surfaces.

N 15.2.12.5 Deflagration venting shall not be required for areas where combustible metal powder is stored or moved only in covered or sealed containers.

N 15.2.13 Separation from Water.

N 15.2.13.1 Combustible metal winning, refining, and casting operations shall be protected from rain and from other possibilities of inadvertent contact with water.

N 15.2.13.1.1* 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) are not permitted in areas containing combustible metals unless a hazards analysis is performed.

N 15.2.13.1.2 Permitted piping in areas in which a combustible metal fire may occur shall be equipped with an emergency shutoff that is identified, located outside the area, and of all-metal construction.

N 15.2.14 Drying Rooms.

N 15.2.14.1 A hazards analysis shall be performed to determine the proper type of drying used for the specific powders being handled as well as the specific parameters used for drying.

N 15.3 Primary Metal Production.

N 15.3.1 Aluminum. This standard shall not apply to the primary production of aluminum.

N 15.3.1.1 Reduction. (Reserved)**N 15.3.1.2 Refining. (Reserved)****N 15.3.1.3 Melting and Casting. (Reserved)**

N 15.3.2 Magnesium. This standard shall not apply to the primary production of magnesium.

N 15.3.2.1 Reduction. (Reserved)**N 15.3.2.2 Refining. (Reserved)****N 15.3.2.3* Melting and Casting.**

N 15.3.2.3.1 Buildings used for the melting and casting of magnesium shall be noncombustible.

N 15.3.2.3.1.1 Melt rooms shall provide access to facilitate fire control.

N 15.3.2.3.1.2* Floors shall be of noncombustible construction and shall be kept clean and free of moisture and standing water.

N 15.3.2.3.2* 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.

N 15.3.2.3.3 Fuel supply lines to melting pots and preheating installations shall have remote fuel shutoffs and combustion safety controls in accordance with NFPA 86 or equivalent.

N 15.3.2.3.4* Prevention of Molten Magnesium Contact with Foreign Materials.

N 15.3.2.3.4.1 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.

N 15.3.2.3.4.2 Crucible interiors and covers shall be maintained free of iron oxide scale, which could fall into the molten metal.

N 15.3.2.3.4.3 Molten magnesium systems shall overflow or relieve to secondary containments designed to handle