

NFPA®

484

Standard for
Combustible Metals

2022



NFPA® 484

Standard for Combustible Metals

2022 Edition



NFPA, 1 Batterymarch Park, Quincy, MA 02269-9101
An International Codes and Standards Organization

Documents
Document Sharing Hub

IMPORTANT NOTICES AND DISCLAIMERS CONCERNING NFPA® STANDARDS

NFPA® codes, standards, recommended practices, and guides (“NFPA Standards”), of which the document contained herein is one, are developed through a consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on fire and other safety issues. While the NFPA administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in NFPA Standards.

The NFPA disclaims liability for any personal injury, property, or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on NFPA Standards. The NFPA also makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

In issuing and making NFPA Standards available, the NFPA is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the NFPA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The NFPA has no power, nor does it undertake, to police or enforce compliance with the contents of NFPA Standards. Nor does the NFPA list, certify, test, or inspect products, designs, or installations for compliance with this document. Any certification or other statement of compliance with the requirements of this document shall not be attributable to the NFPA and is solely the responsibility of the certifier or maker of the statement.

REVISION SYMBOLS IDENTIFYING CHANGES FROM THE PREVIOUS EDITION

Text revisions are shaded. A **Δ** before a section number indicates that words within that section were deleted and a **Δ** to the left of a table or figure number indicates a revision to an existing table or figure. When a chapter was heavily revised, the entire chapter is marked throughout with the **Δ** symbol. Where one or more sections were deleted, a **•** is placed between the remaining sections. Chapters, annexes, sections, figures, and tables that are new are indicated with an **N**.

Note that these indicators are a guide. Rearrangement of sections may not be captured in the markup, but users can view complete revision details in the First and Second Draft Reports located in the archived revision information section of each code at www.nfpa.org/docinfo. Any subsequent changes from the NFPA Technical Meeting, Tentative Interim Amendments, and Errata are also located there.

REMINDER: UPDATING OF NFPA STANDARDS

Users of NFPA codes, standards, recommended practices, and guides (“NFPA Standards”) should be aware that these documents may be superseded at any time by the issuance of a new edition, may be amended with the issuance of Tentative Interim Amendments (TIAs), or be corrected by Errata. It is intended that through regular revisions and amendments, participants in the NFPA standards development process consider the then-current and available information on incidents, materials, technologies, innovations, and methods as these develop over time and that NFPA Standards reflect this consideration. Therefore, any previous edition of this document no longer represents the current NFPA Standard on the subject matter addressed. NFPA encourages the use of the most current edition of any NFPA Standard [as it may be amended by TIA(s) or Errata] to take advantage of current experience and understanding. An official NFPA Standard at any point in time consists of the current edition of the document, including any issued TIAs and Errata then in effect.

To determine whether an NFPA Standard has been amended through the issuance of TIAs or corrected by Errata, visit the “Codes & Standards” section at www.nfpa.org.

ADDITIONAL IMPORTANT NOTICES AND DISCLAIMERS CONCERNING NFPA® STANDARDS

Updating of NFPA Standards

Users of NFPA codes, standards, recommended practices, and guides (“NFPA Standards”) should be aware that these documents may be superseded at any time by the issuance of a new edition, may be amended with the issuance of Tentative Interim Amendments (TIAs), or be corrected by Errata. It is intended that through regular revisions and amendments, participants in the NFPA standards development process consider the then-current and available information on incidents, materials, technologies, innovations, and methods as these develop over time and that NFPA Standards reflect this consideration. Therefore, any previous edition of this document no longer represents the current NFPA Standard on the subject matter addressed. NFPA encourages the use of the most current edition of any NFPA Standard [as it may be amended by TIA(s) or Errata] to take advantage of current experience and understanding. An official NFPA Standard at any point in time consists of the current edition of the document, including any issued TIAs and Errata then in effect.

To determine whether an NFPA Standard has been amended through the issuance of TIAs or corrected by Errata, visit the “Codes & Standards” section at www.nfpa.org.

Interpretations of NFPA Standards

A statement, written or oral, that is not processed in accordance with Section 6 of the Regulations Governing the Development of NFPA Standards shall not be considered the official position of NFPA or any of its Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

Patents

The NFPA does not take any position with respect to the validity of any patent rights referenced in, related to, or asserted in connection with an NFPA Standard. The users of NFPA Standards bear the sole responsibility for determining the validity of any such patent rights, as well as the risk of infringement of such rights, and the NFPA disclaims liability for the infringement of any patent resulting from the use of or reliance on NFPA Standards.

NFPA adheres to the policy of the American National Standards Institute (ANSI) regarding the inclusion of patents in American National Standards (“the ANSI Patent Policy”), and hereby gives the following notice pursuant to that policy:

NOTICE: The user’s attention is called to the possibility that compliance with an NFPA Standard may require use of an invention covered by patent rights. NFPA takes no position as to the validity of any such patent rights or as to whether such patent rights constitute or include essential patent claims under the ANSI Patent Policy. If, in connection with the ANSI Patent Policy, a patent holder has filed a statement of willingness to grant licenses under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, copies of such filed statements can be obtained, on request, from NFPA. For further information, contact the NFPA at the address listed below.

Law and Regulations

Users of NFPA Standards should consult applicable federal, state, and local laws and regulations. NFPA does not, by the publication of its codes, standards, recommended practices, and guides, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

NFPA Standards are copyrighted. They are made available for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of safe practices and methods. By making these documents available for use and adoption by public authorities and private users, the NFPA does not waive any rights in copyright to these documents.

Use of NFPA Standards for regulatory purposes should be accomplished through adoption by reference. The term “adoption by reference” means the citing of title, edition, and publishing information only. Any deletions, additions, and changes desired by the adopting authority should be noted separately in the adopting instrument. In order to assist NFPA in following the uses made of its documents, adopting authorities are requested to notify the NFPA (Attention: Secretary, Standards Council) in writing of such use. For technical assistance and questions concerning adoption of NFPA Standards, contact NFPA at the address below.

For Further Information

All questions or other communications relating to NFPA Standards and all requests for information on NFPA procedures governing its codes and standards development process, including information on the procedures for requesting Formal Interpretations, for proposing Tentative Interim Amendments, and for proposing revisions to NFPA standards during regular revision cycles, should be sent to NFPA headquarters, addressed to the attention of the Secretary, Standards Council, NFPA, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101; email: stds_admin@nfpa.org.

For more information about NFPA, visit the NFPA website at www.nfpa.org. All NFPA codes and standards can be viewed at no cost at www.nfpa.org/docinfo.

Copyright © 2021 National Fire Protection Association®. All Rights Reserved.

NFPA® 484

Standard for

Combustible Metals

2022 Edition

This edition of NFPA 484, *Standard for Combustible Metals*, was prepared by the Technical Committee on Combustible Metals and Metal Dusts, released by the Correlating Committee on Combustible Dusts, and acted on by the NFPA membership during the 2021 NFPA Technical Meeting held June 14–July 2. It was issued by the Standards Council on August 26, 2021, with an effective date of September 15, 2021, 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 September 15, 2021.

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, the original edition of NFPA 484 provided safety requirements for all combustible metals, including for processing, storage, handling, dust collection, housekeeping, and fire protection.

The 2006 edition of NFPA 484, *Standard for Combustible Metals*, contained several major changes, including a new title. A new chapter, Chapter 4, included 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 from Chapters 5 through 12.

The 2009 edition of NFPA 484 contained the following changes:

- (1) Addition of 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 terms, including *metal dust*, *finer*, *superfines*, *ultrafines*, *flakes*, *paste*, and *ribbon*. A definition for *screening test* was also added. The committee clarified when the standard would apply rather than when the standard would not apply. New information was included in Chapter 16 to clarify the requirements for testing and classifying potentially combustible metals.

- (3) Management of change requirements were added to chapters where they had not been previously identified.
- (4) New information was added about wet dust collection systems and housekeeping, both of which are important issues for the prevention of fires and explosions. Personal protective equipment (PPE) requirements were also 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. In addition, information was added to address emergency response requirements.
- (7) Hazard analysis requirements were made 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 was changed to include revised procedures for material characterization and determining combustibility and explosibility of metal dusts. As part of those requirements, test data or historical data were permitted to be used. Chapter 5 was changed to include requirements for management system elements, such as management of change, hazard analysis, and personal protective equipment. As part of an effort to consolidate the 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 was revised to include new requirements for 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 systems. The committee also modified Chapters 11 through 18 by moving requirements common to all the metal types (such as PPE, management of change, dust collection, ignition sources, and hazard analysis) to the fundamental chapters (Chapters 4 through 9). The committee also added acceptance criteria to Chapter 19 for metal recycling.

The 2019 edition of NFPA 484 was a complete reorganization of the document. Many of the changes were made to align the document with NFPA 652, *Standard on the Fundamentals of Combustible Dust*. A new Chapter 7 was added on Dust Hazard Analysis.

Chapter 4, General, was revised to include material on objectives and compliance options to align with NFPA 652. It was also modified to include requirements on Management of Change and Personnel Protective Equipment.

New chapters were 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, was completely rewritten to provide clarity for users. Chapter 15, Legacy Metals, consolidated the common requirements for aluminum, magnesium, niobium, tantalum, titanium, zirconium, and hafnium into a single location. Note that the material specific to these metals remains in the metal-specific chapters.

In addition to the above changes, definitions in Chapter 3 were reviewed and updated to correlate with those in NFPA 652, the fundamentals document. Where requirements in the code were retroactive, statements were included to clearly indicate that to the user. Material was 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 clarified and strengthened the requirements regarding static electricity. Changes were also made to the requirements for electrical area classification from NFPA 70®, *National Electrical Code*®, to clarify that the committee did not agree with the definition of combustible dust found in NFPA 70. The committee also clarified that the zone classification system must not be used for metal dusts.

For the 2022 edition, the standard has been reorganized so that the first nine chapters correlate with the topics covered in NFPA 652, as well as to organize the remaining chapters so that the requirements in the first nine chapters do not conflict with other areas of the standard. Language has been added to the annex to address hazards that might exist in quantities under the standard's applicability thresholds.

In addition, a requirement has been added for the K_{st} value to be doubled for certain metals unless their explosibility characteristics are determined in a 1 m³ or larger test vessel, and annex material has been added to explain this requirement. The requirements for fire detection for dry-type air-material separators have also been revised to allow for methods other than surface-mounted devices and to require that all filter locations (if present) be monitored.

The Legacy Metals chapter has been reorganized to consolidate the requirements that apply to all legacy metals, and the chapter on Additive Manufacturing has been revised to address the growing utilization of metal powders in additive manufacturing, addressing dust hazard analysis, the location of emergency shutdown controls, harvesting printed objects, powder storage, and operator training.

Correlating Committee on Combustible Dusts

Kevin Kreitman, *Chair*
Albany Fire Department, OR [E]

Chris Aiken, Cargill, Inc., MN [U]
John M. Cholin, J. M. Cholin Consultants Inc., NJ [SE]
Martin P. Clouthier, JENSEN HUGHES, Canada [SE]
Gregory F. Creswell, Cambridge-Lee Industries, PA [M]
Scott G. Davis, GexCon US, MD [SE]
Walter L. Frank, Frank Risk Solutions, Inc., DE [SE]
Robert C. Gombar, Baker Engineering & Risk Consultants, Inc., MD [U]
Rep. US Beet Sugar Association
John A. LeBlanc, FM Global, MA [I]
Rep. FM Global

Arthur P. Mattos, Jr., TUV SUD America Inc./Global Risk Consultants, NC [SE]
Jack E. Osborn, Airdusco, Inc., TN [M]
Jeffrey R. Roberts, AXA XL/Global Asset Protection Services, LLC, MS [I]
Jef Snoeys, Fike Corporation, Belgium [M]
Bill Stevenson, CV Technology, Inc., FL [M]
J. Anthony Yount, Ardent Mills, LLC, CO [U]

Alternates

Christopher D. Headen, Cargill, Inc., MN [U]
(Alt. to Chris Aiken)
Jason Krbec, CV Technology, Inc., FL [M]
(Alt. to Bill Stevenson)
Edward R. LaPine, JENSEN HUGHES, NY [SE]
(Alt. to Martin P. Clouthier)
Adam Morrison, Fike Corporation, MO [M]
(Alt. to Jef Snoeys)

Arthur G. Sapper, Ogletree Deakins, DC [U]
(Alt. to Robert C. Gombar)
Jeffery W. Sutton, TUV SUD America Inc./Global Risk Consultants Corporation, MN [SE]
(Alt. to Arthur P. Mattos, Jr.)

Nonvoting

Brad D. Burridge, Novelis, Inc., KY [U]
Rep. TC on Fundamentals of Combustible Dusts
Peter Danis, Novelis, GA [U]
Mark W. Drake, Liberty Mutual, KS [I]
Rep. TC on Combustible Metals and Metal Dusts
William R. Hamilton, US Department of Labor, DC [E]
Laura E. Moreno, NFPA Staff Liaison

Timothy J. Myers, Exponent, Inc., MA [SE]
Rep. TC on Agricultural Dusts
Mark L. Runyon, Marsh Risk Consulting, OR [I]
Rep. TC on Handling and Conveying of Dusts, Vapors, and Gases

This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

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

Committee Scope: This Committee shall have primary responsibility for documents on 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.

Technical Committee on Combustible Metals and Metal Dusts

Mark W. Drake, *Chair*
Liberty Mutual, KS [I]

Donna R. Bruce, *Secretary*
KEMET Electronics Corporation, SC [U]

Steve James Barwin, SLM Solutions NA, MI [M]
Philip Basile, Clayton Associates, NJ [M]
Elizabeth C. Buc, Fire & Materials Research Laboratory, LLC, MI [RT]
Brad D. Burrige, Novelis, Inc., KY [U]
Tom Christman, Knoxville, TN [SE]
Ryan Condon, ATI-Wah Chang, OR [M]
Gregory F. Creswell, Cambridge-Lee Industries, PA [M]
Ashok Ghose Dastidar, Fauske & Associates, LLC, IL [U]
Scott G. Davis, GexCon US, MD [SE]
Scott E. Dillon, Crane Engineering, MN [SE]
Peter F. Downing, Environment & Safety Solutions, Inc., NJ [SE]
Michael David Heroux, American International Group, Inc. (AIG), OH [I]
Eli Horden, The Boeing Company, WA [U]
Daniel J. Hubert, Amerex/Janus Fire Systems, IN [M]
Dehong Kong, Princeton Safety Solutions, Inc., NJ [SE]

Kevin Kreitman, Albany Fire Department, OR [E]
Timothy J. Myers, Exponent, Inc., MA [SE]
Jack E. Osborn, Airdusco, Inc., TN [M]
Nicholas S. Reding, Fike Corporation, MO [M]
Samuel A. Rodgers, Honeywell, Inc., VA [U]
Mark S. Rosenberger, Los Alamos National Laboratories, NM [U]
Andrew Ryerson, FM Global, MA [I]
Rep. FM Global
Gregory M. Super, Eckart America, OH [M]
Rep. The Aluminum Association, Inc.
Patrick A. Thornton, Oak Ridge National Laboratory, TN [U]
Erdem A. Ural, Loss Prevention Science & Technologies, Inc., MA [SE]
Richard S. Varga, Niagara Metallurgical Products, Canada [U]
David K. Young, Idaho National Laboratory, ID [RT]
Robert G. Zalosh, Firexplo, MA [SE]
Stephen Zimmerman, Intrepid Electronic Systems, CA [IM]

Alternates

Jason L. Angell, Liberty Mutual, KY [I]
(Alt. to Mark W. Drake)
Scott D. Cowan, Albany Fire Department, OR [E]
(Alt. to Kevin Kreitman)
Keenan Thomas Dotson, Los Alamos National Laboratories (LANL), NM [U]
(Alt. to Mark S. Rosenberger)
Ryan Giberson, Clayton Associates, NJ [M]
(Alt. to Philip Basile)
Warren Greenfield, WG Associates LLC, NJ [SE]
(Alt. to Robert G. Zalosh)
Paul F. Hart, American International Group, Inc. (AIG), IL [I]
(Alt. to Michael David Heroux)
Jason Hudson, Novelis, Inc., GA [U]
(Alt. to Brad D. Burrige)
Laura Jacobsen, The Boeing Company, CA [U]
(Alt. to Eli Horden)

Shay Elliott Massey, Oak Ridge National Laboratory, TN [U]
(Alt. to Patrick A. Thornton)
John E. McConaghie, Luxfer MEL Technologies/Magnesium Elektron Powders NJ, NJ [U]
(Alt. to Richard S. Varga)
Brion Russell Pearson, Idaho National Laboratory, ID [RT]
(Alt. to David K. Young)
Shanker Pershad, Honeywell International, VA [U]
(Alt. to Samuel A. Rodgers)
Scott Ryan, Allegheny Technologies Inc. (ATI), NC [M]
(Alt. to Ryan Condon)
Lon L. Scholl, Fike/Suppression Systems Inc., PA [M]
(Alt. to Nicholas S. Reding)
James Eamon Vickery, Exponent, MA [SE]
(Alt. to Timothy J. Myers)

Nonvoting

William R. Hamilton, US Department of Labor, DC [E]
Albert Muller, Lebanon, NJ [O]
(Member Emeritus)

Robert W. Nelson, Pocasset, MA [O]
(Member Emeritus)

Laura E. Moreno, NFPA Staff Liaison

This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

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

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

Contents

Chapter 1 Administration	484- 7	8.15 Employee Participation.	484- 22
1.1 Scope.	484- 7	Chapter 9 Hazard Management: Mitigation and Prevention	484- 22
1.2 Purpose.	484- 7	9.1 Inherently Safer Designs.	484- 22
1.3 Application.	484- 8	9.2 Building Design.	484- 22
1.4 Conflicts.	484- 8	9.3 Equipment Design.	484- 25
1.5 Retroactivity.	484- 8	9.4 Ignition Source Control.	484- 28
1.6 Equivalency.	484- 8	9.5 Pyrophoric Dusts. (Reserved)	484- 31
1.7 Units and Formulas.	484- 8	9.6 Dust Control.	484- 31
Chapter 2 Referenced Publications	484- 8	9.7 Explosion Prevention/Protection.	484- 32
2.1 General.	484- 8	9.8 Fire Protection.	484- 32
2.2 NFPA Publications.	484- 8	Chapter 10 Fire Prevention, Fire Protection, and Emergency Response	484- 33
2.3 Other Publications.	484- 9	10.1 Retroactivity.	484- 33
2.4 References for Extracts in Mandatory Sections.	484- 10	10.2 General.	484- 33
Chapter 3 Definitions	484- 10	10.3 Operating Procedures and Practices.	484- 33
3.1 General.	484- 10	10.4 Fire Prevention.	484- 33
3.2 NFPA Official Definitions.	484- 10	10.5 Fire Protection.	484- 34
3.3 General Definitions.	484- 10	10.6 Training and Hazard Awareness.	484- 35
Chapter 4 General Requirements	484- 14	10.7 Emergency Planning/Preparedness and Response.	484- 36
4.1 General.	484- 14	10.8 Emergency Response.	484- 37
4.2 Objectives.	484- 14	10.9 Incident Investigation.	484- 38
Chapter 5 Hazard Identification — Determination of the Combustibility or Explosibility of a Metal, Metal Powder, or Metal Dust	484- 15	Chapter 11 Housekeeping	484- 38
5.1 Responsibility.	484- 15	11.1 Retroactivity.	484- 38
5.2 Overview.	484- 15	11.2 Applicability.	484- 38
5.3 Basic Material Characterization.	484- 15	11.3 Housekeeping Plan.	484- 38
5.4 Determination of Combustibility.	484- 15	11.4 Cleanup Procedures for Fugitive Dust Accumulations.	484- 38
5.5 Determination of Explosibility.	484- 15	11.5 Cleanup of Spilled Dust, Fine or Powder.	484- 38
5.6 Use of Test Data for Hazard Analysis.	484- 16	11.6 Vacuum Cleaning.	484- 38
5.7 Determination of Flash-Fire Potential. (Reserved)	484- 16	11.7 Compressed Air Cleaning Requirements.	484- 38
5.8 Organometallic Materials. (Reserved)	484- 16	11.8 Water-Cleaning Requirements.	484- 39
Chapter 6 Performance-Based Design Option	484- 16	11.9 Cleaning Frequency.	484- 39
6.1 General Requirements.	484- 16	11.10 General Precautions.	484- 39
6.2 Design Objectives.	484- 17	Chapter 12 Control of Ignition Sources	484- 39
6.3 Performance Criteria.	484- 17	12.1 Retroactivity.	484- 39
6.4 Design Scenarios.	484- 17	12.2 Hot Work.	484- 39
6.5 Evaluation of Proposed Design.	484- 18	12.3 Control of Friction Hazards.	484- 39
6.6 Retained Prescriptive Requirements.	484- 18	12.4 Electrical Area Classification.	484- 40
Chapter 7 Hazard Analysis	484- 18	12.5 Portable Electrical and Electronic Equipment. .	484- 40
7.1 General Requirements.	484- 18	Chapter 13 Pneumatic Conveying, Dust Collection, and Centralized Vacuum Cleaning Systems	484- 40
7.2 Dust Hazard Analysis (DHA).	484- 18	13.1 Retroactivity.	484- 40
7.3 Molten Metal Hazard Analysis.	484- 19	13.2 Dust Collection.	484- 40
7.4 Risk Evaluation.	484- 20	13.3 Centralized Vacuum Cleaning System.	484- 46
7.5 Dust Explosion and Flash-Fire Hazard Areas.	484- 20	13.4 Portable Vacuum Cleaners.	484- 46
Chapter 8 Management Systems	484- 20	13.5 Pneumatic Conveying of Powder.	484- 46
8.1 Retroactivity.	484- 20	13.6 Powder Collection.	484- 47
8.2 General.	484- 20	Chapter 14 Nanometal Powders	484- 48
8.3 Operating Procedures and Practices.	484- 20	14.1 Retroactivity.	484- 48
8.4 Housekeeping.	484- 21	14.2 General.	484- 48
8.5 Hot Work.	484- 21	14.3 Nanoparticle Production Processes.	484- 48
8.6 Personal Protective Equipment (PPE).	484- 21	14.4 Equipment Design and Operation.	484- 48
8.7 Inspection, Testing, and Maintenance.	484- 21	14.5 Housekeeping.	484- 49
8.8 Training and Hazard Awareness.	484- 21	Chapter 15 Additive Manufacturing	484- 49
8.9 Contractors.	484- 21	15.1 Retroactivity.	484- 49
8.10 Emergency Planning and Response.	484- 22	15.2 General Requirements.	484- 49
8.11 Incident Investigation.	484- 22		
8.12 Management of Change.	484- 22		
8.13 Documentation Retention.	484- 22		
8.14 Management Systems Review.	484- 22		

15.3	Additive Manufacturing Equipment and Operations.	484– 49	19.2	Recycling and Waste Management of Combustible Metal — Collection, Storage, and Handling of Fines Generated During Scrap Receiving, Storage, Recycling, and Waste Treatment.	484– 70
15.4	Equipment and Object Cleaning.	484– 51	19.3	Storage of Combustible Metals for Recycling and Waste Management.	484– 71
15.5	Training.	484– 51	19.4	Sample Identification and Collection for Metals in a Combustible Form.	484– 72
15.6	Emergency Response.	484– 51	19.5	Personal Protective Equipment (PPE).	484– 72
Chapter 16	Alkali Metals	484– 52	19.6	Reactivity.	484– 72
16.1	General Provisions.	484– 52	19.7	Management of Change.	484– 72
16.2	Facility Design Requirements.	484– 52	19.8	Facility Design Requirements.	484– 72
16.3	Primary Metal Production.	484– 52	19.9	Emergency Preparedness.	484– 72
16.4	Powder Production. (Reserved)	484– 53	19.10	Processing.	484– 72
16.5	End Users of Powder. (Reserved)	484– 53	19.11	Fire and Explosion Prevention.	484– 73
16.6	Processing and Handling.	484– 53	Annex A	Explanatory Material	484– 74
16.7	Machining, Fabrication, Finishing, and Media Blasting.	484– 53	Annex B	Electrically Conductive Floors	484– 134
16.8	Storage and Handling.	484– 53	Annex C	Supplementary Information on Magnesium	484– 134
16.9	Fire and Explosion Protection.	484– 54	Annex D	Design for Dust Concentration Control in Ductwork	484– 136
16.10	Other. (Reserved)	484– 54	Annex E	Supplementary Information on Tantalum	484– 138
Chapter 17	Legacy Metals	484– 54	Annex F	Supplementary Information on Titanium	484– 141
17.1	General.	484– 54	Annex G	Supplementary Information on Zirconium	484– 143
17.2	Facility Design Requirements.	484– 55	Annex H	Extinguishing Agents That Should Not Be Used on Lithium Fires	484– 146
17.3	Primary Metal Production (Smelting).	484– 55	Annex I	Testing for Detailed Characterization of Explosive Behavior of Materials	484– 146
17.4	Powder Production.	484– 56	Annex J	Informational References	484– 148
17.5	End Users of Powder.	484– 59	Index		484– 152
17.6	Processing and Handling.	484– 60			
17.7	Machining, Fabrication, Finishing, and Media Blasting.	484– 61			
17.8	Storage and Handling.	484– 63			
17.9	Fire and Explosion Prevention.	484– 65			
Chapter 18	Other Metals	484– 66			
18.1	General Provisions.	484– 66			
18.2	Facility Design Requirements.	484– 66			
18.3	Primary Metal Production.	484– 66			
18.4	Powder Production.	484– 67			
18.5	End Users of Powder.	484– 67			
18.6	Processing.	484– 68			
18.7	Machining, Fabrication, Finishing, and Media Blasting.	484– 69			
18.8	Storage and Handling.	484– 69			
18.9	Fire and Explosion Prevention.	484– 70			
18.10	Other. (Reserved)	484– 70			
Chapter 19	Recycling and Waste Management Facilities	484– 70			
19.1	General Provisions.	484– 70			

NFPA 484

Standard for

Combustible Metals

2022 Edition

IMPORTANT NOTE: This NFPA document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading “Important Notices and Disclaimers Concerning NFPA Standards.” They can also be viewed at www.nfpa.org/disclaimers or obtained on request from NFPA.

UPDATES, ALERTS, AND FUTURE EDITIONS: New editions of NFPA codes, standards, recommended practices, and guides (i.e., NFPA Standards) are released on scheduled revision cycles. This edition may be superseded by a later one, or it may be amended outside of its scheduled revision cycle through the issuance of Tentative Interim Amendments (TIAs). An official NFPA Standard at any point in time consists of the current edition of the document, together with all TIAs and Errata in effect. To verify that this document is the current edition or to determine if it has been amended by TIAs or Errata, please consult the National Fire Codes® Subscription Service or the “List of NFPA Codes & Standards” at www.nfpa.org/docinfo. In addition to TIAs and Errata, the document information pages also include the option to sign up for alerts for individual documents and to be involved in the development of the next edition.

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

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced and extracted 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 Metals.

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 metal in any form.

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 metals shall include, but shall not be limited to, machining,

sawing, grinding, sanding, buffing, polishing, and thermal spraying.

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

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

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

1.1.6* This standard provides requirements for mixtures that contain metals exhibiting combustion characteristics of metals covered by this standard. (See 5.2.4 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 it is established by testing 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 mixture of metal and metal-oxide that can undergo an exothermic oxidation-reduction (thermite) reaction.

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.

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 This standard shall be used to supplement the requirements established by NFPA 652.

1.4 Conflicts.

1.4.1 Where a conflict exists between a requirement of NFPA 652 and a requirement of this standard, the requirement of this standard shall apply.

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

1.4.3 Where this standard neither prohibits nor provides a requirement, the requirement in NFPA 652 shall apply.

1.4.4 Where a conflict between a general requirement of this standard and a specific requirement of this standard exists, the specific requirement shall apply.

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 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.

1.7 Units and Formulas.

1.7.1 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).

1.7.2* 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.

1.7.3 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.

1.7.4 Where extracted text contains values expressed in only one system of units, the values in the extracted text have been retained without conversion to preserve the values established by the responsible technical committee in the source document.

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*, 2021 edition.

NFPA 2, *Hydrogen Technologies Code*, 2020 edition.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2022 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2021 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2021 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 2021 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2022 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2022 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2019 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2021 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2022 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2018 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2022 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2020 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2021 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, 2020 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, 2021 edition.

NFPA 34, *Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*, 2021 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 2019 edition.

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

NFPA 54, *National Fuel Gas Code*, 2021 edition.

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

NFPA 69, *Standard on Explosion Prevention Systems*, 2019 edition.

NFPA 70®, *National Electrical Code®*, 2020 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2022 edition.

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

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2022 edition.

NFPA 85, *Boiler and Combustion Systems Hazards Code*, 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*, 2020 edition.

NFPA 101®, *Life Safety Code®*, 2021 edition.

NFPA 220, *Standard on Types of Building Construction*, 2021 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2021 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 2021 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*, 2020 edition.

NFPA 652, *Standard on the Fundamentals of Combustible Dust*, 2022 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2020 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2022 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2019 edition.

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

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2021 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*, 2020 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2021 edition.

2.3 Other Publications.

2.3.1 ASME Publications. American Society of Mechanical Engineers, 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*, 2020.

ASTM E136, *Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*, 2019a.

ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*, 2019.

ASTM E1515, *Standard Test Method for Minimum Explosible Concentration of Combustible Dusts*, 2014.

ASTM E2019, *Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air*, 2003, reapproved 2019.

ASTM E2931, *Standard Test Method for Limiting Oxygen (Oxidant) Concentration of Combustible Dust Clouds*, 2013, reapproved 2019.

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

ISO/ASTM 52900, *Standard Terminology for Additive Manufacturing — General Principles — Terminology*, 2015.

2.3.3 IEC Publications. International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland.

IEC 61340-4-4, *Electrostatics — Part 4-4: Standard Test Methods for Specific Applications — Electrostatic Classification of Flexible Intermediate Bulk Containers (FIBC)*, 2005.

2.3.4 ISA Publications. International Society of Automation, 67 T. W. Alexander Drive, PO Box 12277, Research Triangle Park, NC 27709.

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

2.3.5 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.

2.3.6 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*, 2019 edition.

NFPA 70®, *National Electrical Code®*, 2020 edition.

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

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*, 2020 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2021 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*, 2020 edition.

NFPA 921, *Guide for Fire and Explosion Investigations*, 2021 edition.

NFPA 1250, *Recommended Practice in Fire and Emergency Service Organization Risk Management*, 2020 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 equip-

ment, 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.

3.3.1 Abort Gate/Damper. A device for the quick diversion of material or air to the exterior of a building or other safe location in the event of a fire. [652, 2019]

3.3.2 Additive Manufacturing (AM). The process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies. [ISO/ASTM 52900, 2015]

3.3.3* Air-Material Separator (AMS). A device designed to separate the conveying air from the material being conveyed. [652, 2019]

3.3.3.1 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]

3.3.4* 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]

3.3.5 Alkali Metals. See 3.3.52.1.

3.3.6 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.

3.3.7 Aluminum Powder. See 3.3.63.3.

3.3.8 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]

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

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

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

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

3.3.12* 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]

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

3.3.14 Combustible Metal. See 3.3.52.2.

3.3.14.1* 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.

3.3.14.2 Combustible Metal Particulate. See 3.3.14.1, Combustible Metal Dust.

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

3.3.15* 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]

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

N 3.3.17* Conductive. Possessing the ability to allow the flow of an electric charge. [652, 2019]

N 3.3.17.1 Conductive Dusts. Dusts with a volume resistivity of less than 10^6 ohm-m. [652, 2019]

N 3.3.18 Conductor. A material or object that allows an electric charge to flow easily through it. [77, 2019]

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

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

3.3.21 Deflagration Hazard Area.

3.3.21.1 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.

3.3.21.2 Dust Flash-Fire Hazard Area. An area where combustible dust accumulation on exposed or concealed surfaces, outside of equipment or containers, can result in personnel injury from thermal dose during a dust deflagration, as well as any areas where dust clouds of a hazardous

concentration exist during normal operation. A propagating deflagration yield a flash-fire through the hazard area.

3.3.22 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, 2020]

N 3.3.23* Dissipative. A material or a construction that will reduce static charge to acceptable levels. [77, 2019]

3.3.24 Dryer. A piece of processing equipment using temperature or pressure change to reduce the moisture or volatile content of the material being handled. [654, 2020]

3.3.25 Duct. Pipes, tubes, or other enclosures used for the purpose of pneumatically conveying materials. [91, 2020]

3.3.26 Dust. See 3.3.14.1, Combustible Metal Dust.

3.3.26.1* 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]

3.3.26.1.1 Dry-Type AMS. A device that does not use liquid to separate the material being conveyed from the conveying medium, such as cyclones or media collectors.

3.3.26.1.2 Wet-Type AMS. A device that uses liquid to separate the material being conveyed from the conveying medium.

3.3.26.2 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]

3.3.26.3 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]

3.3.26.4* 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]

3.3.27 Eutectic Reaction. (Reserved)

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

3.3.29 Explosion. The bursting or rupture of an enclosure or a container due to the development of internal pressure from a deflagration. [69, 2019]

3.3.30 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.

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

3.3.30.2 Ultrafines. Particles with size generally less than 0.1 micron (µm).

3.3.31 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]

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

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

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

3.3.35 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]

3.3.36 Fugitive Dusts. Dust that escapes from equipment and containers. [652, 2019]

3.3.37 Fugitive Material. See 3.3.49.1.

3.3.38 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]

3.3.39 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.

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

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

3.3.42* 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 3.3.43* Identified (as applied to equipment). Recognizable as suitable for the specific purpose, function, use, environment, application, and so forth, where described in a particular Code requirement. [70:100]

3.3.44* 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]

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

3.3.46* 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 3.3.47 Intermediate Bulk Containers. [652, 2019]

N 3.3.47.1* Flexible Intermediate Bulk Container (FIBC). Large bags typically made from nonconductive woven fabric that are used for storage and handling of bulk solids. [652, 2019]

N 3.3.47.1.1 Type A FIBC. An FIBC made from nonconductive fabric with no special design features for control of electrostatic discharge hazards. [652, 2019]

N 3.3.47.1.2 Type B FIBC. An FIBC made from nonconductive fabric where the fabric or the combination of the fabric shell, coating, and any loose liner has a breakdown voltage of less than 6000 volts. [652, 2019]

N 3.3.47.1.3 Type C FIBC. An FIBC made from conductive material or nonconductive woven fabric incorporating interconnected conductive threads of specified spacing with all conductive components connected to a grounding tab. [652, 2019]

N 3.3.47.1.4 Type D FIBC. An FIBC made from fabric and/or threads with special static properties designed to control electrostatic discharge energy without a requirement for grounding the FIBC. [652, 2019]

N 3.3.47.2* Rigid Intermediate Bulk Container (RIBC). An intermediate bulk container (IBC) that can be enclosed in or encased by an outer structure consisting of a steel cage, a single-wall metal or plastic enclosure, or a double wall of foamed or solid plastic. [652, 2019]

N 3.3.47.2.1 Insulating RIBC. An RIBC constructed entirely of solid plastic or solid plastic and foam composite that cannot be electrically grounded. [652, 2019]

3.3.48 Limiting Oxidant Concentration (LOC). The concentration of oxidant in a fuel-oxidant-diluent mixture below which a deflagration cannot occur under specified conditions. [69, 2019]

3.3.49 Material.

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

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

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

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

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

3.3.52* 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.

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

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

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

3.3.52.4 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.

3.3.52.5* 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.

▲ **3.3.53* 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. [652, 2019]

▲ **3.3.54* 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. [652, 2019]

3.3.55 Mixtures. (Reserved)

3.3.56* 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 14.2.2.)

3.3.57* 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.

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

3.3.58.1 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.

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

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

3.3.60* 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]

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

3.3.62 Portable Vacuum Cleaner. A movable assembly consisting basically of a vacuum source [air-moving device (AMD)], an air-material separator (AMS) using either liquid or filter

media within an enclosure, and a vacuum hose, used to remove dusts and particles from surfaces. [652, 2019]

3.3.63 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.

3.3.63.1* Aluminum Flake Powder. See 3.3.63.3, Aluminum Powder.

3.3.63.2 Aluminum Granular Powder. See 3.3.63.3, Aluminum Powder.

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

3.3.63.4* 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.

3.3.63.5 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.

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

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

3.3.65 Pyrophoric Material. See 3.3.49.2.

3.3.66 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]

3.3.67* 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.

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

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

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

3.3.70* Risk Assessment. An assessment of the likelihood, vulnerability, and magnitude of the incidents that could result from exposure to hazards. [1250, 2020]

3.3.71 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.

△ **3.3.72 Segregation.** A hazard management strategy in which a physical barrier is established between the hazard area and an area to be protected. [652, 2019]

△ **3.3.73 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. [652, 2019]

△ **3.3.74* Spark.** A localized source of thermal or electrical energy capable of igniting combustible material. [652, 2019]

N **3.3.74.1* Capacitive Spark.** A short-duration electric discharge due to a sudden breakdown of air or some other insulating material separating two conductors at different electric potentials, accompanied by a momentary flash of light; also known as electric spark, spark discharge, and sparkover. [652, 2019]

N **3.3.74.2* Thermal Spark.** A moving particle of solid material that emits radiant energy sufficient to act as an ignition source due to either its temperature or the process of combustion on its surface. [652, 2019]

3.3.75 Spark-Resistant Material. See 3.3.49.3.

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

3.3.77 Spontaneous Heating. Process whereby a material increases in temperature without drawing heat from its surroundings. [921, 2021]

N **3.3.78 Static Dissipative.** See 3.3.23, Dissipative.

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

3.3.80 Tantalum Powder. See 3.3.63.5.

3.3.81 Tantalum Ultrafines. (Reserved)

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

3.3.83 Threshold Housekeeping Dust Accumulation. The maximum quantity of dust permitted to be present before cleanup is required. [652, 2019]

3.3.84 Titanium Fines. (Reserved)

3.3.85 Wall.

3.3.85.1 Fire Barrier Wall. A wall, other than a fire wall, having a fire resistance rating. [221, 2021]

3.3.85.2 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, 2021]

3.3.86 Zirconium Fines. (Reserved)

Chapter 4 General Requirements

N **4.1* General.** The owner/operator of a facility with potentially combustible dust shall be responsible for the following activities:

- (1) Determining the combustibility and explosibility hazards of materials in accordance with Chapter 5

- (2) Identifying and assessing any fire, flash fire, and explosion hazards in accordance with Chapter 7
- (3) Managing the identified fire, flash fire, and explosion hazards in accordance with 4.2.3
- (4) Communicating the hazards to affected personnel in accordance with Section 8.8 [652:4.1]

4.2 Objectives. The objectives stated in this section shall be interpreted as intended outcomes of this standard and not as prescriptive requirements. [652:4.2]

△ 4.2.1 Life Safety.

N **4.2.1.1*** The facility, processes, and equipment shall be designed, constructed, equipped, and maintained and management systems shall be implemented to reasonably protect occupants not in the immediate proximity of the ignition from the effects of fire for the time needed to evacuate, relocate, or take refuge. [652:4.2.1.1]

N **4.2.1.2** The facility, processes, and equipment shall be designed, constructed, equipped, and maintained and management systems shall be implemented to reasonably prevent serious injury from flash fires. [652:4.2.1.2]

N **4.2.1.3** The facility, processes, and equipment shall be designed, constructed, equipped, and maintained and management systems shall be implemented to reasonably prevent injury from explosions. [652:4.2.1.3]

N **4.2.1.4** The structure shall be located, designed, constructed, and maintained to reasonably protect adjacent properties and the public from the effects of fire, flash fire, or explosion. [652:4.2.1.4]

•
△ **4.2.2* Mission Continuity.** The facility, processes, and equipment shall be designed, constructed, equipped, and maintained and management systems shall be implemented 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. [652:4.2.2]

△ **4.2.3* Mitigation of Fire Spread and Explosions.** The facility and processes shall be designed to prevent or mitigate fires, explosions, or consequential releases of hazardous materials that can cause failure of adjacent buildings or building compartments or other enclosures, emergency life safety systems, adjacent properties, adjacent storage, or the facility's structural elements. [652:4.2.3]

4.2.4* Compliance Options. The objectives in Section 4.2 shall be achieved by either of the following means:

- (1) A prescriptive approach in accordance with Chapter 5 and Chapters 7 through 19, as applicable
- (2) A performance-based approach in accordance with Chapter 6

•
4.2.5 Where a dust fire, deflagration, or explosion hazard exists within a process system, the hazards shall be managed in accordance with this standard. [652:4.2.5]

4.2.6 Where a dust fire, deflagration, or explosion hazard exists within a building or building compartment, the effects of the fire, deflagration, or explosion shall be managed in accordance with this standard. [652:4.2.6]

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

N 5.1 Responsibility. The owner/operator of a facility with potentially combustible dusts shall be responsible for determining whether the materials are combustible or explosible, and, if so, for characterizing their properties as required to support the DHA. [652:5.1]

N 5.1.1 Where dusts are determined to be combustible or explosible, the hazards associated with the dusts shall be assessed in accordance with Chapter 7. [652:5.1.1]

N 5.1.2 Where dusts are determined to be combustible or explosible, controls to address the hazards associated with the dusts shall be identified and implemented in accordance with 4.2.4. [652:5.1.2]

5.2* Overview. The screening test in Section 5.4 and in Section 5.5 shall be conducted to determine if a metal is in combustible or explosible form.

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

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

5.2.3 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.

5.2.4 Application of This Document.

Δ 5.2.4.1 Only those specific forms of 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.)

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

5.2.4.3 Wherever the documentation necessary for compliance with 5.2.2 and 5.2.3 is lacking, the requirements of this document shall apply.

5.2.5* 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.

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

5.2.6 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.

5.3* Basic Material Characterization.

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

5.3.2* 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.

5.4 Determination of Combustibility.

5.4.1* 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*.

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

5.4.2 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

5.4.3 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.

5.4.4* 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.

5.4.5* 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.

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

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

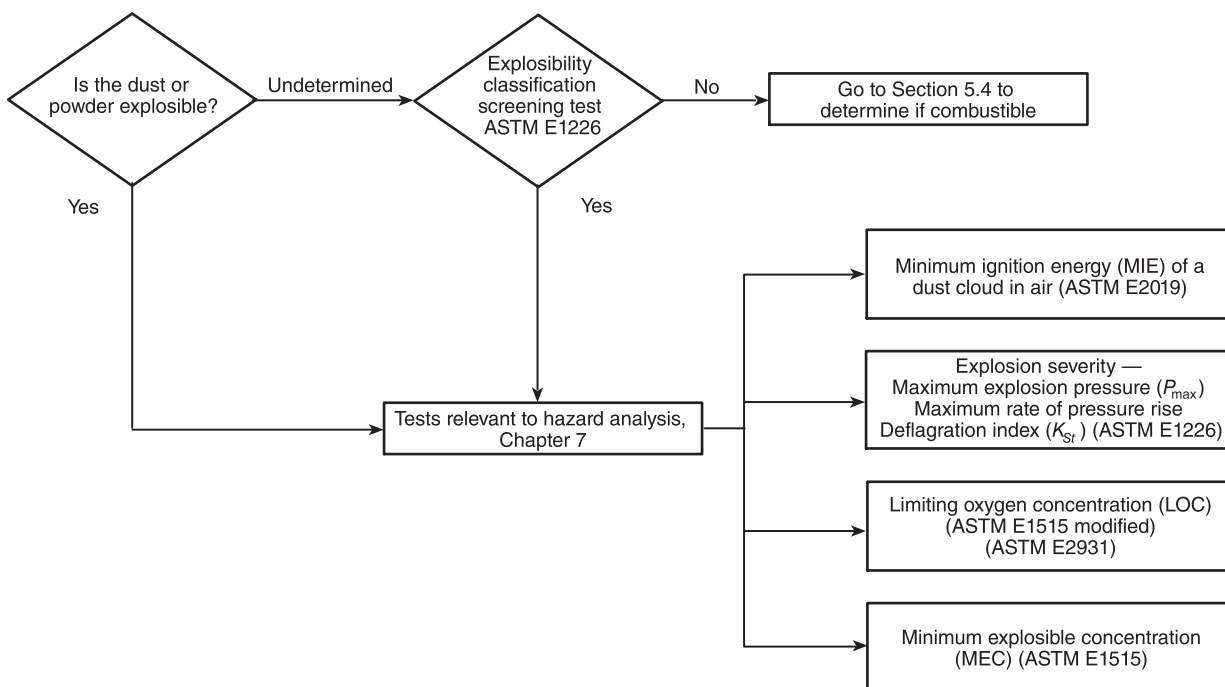
5.5 Determination of Explosibility.

5.5.1* The explosibility of metals, metal powders, metal dusts, and alloys of these materials shall be determined by using the flow chart in Figure 5.5.1.

N 5.5.1.1* For legacy metals, including niobium, and similar alloys or mixtures with adiabatic flame temperature higher than 3300°C, unless K_{st} and P_{max} are determined in nominal 1 m³ or larger calibrated test vessels, the K_{st} value shall be multiplied by a factor of 2 for application of the design methods in accordance with NFPA 68.

Δ 5.5.1.2* If the material is determined to be explosible, some or all of the standard test methods mentioned in Figure 5.5.1 shall be performed as needed for the hazard analysis as described in Chapter 7. If a sample either ignites during ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*, screening testing prior to energizing the ignition source or results in a positive classification, it shall be considered to be explosible.

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



▲ FIGURE 5.5.1 Determination of Explosibility.

5.5.2* 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.

5.5.3* 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.

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

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

5.6 Use of Test Data for Hazard Analysis.

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

5.6.2* 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.

5.7* Determination of Flash-Fire Potential. (Reserved)

● N 5.8* Organometallic Materials. (Reserved)

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.

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.

Chapter 7 Hazard Analysis

7.1* General Requirements.

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

7.1.2 Solid metal in a combustible form shall meet the requirements of Section 5.3.

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

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

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.

7.2 Dust Hazard Analysis (DHA).

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]

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

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

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.

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

7.2.2 Criteria.

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 4.2. [652:7.2.1]

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

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

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]

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

7.2.3 Methodology.

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]

7.2.3.1.1 Recommendations from the DHA shall be tracked to completion.

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.

7.2.3.3 Process Systems.

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

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

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

7.2.3.4 Building or Building Compartments.

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

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]

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

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

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

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]

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.

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]

7.3 Molten Metal Hazard Analysis.

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.

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

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

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

7.3.2 Criteria.

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 4.2.

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

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

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

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.

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

7.3.3 Methodology.

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

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

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

7.3.3.2 Material Evaluation.

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

7.3.3.3 Process Systems.

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

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

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

7.3.3.4 Building or Building Compartments.

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

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]

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

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]

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

N 7.4 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

N 7.5 Dust Explosion and Flash-Fire Hazard Areas.

N 7.5.1 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 16 through 18 — and Chapter 10.

N 7.5.2 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.

N Chapter 8 Management Systems

N 8.1 Retroactivity. This chapter shall be applied retroactively to new and existing facilities and processes. [652:8.1]

N 8.2* General. The procedures and training in this chapter shall be delivered in a language that the participants can understand. [652:8.2]

N 8.3 Operating Procedures and Practices. Operating procedures and practices shall comply with Section 10.3.

N 8.4 Housekeeping. Housekeeping shall comply with Chapter 11.

N 8.5* Hot Work.

N 8.5.1* In addition to the requirements of NFPA 51B, all hot work activities shall comply with the requirements in 8.5.2 through 8.5.5. [652:8.5.1]

N 8.5.2* The area affected by hot work shall be thoroughly cleaned of combustible dust prior to commencing any hot work. [652:8.5.2]

N 8.5.3 Equipment that contains combustible dust and is located within the hot work area shall be shut down, shielded, or both. [652:8.5.3]

N 8.5.4 When the hot work poses an ignition risk to the combustible dust within equipment, the equipment shall be shut down and cleaned prior to commencing such hot work. [652:8.5.4]

N 8.5.5 Floor and wall openings within the hot work area shall be covered or sealed. [652:8.5.5]

N 8.5.6 Use of portable electrical equipment that does not comply with the electrical classification of the area where it is to be used shall be authorized and controlled in accordance with the hot work procedure as outlined in Section 8.5. [652:8.5.6]

N 8.6* Personal Protective Equipment (PPE).

N 8.6.1 PPE Hazard Analysis.

N 8.6.1.1 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.

N 8.6.1.2* 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.

N 8.6.2 Primary PPE for Molten Metals.

N 8.6.2.1 Primary PPE for molten metals shall include all of the items described in paragraphs 8.6.2.2 to 8.6.2.5.

N 8.6.2.2 Face shields, neck protection, and safety glasses shall be used as part of the primary PPE for molten metal exposures.

N 8.6.2.3* 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*.

N 8.6.2.4 Gloves or mittens shall be worn and shall be loose fitting, easily removable, and compatible with the hazards of the pertinent molten metals.

N 8.6.2.5 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.

N 8.6.3 Primary PPE for Dust Flash Fires.

N 8.6.3.1* Primary PPE for dust flash fires shall include flame-resistant garments in accordance with the workplace hazard assessment required by NFPA 2113.

N 8.6.3.2* 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.

N 8.6.3.3 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.

N 8.6.3.4 Primary PPE for dust flash fires shall include shirts, trousers, or coveralls.

N 8.6.3.4.1 Trousers or coveralls shall cover the tops of footwear.

N 8.6.3.5 Primary PPE for dust flash fires shall include safety shoes without exposed metal.

N 8.6.3.6* Primary PPE for dust flash fires shall include gloves made of heat-resistant fabrics.

N 8.6.3.7* 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.

N 8.6.4 Secondary PPE for General Work Areas Near or Containing Combustible Metals.

N 8.6.4.1 Safety glasses with side shields and hard hats shall be required as part of the secondary PPE.

N 8.6.4.2 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.

N 8.6.4.3 Secondary PPE shall have some measure of flame resistance determined as part of the PPE hazard analysis.

N 8.6.4.4* When worn in areas containing dusts with minimum ignition energies less than 100 mJ, secondary PPE shall be made of static-dissipative materials.

N 8.6.4.5 Secondary PPE worn in areas containing alkali metals shall have an external clothing layer that is impervious to body moisture.

N 8.6.4.5.1* 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.

N 8.7 Inspection, Testing, and Maintenance. Inspection, testing, and maintenance shall comply with Section 10.4.

N 8.8 Training and Hazard Awareness. Training and hazard awareness shall comply with Section 10.6.

N 8.9 Contractors.

N 8.9.1 Owner/operators shall ensure the requirements of Section 8.9 are met. [652:8.9.1]

N 8.9.2* Only qualified contractors shall be employed for work involving the installation, repair, or modification of buildings (interior and exterior), machinery, and fire and explosion protection equipment that could adversely affect the prevention, control, or mitigation of fires and explosions. [652:8.9.2]

N 8.9.3* Contractor Training.

N 8.9.3.1 Contractors operating owner/operator equipment shall be trained and qualified to operate the equipment and perform the work. [652:8.9.3.1]

N 8.9.3.2 Contractor training shall be documented. [652:8.9.3.2]

N 8.9.3.3* Contractors working on or near a given process shall be made aware of the potential hazards from and exposures to fires and explosions. [652:8.9.3.3]

N 8.9.3.3.1 Contractors shall be trained on the hazards as identified in Chapter 10.

N 8.9.3.4 Contractors shall be trained and required to comply with the facility's safe work practices and policies in accordance with 10.3.2. [652:8.9.3.4]

N 8.9.3.5 Contractors shall be trained on the facility's emergency response and evacuation plan, including, but not limited to, emergency reporting procedures, safe egress points, and evacuation area. [652:8.9.3.5]

N 8.10 Emergency Planning and Response. Emergency planning and response shall comply with Section 10.7.

N 8.11* Incident Investigation.

N 8.11.1* The owner/operator shall have a system to ensure that incidents that result in a fire, deflagration, or explosion are reported and investigated in a timely manner. [652:8.11.1]

N 8.11.2 The investigation shall be documented and include findings and recommendations. [652:8.11.2]

N 8.11.3 A system shall be established to address and resolve the findings and recommendations. [652:8.11.3]

N 8.11.4* The investigation findings and recommendations shall be reviewed with affected personnel. [652:8.11.4]

N 8.12 Management of Change.

N 8.12.1* Written procedures shall be established and implemented to manage proposed changes to process materials, staffing, job tasks, technology, equipment, procedures, and facilities. [652:8.12.1]

N 8.12.2 The procedures shall ensure that the following are addressed prior to any change:

- (1)* The basis for the proposed change
- (2)* Safety and health implications
- (3) Whether the change is permanent or temporary, including the authorized duration of temporary changes
- (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

[652:8.12.2]

N 8.12.3* Implementation of the management of change procedure shall not be required for replacements-in-kind. [652:8.12.3]

N 8.12.4 Design and procedures documentation shall be updated to incorporate the change. [652:8.12.4]

N 8.13* Documentation Retention.

N 8.13.1 The owner/operator shall establish a program and implement a process to manage the retention of documentation, including, but not limited to, the following:

- (1) Training records
 - (2) Equipment inspection, testing, and maintenance records
 - (3)* Incident investigation reports
 - (4) Dust hazards analyses
 - (5)* Process and technology information
 - (6)* Management of change documents
 - (7) Emergency response plan documents
 - (8)* Contractor records
- [652:8.13.1]

N 8.14 Management Systems Review.

N 8.14.1 The owner/operator shall evaluate the effectiveness of the management systems presented in this standard by conducting a periodic review of each management system. [652:8.14.1]

N 8.14.2 The owner/operator shall be responsible for maintaining and evaluating the ongoing effectiveness of the management systems presented in this standard. [652:8.14.2]

N 8.15* Employee Participation. Owner/operators shall establish and implement a system to consult with and actively involve affected personnel and their representatives in the implementation of this standard. [652:8.15]

N Chapter 9 Hazard Management: Mitigation and Prevention

N 9.1* Inherently Safer Designs.

N 9.2 Building Design.

N 9.2.1 Risk Assessment. A documented risk assessment acceptable to the AHJ shall be permitted to be conducted to determine the level of building design and protection features to be provided, including, but not limited to, the measures addressed in Section 9.2. [652:9.2.1]

N 9.2.2* Construction. The type of construction shall be in accordance with the building code adopted by the AHJ. [652:9.2.2]

N 9.2.3 Building or Building Compartment Protection.

N 9.2.3.1* Each building or building compartment where a dust deflagration hazard exists shall be protected from the consequence of deflagration. [652:9.2.3.1]

N 9.2.3.2* If a building or building compartment contains a dust explosion hazard outside of equipment, such areas shall be provided with deflagration venting to a safe area in accordance with NFPA 68. [652:9.2.3.2]

- N 9.2.3.2.1** Venting to relieve pressure shall be located through an outside wall or roof. [652:9.2.3.2.1]
- N 9.2.3.2.2** The fireball, blast hazards, and missile hazards that are created by deflagration venting shall not expose additional personnel or property assets. [652:9.2.3.2.2]
- N 9.2.4 Life Safety.** Building configuration and appurtenances shall comply with the life safety requirements of the building and fire prevention codes adopted by the AHJ. [652:9.2.4]
- N 9.2.4.1** Where a dust deflagration hazard exists in a building or building compartment outside of equipment, building configuration and appurtenances shall comply with the life safety requirements of the building and fire prevention codes for a hazardous occupancy adopted by the AHJ. [652:9.2.4.1]
- N 9.2.4.2** Where a dust explosion hazard exists in a building or building compartment and an enclosed means of egress is provided, it shall be designed to withstand potential external overpressure from building deflagration. [652:9.2.4.2]
- N 9.2.5 Construction Features to Limit Accumulation.**
- N 9.2.5.1*** Interior surfaces where dust accumulations can occur shall be designed and constructed so as to facilitate cleaning and to minimize combustible dust accumulations. [652:9.2.5.1]
- N 9.2.5.2** Enclosed building spaces inaccessible to routine housekeeping shall be sealed to prevent dust accumulation. [652:9.2.5.2]
- N 9.2.5.3*** Enclosed building spaces that are difficult to access for routine housekeeping shall be designed to facilitate routine inspection for the purpose of determining the need for periodic cleaning. [652:9.2.5.3]
- N 9.2.6 Separation of Hazard Areas from Other Hazard Areas and from Other Occupancies.**
- N 9.2.6.1** Areas where a dust deflagration hazard exists in a building or building compartment (excluding hazard within equipment) shall be segregated, separated, or detached from other occupancies to minimize damage from a fire or an explosion. [652:9.2.6.1]
- N 9.2.6.2 Use of Segregation.**
- N 9.2.6.2.1** Physical barriers erected for the purpose of limiting fire spread shall be designed in accordance with NFPA 221. [652:9.2.6.2.1]
- N 9.2.6.2.2** Physical barriers erected to segregate fire hazard areas, including all penetrations and openings of floors, walls, ceilings, or partitions, shall have a minimum fire resistance rating based on the anticipated fire duration. [652:9.2.6.2.2]
- N 9.2.6.2.3** Physical barriers, including all penetrations and openings of floors, walls, ceilings, or partitions, 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. [652:9.2.6.2.3]
- N 9.2.6.3 Use of Separation.**
- N 9.2.6.3.1*** Separation shall be permitted to be used to limit the dust explosion hazard or deflagration hazard area within a building when it is supported by a documented engineering evaluation acceptable to the AHJ. [652:9.2.6.3.1]
- N 9.2.6.3.2*** The required separation distance between the dust explosion hazard or deflagration hazard area and surrounding exposures shall be determined by an engineering evaluation that addresses the following:
- (1) Properties of the materials
 - (2) Type of operation
 - (3) Amount of material likely to be present outside the process equipment
 - (4) Building and equipment design
 - (5) Nature of surrounding exposures
- [652:9.2.6.3.2]
- N 9.2.6.3.3** Either the separation area shall be free of dust or where dust accumulations exist on any surface, the color of the surface on which the dust has accumulated shall be readily discernible. [652:9.2.6.3.3]
- N 9.2.6.3.4** Where separation is used to limit the dust flash-fire hazard area, in no case shall the required separation distance determined in 9.2.6.3.2 be less than 11 m (35 ft). [652:9.2.6.3.4]
- N 9.2.6.3.5*** 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. [652:9.2.6.3.5]
- N 9.2.6.4 Use of Detachment.**
- N 9.2.6.4.1** Detachment shall be permitted to be used to limit the dust hazard area to a physically separated adjacent building. [652:9.2.6.4.1]
- N 9.2.6.4.2*** The required detachment distance between the dust explosion hazard area or the deflagration hazard area and surrounding exposures shall be determined by an engineering evaluation that addresses the following:
- (1) Properties of the materials
 - (2) Type of operation
 - (3) Amount of material likely to be present outside the process equipment
 - (4) Building and equipment design
 - (5) Nature of surrounding exposures
- [652:9.2.6.4.2]
- N 9.2.7* Additional Facility Design Requirements for All Metals.**
- N 9.2.7.1 General.**
- N 9.2.7.1.1** In addition to the requirements of this chapter, buildings shall comply with the applicable provisions of locally adopted building and fire safety codes.
- N 9.2.7.1.2** Where local, state, and national building codes require modifications, such modifications shall be permitted for conformance to these codes if a hazard analysis is conducted to ensure the modifications do not create a greater risk.
- N 9.2.7.1.3** Installation of automatic sprinkler protection, where used, shall comply with Chapter 10.
- N 9.2.7.1.4** 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 local building codes.
- N 9.2.7.1.5** Fuel supply lines shall have an emergency shutoff valve located within easy access outside of the building.

- N 9.2.7.1.6** Emergency shutoff valves shall be clearly identified.
- N 9.2.7.1.7** Fittings used on outlets of compressed air and inert gas lines shall not be interchangeable, so as to prevent potential explosions caused by inadvertently using compressed air in place of low-pressure inert gas.
- N 9.2.7.1.8** One or more remotely located control stations shall be provided to allow the selective shutdown of process equipment in an emergency.
- N 9.2.7.2 Building Location, Separation, and Segregation.**
- N 9.2.7.2.1** A hazards analysis shall be conducted to determine the minimum required separation distance for individual buildings and operations within powder, primary production, melting, recycling, and waste management facilities.
- N 9.2.7.2.2** All buildings used for the processing, packing, or loading for shipment of recyclable materials shall be constructed of noncombustible materials throughout and shall have non-load-bearing walls.
- N 9.2.7.2.3** 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 9.2.7.2.4** The annulus of all pipe, conduit, and ventilation penetrations shall be sealed.
- N 9.2.7.2.5** All doors in fire-rated walls and partitions shall be listed, self-closing fire doors installed in accordance with NFPA 80.
- N 9.2.7.3 Building Construction.**
- N 9.2.7.3.1 Noncombustible Construction.**
- N 9.2.7.3.1.1** Paragraph 9.2.7.3 shall apply to buildings or portions of buildings that are dedicated to the handling, processing, or storage of metal in combustible or molten form.
- N 9.2.7.3.1.2** Buildings dedicated to the storage, handling, processing, or use of combustible metals shall be constructed of noncombustible materials, unless a hazard analysis has been performed that shows that noncombustible construction is not required.
- N 9.2.7.3.1.3** Buildings housing furnaces, boring and crushing facilities, and refining operations shall be constructed of noncombustible materials.
- N 9.2.7.3.1.4** Construction of other than noncombustible materials shall be permitted if equivalent protection can be demonstrated.
- N 9.2.7.3.2 Roofs, Ceilings, and Walls.**
- N 9.2.7.3.2.1*** Roof decks shall be watertight.
- N 9.2.7.3.2.2** 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 9.2.7.3.2.3** 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 9.2.7.3.2.4** 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 9.2.7.3.2.5** The requirements of 9.2.7.3.2.4 shall also apply to elevated platforms, balconies, floors, and gratings.
- N 9.2.7.3.3 Floors and Surfaces.**
- N 9.2.7.3.3.1** In areas where combustible metals are stored, handled, or processed, floors shall be a solid surface and shall be constructed with materials that are compatible and nonreactive with the metals in use.
- N 9.2.7.3.3.2** The floor shall be capable of providing containment of molten metals resulting from fire.
- N 9.2.7.3.3.3** Floors, elevated platforms, balconies, and gratings shall be made of noncombustible hard surfaces and nonslip materials, and shall be installed with a minimum number of joints in which powder can collect.
- N 9.2.7.3.3.4** Floors in reduction, boring, and crushing buildings shall be made of noncombustible materials, such as concrete, brick, or steel plate.
- N 9.2.7.3.3.5** Aisles shall be provided for maneuverability of material-handling equipment, for accessibility, and to facilitate firefighting operations.
- N 9.2.7.3.3.6** The buildings shall be designed so that all internal surfaces are readily accessible to facilitate cleaning.
- N 9.2.7.3.3.7*** Interior surfaces where dust accumulations can occur shall be designed and constructed (and angled greater than the angle of repose) to facilitate cleaning and to minimize combustible dust accumulation.
- N 9.2.7.4* Ventilation, Heating, and Cooling.**
- N 9.2.7.4.1** Where hydrogen generation occurs during the process, ventilation shall be provided for the dissipation of hydrogen to the atmosphere.
- N 9.2.7.4.2** Mechanical ventilation systems shall be designed and installed in accordance with the locally adopted building and fire code.
- N 9.2.7.4.3** Where compatible with metal processing operations, 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 9.2.7.4.3.1** Indirect hot air shall be permitted if the heating unit is located in a combustible metal dust-free location adjacent to the room or area where heated air is required.
- N 9.2.7.4.3.2** Fans or blowers used to convey the heated or cooled air shall be located in a combustible metal dust-free location.
- N 9.2.7.4.3.3** The air supply shall be taken from outside or from a location that is free of combustible metal dust.
- N 9.2.7.4.3.4** 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 9.2.7.4.3.5** The requirements of 9.2.7.4.3.1 through 9.2.7.4.3.4 shall not apply to areas where metal is melted.
- N 9.2.7.5 Explosion Mitigation/Deflagration Venting.**
- N 9.2.7.5.1*** 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 9.2.7.5.2** 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 9.2.7.5.3*** Deflagration vents shall not be directed to any indoor area where combustible metal powders or dusts are present in quantities that present a potential fire or explosion hazard.
- N 9.2.7.5.4** Equipment shall be located or arranged in a manner that minimizes combustible dust accumulation on surfaces.
- N 9.2.7.5.5** Deflagration venting shall not be required for areas where combustible metal powder is stored or moved only in covered or sealed containers.
- N 9.2.7.5.6*** 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 9.2.7.6* Grounding and Bonding.** All process equipment and all building steel shall be bonded and grounded in accordance with *NFPA 70*.
- N 9.2.7.7 Drying Rooms.** A hazards analysis shall be performed to determine the proper type of drying necessary for the specific powders being handled, as well as the specific parameters used for drying.
- N 9.2.8 Additional Facility Design Requirements for Legacy Metals.**
- N 9.2.8.1 General.**
- N 9.2.8.1.1** Individuals or firms designing facilities and/or equipment for the processing of specific combustible metal shall be briefed by individual(s) or firm(s) knowledgeable in the specific hazards associated with the manufacturing, handling, processing, and storage of the specific combustible metal and this standard.
- N 9.2.8.1.2** In addition to the requirements of this chapter, buildings shall comply with the applicable provisions of locally adopted building and fire safety codes.
- N 9.2.8.1.3** Where local, state, and national building codes require modifications, such modifications shall be permitted for conformance to these codes if a hazard analysis is conducted to ensure the modifications do not create a greater risk.
- N 9.2.8.2 Building Location, Separation, and Segregation.**
- N 9.2.8.2.1** Separate buildings shall be required where different operations, including, but not limited to, atomization, grinding, crushing, screening, blending, or packaging, are performed.
- N 9.2.8.2.2** More than one operation within the same building shall be permitted if the design provides equivalent protection.
- N 9.2.8.2.3** 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 9.2.8.2.4** Two buildings less than 15 m (50 ft) apart shall be permitted if the wall facing 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 9.2.8.2.5** A combustible metal powder production plant 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 9.2.8.2.6** 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 9.2.8.2.7** 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 9.2.8.3 Separation from Water.**
- N 9.2.8.3.1** Combustible metal winning, refining, and casting operations shall be protected from rain and other possible sources of inadvertent contact with water.
- N 9.2.8.3.2** Water leakage inside or into any building where the water can contact water-reactive combustible metal shall be prevented.
- N 9.2.8.3.3*** Water pipes or pipes that can contain water for uses other than process or production support (e.g., sprinkler piping, domestic water pipes, roof drains, and waste pipes) shall not be permitted in areas containing combustible metals unless a hazards analysis is performed.
- N 9.2.8.3.4** Piping permitted by 9.2.8.3.3 shall be equipped with an emergency shutoff that is identified and located outside the area.
- N 9.2.8.3.5** Sprinkler systems installed in accordance with NFPA 13 shall be permitted in areas where combustibles other than combustible metals create a more severe hazard than the combustible metals and where acceptable to an authority having jurisdiction that is knowledgeable of the hazards associated with the combustible metal.
- N 9.3 Equipment Design.**
- N 9.3.1* Risk Assessment.** A documented risk assessment acceptable to the AHJ shall be permitted to be conducted to determine the level of protection to be provided, including, but not limited to, protection measures addressed in Section 9.3. [652:9.3.1]
- N 9.3.2 Design for Dust Containment.**
- N 9.3.2.1** All components of enclosed systems that handle combustible particulate solids shall be designed to prevent the escape of dust, except for openings intended for intake and discharge of air and material. [652:9.3.2.1]

N 9.3.2.2 Where the equipment cannot be designed for dust containment, dust collection shall be provided. (See also 9.3.3.) [652:9.3.2.2]

N 9.3.3 Pneumatic Conveying, Dust Collection, and Centralized Vacuum Cleaning Systems. Pneumatic conveying, dust collection, and centralized vacuum cleaning systems shall comply with Chapter 13.

N 9.3.4 AMS. AMS shall comply with Chapter 13.

N 9.3.5 Air-Moving Devices (Fans and Blowers). Air-moving devices shall comply with Chapter 13.

N 9.3.6 Duct Systems. Duct systems shall comply with Chapter 13.

N 9.3.7 Sight Glasses. Sight glasses shall not be permitted to be used in pneumatic conveying systems for combustible metals.

N 9.3.8 Abort Gates/Dampers.

N 9.3.8.1 Construction.

N 9.3.8.1.1 Abort gates and abort dampers shall be constructed of noncombustible materials. [652:9.3.8.1.1]

N 9.3.8.1.2 Abort gates and abort dampers shall be actuated by spark detection or equivalent automatic detection in the duct or pipe upstream of the device. [652:9.3.8.1.2]

N 9.3.8.1.3 The detection system and abort gate shall respond to prevent sparks, glowing embers, or burning materials from passing beyond the abort gate. [652:9.3.8.1.3]

N 9.3.8.1.4 The abort gate or abort damper shall be installed so that it diverts airflow to a restricted area to safely discharge combustion gases, flames, burning solids, or process gases or fumes. [652:9.3.8.1.4]

N 9.3.8.2 Manual Reset.

N 9.3.8.2.1 An abort gate or abort damper shall be provided with a manually activated reset located proximate to the device such that, subsequent to operation, it can be returned to the normal operating position at the damper/gate. [652:9.3.8.2.1]

N 9.3.8.2.2 Automatic or remote reset provisions shall not be permitted. [652:9.3.8.2.2]

N 9.3.8.3 Integrity of Actuation Circuits.

N 9.3.8.3.1 All fire protection abort gates or abort dampers shall be connected to the fire detection control panel via Class A or Class D circuits as described in *NFPA 72*. [652:9.3.8.3.1]

N 9.3.8.3.2 When the abort gate is connected via a Class A circuit, supervision shall include the continuity of the abort gate or abort damper releasing device, whether that device is a solenoid coil, a detonator (explosive device) filament, or other such device. [652:9.3.8.3.2]

N 9.3.9 Bulk Storage Enclosures.

N 9.3.9.1 General.

N 9.3.9.1.1 For the purposes of this section, bulk storage enclosures shall include items such as bins, tanks, hoppers, and silos. [652:9.3.9.1.1]

N 9.3.9.1.2* The requirements of this section shall not apply to containers that are used for transportation of the material. [652:9.3.9.1.2]

N 9.3.9.2* Construction. Bulk storage enclosures, whether located inside or outside of buildings, shall be constructed so as not to represent an increase in the fire load beyond the capabilities of the existing fire protection. [652:9.3.9.2]

N 9.3.9.3 Fixed Bulk Storage Location.

N 9.3.9.3.1 Where an explosion hazard exists, fixed bulk storage enclosures shall be located outside of buildings. [652:9.3.9.3.1]

N 9.3.9.3.2 Fixed bulk storage enclosures shall be permitted to be located inside buildings where one of the following applies:

- (1) Fixed bulk storage enclosures are protected in accordance with 9.7.3.
- (2)* Fixed bulk storage enclosures are less than 0.2 m³ (8 ft³) [652:9.3.9.3.2]

N 9.3.9.4* Interior Surfaces. Interior surfaces shall be designed and constructed to facilitate cleaning and to minimize combustible dust accumulation. [652:9.3.9.4]

N 9.3.9.5 Access Doors and Access Openings. Where provided to permit inspection, cleaning, and maintenance, access doors and access openings shall meet the following requirements:

- (1) They shall be designed to prevent dust leaks.
- (2) They shall be permitted to be used as deflagration vents if they are specifically designed for both purposes.
- (3) They shall be bonded and grounded.
- (4) If not designed to be used as deflagration vents, they shall be designed to the same strength as the AMS [652:9.3.9.5]

N 9.3.10* Size Reduction.

N 9.3.10.1 Before material is processed by size reduction equipment, foreign materials shall be excluded or removed as required by 9.4.12. [652:9.3.10]

N 9.3.10.2 Size reduction shall also meet the requirements of applicable chapters of this standard.

N 9.3.11* Particle Size Separation.

N 9.3.11.1 Particle separation devices shall be designed to control fugitive dust emissions per Section 9.6. [652:9.3.11.1]

N 9.3.11.2 Flexible connectors shall be in conformance with 9.3.6. [652:9.3.11.2]

N 9.3.12 Pressure Protection Systems.

N 9.3.12.1 Vacuum Breakers. Vacuum breakers shall be installed on negative-pressure systems if the enclosure is not designed for the maximum vacuum attainable. [652:9.3.12.1]

N 9.3.12.2 Pressure Relief Devices.

N 9.3.12.2.1 Pressure relief devices for relief of pneumatic overpressure shall be installed on positive-pressure systems. [652:9.3.12.2.1]

N 9.3.12.2.2 The requirement of 9.3.12.2.1 shall not apply to systems that are designed for a gauge pressure of less than 103 kPa (15 psi) and are provided with safety interlocks designed to prevent overpressure in accordance with ISA 84.00.01, *Functional Safety: Application of Safety Instrumented Systems for the Process Industry Sector*. [652:9.3.12.2.2]

N 9.3.12.2.3 The requirement of 9.3.12.2.1 shall not apply to systems that are designed for a gauge pressure of less than

103 kPa (15 psi) and are capable of containing the maximum pressure attainable. [652:9.3.12.2.3]

N 9.3.12.2.4* Pressure relief devices shall not be vented to an area where a dust explosion hazard or dust flash-fire hazard exists in accordance with 7.3.3.4. [652:9.3.12.2.4]

N 9.3.12.3 Airflow Control Valves.

N 9.3.12.3.1 Airflow control valves that are installed in pneumatic conveying, dust collection, or centralized vacuum cleaning systems shall provide a tight shutoff. [652:9.3.12.3.1]

N 9.3.12.3.2 Airflow control valves shall be sized to allow passage of the design airflow when the valve is fully open. [652:9.3.12.3.2]

N 9.3.12.3.3 The position of airflow control valves shall be visually indicated. [652:9.3.12.3.3]

N 9.3.12.3.4 Manually adjusted airflow control valves, dampers, or gates, shall have a means of being secured so as to prevent subsequent adjustment or manipulation once the system is set. [652:9.3.12.3.4]

N 9.3.12.3.5 Diverter valves shall effect a positive diversion of the material and shall mechanically seal all other directions from air or material leakage. [652:9.3.12.3.5]

N 9.3.13 Material Feeding Devices.

N 9.3.13.1 Material Feeding Devices.

N 9.3.13.1.1 Mechanical feeding devices shall be equipped with a shear pin or overload detection device and alarm. [652:9.3.13.1.1]

N 9.3.13.1.2 The alarm shall sound at the operator control station. [652:9.3.13.1.2]

N 9.3.13.2 Drives.

N 9.3.13.2.1 All drives used in conjunction with feeders, air locks, and other material feeding devices shall be directly connected. [652:9.3.13.2.1]

N 9.3.13.2.2 Belt, chain and sprocket, or other indirect drives that are designed to stall the driving forces without slipping and to provide for the removal of static electric charges shall be permitted to be used. [652:9.3.13.2.2]

N 9.3.14* Bucket Elevators.

N 9.3.14.1 Elevator casings, head and boot sections, and connecting ducts shall be designed to control fugitive dust emissions and shall be constructed of noncombustible materials. [652:9.3.14.1]

N 9.3.14.2 Where provided, inlet and discharge hoppers shall be designed to be accessible for cleaning and inspection. [652:9.3.14.2]

N 9.3.14.3 Power Cutoff.

N 9.3.14.3.1 Each leg shall be provided with a speed sensor device that will cut off the power to the drive motor and actuate an alarm in the event the leg belt slows to 80 percent of normal operating speed. [652:9.3.14.3.1]

N 9.3.14.3.2 Feed to the elevator leg by mechanical means shall be stopped or diverted. [652:9.3.14.3.2]

N 9.3.14.4 Belts.

N 9.3.14.4.1* Belt-driven bucket elevators shall have nonslip material (lagging) installed on the head pulley to minimize slippage. [652:9.3.14.4.1]

N 9.3.14.4.2* Belts and lagging shall be static dissipative and fire resistant. [652:9.3.14.4.2]

N 9.3.14.4.3 No bearings shall be located in the bucket elevator casing. [652:9.3.14.4.3]

N 9.3.14.4.4* Head and boot sections shall be provided with openings to allow for cleanout, inspection, and alignment of the pulley and belt. [652:9.3.14.4.4]

N 9.3.14.5 Drive.

N 9.3.14.5.1* The bucket elevator shall be driven by a motor and drive train that is capable of handling the full-rated capacity of the elevator without overloading. [652:9.3.14.5.1]

N 9.3.14.5.2 The drive shall be capable of starting the unchoked elevator under full (100 percent) load. [652:9.3.14.5.2]

N 9.3.14.6 Monitors.

N 9.3.14.6.1 Elevators shall have monitors at head and tail pulleys that indicate high bearing temperature, pulley alignment, and belt alignment. [652:9.3.14.6.1]

N 9.3.14.6.2 Abnormal conditions shall actuate an alarm requiring corrective action. [652:9.3.14.6.2]

N 9.3.14.6.3 The alarm specified in 9.3.14.6.2 shall sound at the operator control station. [652:9.3.14.6.3]

N 9.3.14.7 Emergency Controls.

N 9.3.14.7.1 All bins into which material is directly discharged from the bucket elevator and that are not designed with automatic overflow systems shall be equipped with devices to shut down equipment or with high-level indicating devices with visual or audible alarms. [652:9.3.14.7.1]

N 9.3.14.7.2 The audible alarm specified in 9.3.14.7.1 shall sound at the operator control station. [652:9.3.14.7.2]

N 9.3.15* Enclosed Conveyors.

N 9.3.15.1 Housing and Coverings.

N 9.3.15.1.1 Housings for enclosed conveyors (e.g., screw conveyors and drag conveyors) shall be of metal construction and designed to prevent escape of combustible dusts. [652:9.3.15.1.1]

N 9.3.15.1.1.1 Flexible screw conveyors shall not be permitted to be used with metal dusts or powders.

N 9.3.15.1.2 Coverings on cleanout, inspection, and other openings shall be fastened to prevent the escape of combustible dusts. [652:9.3.15.1.2]

N 9.3.15.2 Power Shutoff.

N 9.3.15.2.1* All conveyors shall be equipped with a device that shuts off the power to the drive motor and sounds an alarm in the event the conveyor plugs. [652:9.3.15.2.1]

N 9.3.15.2.2 The alarm specified in 9.3.15.2.1 shall alert operators, and feed to the conveyor shall be stopped or diverted. [652:9.3.15.2.2]

N 9.3.16 Mixers and Blenders.

N 9.3.16.1 Mixers and blenders shall be designed to control fugitive dust emissions. [652:9.3.16.1]

N 9.3.16.2 Foreign materials shall be excluded or removed as required by 9.4.12. [652:9.3.16.2]

N 9.3.16.3 Mixers and blenders shall be made of metal, other noncombustible material, or material that does not represent an increased fire load beyond the capabilities of the existing fire protection. [652:9.3.16.3]

N 9.3.17* Dryers. Drying of legacy metals shall comply with the requirements in Chapter 17.

N 9.3.17.1 Drying Media.

N 9.3.17.1.1 Drying media that come into contact with material being processed shall not be recycled to rooms or buildings. [652:9.3.17.1.1]

N 9.3.17.1.2 Drying media shall be permitted to be recycled to the drying process provided the following conditions are met:

- (1) The media passes through a filter, dust separator, or equivalent means of dust removal.
- (2) The vapor flammability of the drying media in the dryer is controlled by either oxidant concentration reduction or combustible concentration reduction in accordance with NFPA 69.

[652:9.3.17.1.2]

N 9.3.17.1.3 Dryers shall be constructed of noncombustible materials. [652:9.3.17.1.3]

N 9.3.17.1.4 Interior surfaces of dryers shall be designed so that accumulations of material are minimized and cleaning is facilitated. [652:9.3.17.1.4]

N 9.3.17.1.5 Access doors or openings shall be provided in all parts of the dryer and connecting conveyors to permit inspection, cleaning, maintenance, and the effective use of portable extinguishers or hose streams. [652:9.3.17.1.5]

N 9.3.17.1.6 Heated dryers shall comply with NFPA 86. [652:9.3.17.1.6]

N 9.3.17.1.7* Heated dryers shall have operating controls arranged to maintain the temperature of the drying chamber within the prescribed limits. [652:9.3.17.1.7]

N 9.3.17.1.8 Heated dryers and their auxiliary equipment shall be equipped with separate excess-temperature-limit controls, independent of the operating controls, arranged to supervise the following:

- (1) Heated air supply to the drying chamber
- (2) Airstream at the discharge of the drying chamber

[652:9.3.17.1.8]

N 9.3.18 Transfer Points. (Reserved)**N 9.4 Ignition Source Control.**

N 9.4.1* Retroactivity. Unless otherwise specified, the requirements of Section 9.4 shall be applied retroactively. [652:9.4.1]

N 9.4.2* Risk Assessment. A documented risk assessment acceptable to the authority having jurisdiction shall be permitted to be conducted to determine the level of ignition source control to be provided including, but not limited to, the controls addressed in Section 9.4. [652:9.4.2]

N 9.4.3 Hot Work. See Section 8.5.

N 9.4.4 Hot Surfaces.

N 9.4.4.1 Retroactivity. This section shall not be required to be applied retroactively. [652:9.4.4]

N 9.4.4.2* Heated external surfaces of process equipment and piping in dust deflagration hazard areas shall be maintained at a temperature at least 50°C (112°F) below the dust layer and dust cloud ignition temperatures measured in a standardized test acceptable to the AHJ. [652:9.4.4.2]

N 9.4.5 Bearings.

N 9.4.5.1 Retroactivity. This section shall not be required to be applied retroactively. [652:9.4.5.1]

N 9.4.5.2 Bearings shall also comply with 12.3.1.

N 9.4.5.3* Bearings that are directly exposed to a combustible dust atmosphere or that are subject to dust accumulation, either of which poses a dust ignition hazard, shall be monitored for overheating. [652:9.4.5.2]

N 9.4.5.4 The owner/operator shall establish frequencies for monitoring bearings in 9.4.5.3. [652:9.4.5.3]

N 9.4.5.5* It shall be permitted to eliminate bearing monitoring based on a risk assessment acceptable to the AHJ. [652:9.4.5.4]

N 9.4.6 Hazardous (Classified) Locations for Electrical Installations. See Section 12.4 for Hazardous (classified) locations for electrical installations.

N 9.4.7* Electrostatic Discharges.**N 9.4.7.1* General Requirements.**

N 9.4.7.1.1* 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.

N 9.4.7.1.1.1 Grounding and bonding of equipment shall be independent of the facility electrical system.

N 9.4.7.1.1.2* Where nonconductive components present a discontinuity in the electrical path, isolated conductive components shall be bonded.

N 9.4.7.1.2* Movable or mobile process equipment or tools of metal construction shall be bonded or grounded or both, prior to use.

N 9.4.7.1.3* 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.

N 9.4.7.1.4 Static dissipative belts shall be used on belt-driven equipment.

N 9.4.7.1.5 Bonding and grounding for dust collection and pneumatic conveying shall be in accordance with Chapter 13.

N 9.4.7.1.6* Grounding of Personnel.

N 9.4.7.1.6.1 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.

N 9.4.7.1.6.2 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.

N 9.4.7.2 Spark-Resistant Tools.

N 9.4.7.2.1* 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.

N 9.4.7.2.2* 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.

N 9.4.7.2.3 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.

N 9.4.7.3 Conductive Equipment.

N 9.4.7.3.1 Particulate handling equipment shall be conductive unless the provisions of 9.4.7.3.2 are applicable. [652:9.4.7.1.1]

N 9.4.7.3.2 Nonconductive system components shall be permitted where all of the following conditions are met:

- (1)* Hybrid mixtures and flammable gas/vapor atmospheres are not present.
- (2)* Conductive particulate solids are not handled.
- (3)* The nonconductive components do not result in isolation of conductive components from ground.
- (4)* The breakdown strength across nonconductive sheets, coatings, or membranes does not exceed 4 kV, and the breakdown strength across nonconductive woven objects does not exceed 6 kV, when used in high surface charging processes.

[652:9.4.7.1.2]

N 9.4.7.3.3* Bonding and grounding with a resistance of less than 1.0×10^6 ohms to ground shall be provided for conductive components. [652:9.4.7.1.3]

N 9.4.7.3.4* Flexible Connectors.

N 9.4.7.3.4.1* Retroactivity. This section shall not be required to be applied retroactively. [652:9.4.7.1.4.1]

N 9.4.7.3.4.2 Flexible connectors shall comply with 9.4.7.1.1.2.

N 9.4.7.3.4.3* Where flammable vapors are not present, flexible connectors with a resistance equal to or greater than 1.0×10^8 ohms shall be permitted under either of the following conditions:

- (1) The dust has an MIE greater than 2000 mJ.
- (2) The maximum powder transfer velocity is less than 10 m/sec (200 fpm).

[652:9.4.7.1.4.3]

N 9.4.7.4 Maximum Particulate Transport Rates.

N 9.4.7.4.1* The maximum particulate transport rates in 9.4.7.4.3 shall apply when the volume of the vessel being filled

is greater than 1 m^3 (35 ft^3) and a single feed stream to the vessel meets both of the following conditions:

- (1)* The suspendable fraction of the transported material has an MIE of less than or equal to 20 mJ.
- (2)* The transported material has an electrical volume resistivity greater than 1.0×10^{10} ohm-m.

[652:9.4.7.2.1]

N 9.4.7.4.2* The maximum particulate transport rate in 9.4.7.4.3 shall apply when the volume of the vessel being filled is greater than 1 m^3 (35 ft^3) and either of the following conditions is met:

- (1)* The transported material having an electrical volume resistivity greater than 1.0×10^{10} ohm-m is loaded into a vessel containing a powder or dust having an MIE less than or equal to 20 mJ.
- (2)* The transported material having an electrical volume resistivity greater than 1.0×10^{10} ohm-m is loaded into a vessel containing a powder or dust having an MIE less than or equal to 20 mJ, followed by a powder or dust having an MIE less than or equal to 20 mJ.

[652:9.4.7.2.2]

N 9.4.7.4.3* Where the conditions of 9.4.7.4.1 or 9.4.7.4.2 are met, the maximum permitted material transport rate of particles shall be limited by the following:

- (1) 1.4 kg/sec (3.1 lb/sec) for particulates larger than 2 mm (0.08 in.).
- (2) 5.6 kg/sec (12.3 lb) for particulates between 0.4 mm (0.016 in.) and 2 mm (0.08 in.) in size.
- (3) 8.3 kg/sec (18.3 lb/sec) for particulates smaller than 0.4 mm (0.016 in.).

[652:9.4.7.2.3]

N 9.4.7.5* Grounding of Personnel.

N 9.4.7.5.1* Where an explosive atmosphere exists and is subject to ignition from an electrostatic spark discharge from ungrounded personnel, personnel involved in manually filling or emptying particulate containers or vessels shall be grounded during such operations. [652:9.4.7.3.1]

N 9.4.7.5.2 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 of the dust cloud is greater than 30 mJ.

[652:9.4.7.3.2]

N 9.4.7.6* Flexible Intermediate Bulk Containers (FIBCs). FIBCs shall be permitted to be used for the handling and storage of combustible particulate solids in accordance with the requirements in 9.4.7.6.2 through 9.4.7.6.8. [652:9.4.7.4]

N 9.4.7.6.1 FIBCs shall not be permitted to be used for the handling and storage of legacy metals except for aluminum.

N 9.4.7.6.2* Electrostatic ignition hazards associated with the particulate and objects surrounding or inside the FIBC shall be included in the DHA required in Chapter 7. [652:9.4.7.4.1]

N 9.4.7.6.3* Type A FIBCs shall be limited to use with noncombustible particulate solids or combustible particulate solids having an MIE greater than 1000 mJ. [652:9.4.7.4.2]

- N 9.4.7.6.3.1** Type A FIBCs shall not be used in locations where flammable vapors are present. [652:9.4.7.4.2.1]
- N 9.4.7.6.3.2*** Type A FIBCs shall not be used with conductive dusts. [652:9.4.7.4.2.2]
- N 9.4.7.6.4*** Type B FIBCs shall be permitted to be used where combustible dusts having an MIE greater than 3 mJ are present. [652:9.4.7.4.3]
- N 9.4.7.6.4.1** Type B FIBCs shall not be used in locations where flammable vapors are present. [652:9.4.7.4.3.1]
- N 9.4.7.6.4.2** Type B FIBCs shall not be used for conductive dusts. (See A.9.4.7.6.3.2.) [652:9.4.7.4.3.2]
- N 9.4.7.6.5*** Type C FIBCs shall be permitted to be used with combustible particulate solids and in locations where Class I Division Group C/D or Zone Group IIA/IIB flammable vapors or gases, as defined by NFPA 70, are present. [652:9.4.7.4.4]
- N 9.4.7.6.5.1** Conductive FIBC elements shall terminate in a grounding tab, and resistance from these elements to the tab shall be or less than or equal to 10^7 ohms. [652:9.4.7.4.4.1]
- N 9.4.7.6.5.2** Type C FIBCs shall be grounded during filling and emptying operations with a resistance to ground of less than 25 ohms. [652:9.4.7.4.4.2]
- N 9.4.7.6.5.3** Type C FIBCs shall be permitted to be used for conductive dusts where a means for grounding the conductive dusts is present. [652:9.4.7.4.4.3]
- N 9.4.7.6.6*** Type D FIBCs shall be permitted to be used with combustible particulate solids and in locations where Class I Division Group C/D or Zone Group IIA /IIB flammable vapor or gases, as defined by NFPA 70, having an MIE greater than 0.14 mJ are present. [652:9.4.7.4.5]
- N 9.4.7.6.6.1*** Type D FIBCs shall not be permitted to be used for conductive particulate solids. [652:9.4.7.4.5.1]
- N 9.4.7.6.7*** Type B, Type C, and Type D FIBCs shall be tested and verified as safe for their intended use by a recognized testing organization in accordance with the requirements and test procedures specified in IEC 61340-4-4, *Electrostatics — Part 4-4: Standard Test Methods for Specific Applications — Electrostatic Classification of Flexible Intermediate Bulk Containers (FIBC)*, before being used in hazardous environments. [652:9.4.7.4.6]
- N 9.4.7.6.7.1** Intended use shall include both the product being handled and the environment in which the FIBC will be used. [652:9.4.7.4.6.1]
- N 9.4.7.6.7.2** Materials used to construct inner baffles, other than mesh or net baffles, shall meet the requirements for the bag type in which they are to be used. [652:9.4.7.4.6.2]
- N 9.4.7.6.7.3** Documentation of test results shall be made available to the AHJ. [652:9.4.7.4.6.3]
- N 9.4.7.6.7.4** FIBCs that have not been tested and verified for type in accordance with IEC 61340-4-4, *Electrostatics — Part 4-4: Standard Test Methods for Specific Applications — Electrostatic Classification of Flexible Intermediate Bulk Containers (FIBC)*, shall not be used for combustible dusts or in flammable vapor atmospheres. [652:9.4.7.4.6.4]
- N 9.4.7.6.8*** Deviations from the requirements in 9.4.7.6.2 through 9.4.7.6.7 for safe use of FIBCs shall be permitted based on a documented risk assessment acceptable to the AHJ. [652:9.4.7.4.7]
- N 9.4.7.7 Rigid Intermediate Bulk Containers (RIBCs).**
- N 9.4.7.7.1*** Conductive RIBCs shall be permitted to be used for dispensing into any flammable vapor, gas, dust, or hybrid atmospheres provided that the RIBCs are electrically grounded. [652:9.4.7.5.1]
- N 9.4.7.7.2*** Nonconductive RIBCs shall not be permitted to be used for applications, processes, or operations involving combustible particulate solids or where flammable vapors or gases are present unless a documented risk assessment assessing the electrostatic hazards is acceptable to the AHJ. [652:9.4.7.5.2]
- N 9.4.8 Open Flames and Fuel-Fired Equipment.**
- N 9.4.8.1*** Production, maintenance, or repair activities that can release or lift combustible dust shall not be conducted within 11 m (35 ft) of an open flame or pilot flame. [652:9.4.8.1]
- N 9.4.8.2** Fuel-fired space heaters drawing local ambient air shall not be located within a Class II hazardous (classified) area. [652:9.4.8.2]
- N 9.4.8.3** Fuel-fired process equipment shall be operated and maintained in accordance with the pertinent NFPA standard for the equipment, including the following standards:
- (1) NFPA 31
 - (2) NFPA 54
 - (3) NFPA 85
 - (4) NFPA 86
- [652:9.4.8.3]
- N 9.4.8.4** Inspections and preventive maintenance for fuel fired process equipment shall include verification that there are no significant combustible dust accumulations within or around the equipment. [652:9.4.8.4]
- N 9.4.8.5** Unless the equipment is operated within the limits of 9.4.4.2, provisions shall be made to prevent the accumulation of combustible dust on heated surfaces of heating units. [652:9.4.8.5]
- N 9.4.8.6** In facility locations where airborne dust or dust accumulations on horizontal surfaces are apt to occur, heating units shall be provided with a source of combustion air ducted directly from the building exterior or from an unclassified location. [652:9.4.8.6]
- N 9.4.9 Industrial Trucks.**
- N 9.4.9.1** Industrial trucks shall be listed or approved for the electrical classification of the area, as determined by 9.4.6, and shall be used in accordance with NFPA 505. [652:9.4.9.1]
- N 9.4.9.2*** Where industrial trucks in accordance with NFPA 505 are not commercially available, a documented risk assessment shall be permitted to be used to specify the fire and explosion prevention features for the equipment being used. [652:9.4.9.2]
- N 9.4.10 Process Air and Media Temperatures.**
- N 9.4.10.1*** Heated process equipment containing combustible dust shall have operating controls arranged to maintain the temperature of equipment interiors within the prescribed limits. [652:9.4.10.1]

N 9.4.11 Self-Heating.

N 9.4.11.1* Material in silos and other large storage piles of particulates prone to self-heating shall be managed to control self-heating or have self-heating detection provisions. [652:9.4.11.1]

N 9.4.11.2 Where a self-heating hazard is identified, provisions shall be in place for managing the consequences of self-heating in storage silos or bins. [652:9.4.11.2]

N 9.4.12 Friction and Impact Sparks.

N 9.4.12.1 Means shall be provided to prevent foreign material from entering the system when such foreign material presents an ignition hazard. [652:9.4.12.1]

N 9.4.12.2* Foreign materials, such as tramp metal, that are capable of igniting combustible material being processed shall be removed from the process stream. [652:9.4.12.2]

N 9.4.12.3 Tramp materials that present an ignition potential shall be permitted to be in the material inlet stream if the equipment is provided with explosion protection. [652:9.4.12.3]

N 9.4.12.4* Clearances and alignment of high-speed moving parts in equipment that is processing combustible particulates shall be checked at intervals established by the owner/operator based on wear experience unless the equipment is equipped with vibration monitors and alarms or routine manual monitoring is performed. [652:9.4.12.4]

N 9.4.12.5 The alignment and clearance of buckets in elevators that are transporting combustible particulates shall be checked at intervals established by the owner/operator based on facility wear experience unless the elevators are equipped with belt alignment monitoring devices. [652:9.4.12.5]

N 9.4.13 Propellant-Actuated Tools.

N 9.4.13.1* 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.

N 9.4.13.2 Propellant-actuated tools shall be used in accordance with Section 12.2.

N 9.4.14 Electrical Power and Control.

N 9.4.14.1 All electrical equipment and wiring shall be installed in accordance with *NFPA 70*.

N 9.4.14.2 All process equipment and all building steel shall be bonded and grounded in accordance with *NFPA 70*.

N 9.4.14.3 All manufacturing buildings shall be provided with emergency lighting systems in accordance with *NFPA 101*.

N 9.4.14.4 Control equipment, control rooms, and offices meeting the requirements of *NFPA 496* shall be permitted.

N 9.4.14.5 Preventive maintenance for electrical equipment shall be established commensurate with the environment and conditions.

N 9.4.14.6 One or more remotely located control stations shall be provided to allow the safe and selective shutdown of process equipment in an emergency.

N 9.4.14.7 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.

N 9.4.14.8 Where process equipment presents an internal deflagration hazard, an interlock shall prevent equipment operation unless associated access panels are fully closed.

N 9.4.15 Smoking.

N 9.4.15.1* Smoking shall not be permitted in areas where metals in a combustible form are present.

N 9.4.15.2 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.

N 9.4.15.3 The use of electronic cigarettes (vaping) shall be in accordance with Section 12.5.

N 9.4.15.4 Smoking shall be permitted only in designated areas.

N 9.4.15.5 No-smoking areas shall be posted with "No Smoking" signs.

N 9.4.15.6 Where smoking is prohibited throughout an entire plant, the use of signage shall be at the discretion of the facility management.

N 9.4.16 Additional Requirements. In addition to the requirements in Section 9.4, the requirements in Chapter 12 shall also apply.

N 9.5 Pyrophoric Dusts. (Reserved)**N 9.6 Dust Control.**

N 9.6.1* Continuous suction or some other means to control fugitive dust emissions shall be provided for processes where combustible dust is liberated in normal operation. [652:9.6.1]

N 9.6.1.1 Where continuous suction is used, the dust shall be conveyed to air-material separators designed in accordance with 9.3.2. [652:9.6.1.1]

N 9.6.2 Liquid Dust Suppression Methods for Dust Control. Liquid dust suppression methods shall not be used with combustible metals unless acceptable through the DHA.

N 9.6.3* Fans for Continuous Dust Control. It shall be permitted to install and use fans to limit dust accumulation in elevated areas that are otherwise difficult to reach for housekeeping. [652:9.6.3]

N 9.6.3.1 Fans shall be appropriate for the electrical classification in the areas where they are used. [652:9.6.3.1]

N 9.6.3.2 Fans shall be provided in sufficient numbers and locations as required to keep the target areas free of dust accumulations. [652:9.6.3.2]

N 9.6.3.3 Fans shall be in operation whenever the equipment generating the dusts is in operation. [652:9.6.3.3]

N 9.6.3.4 Fans shall be interlocked to automatically shut down in the event of sprinkler system operation. [652:9.6.3.4]

N 9.6.3.5 Dust dispersed by the fans shall not create an explosive dust cloud. [652:9.6.3.5]

N 9.6.3.6 The location and range of motion of the fans shall be designed to prevent flow impingement on floors or open equipment containing entrainable dust. [652:9.6.3.6]

N 9.6.3.7 Areas that will be swept by the fans shall be free of dust accumulations prior to placing the fans in operation and after every shutdown. [652:9.6.3.7]

N 9.6.3.8* These fans shall be used in conjunction with the housekeeping program to remove dust from the facility. [652:9.6.3.8]

N 9.6.3.9* Concealed spaces, such as areas above suspended ceilings, shall be sealed to prevent dust accumulation. [652:9.6.3.9]

N 9.6.3.10 These systems shall not be used where areas above suspended ceilings are used as return air plenums for HVAC systems. [652:9.6.3.10]

N 9.6.3.11 Periodic inspections shall be performed to ensure that dust accumulations are maintained below the threshold dust layer thicknesses determined in 11.4. [652:9.6.3.11]

N 9.6.4 Additional Requirements. In addition to the requirements in Section 9.6, the requirements in Chapter 13 shall also apply.

N 9.7 Explosion Prevention/Protection.

N 9.7.1 General. Where a dust explosion hazard exists within an enclosure, measures shall be taken as specified in Section 9.7 to protect personnel from the consequences of a deflagration in that enclosure. [652:9.7.1]

N 9.7.2 Risk Assessment. A documented risk assessment acceptable to the AHJ shall be permitted to be conducted to determine the level of protection to be provided, including, but not limited to, the measures addressed in Section 9.7. [652:9.7.2]

N 9.7.3 Equipment Protection.

N 9.7.3.1* General. Where an explosion hazard exists within any operating equipment greater than 0.2 m³ (8 ft³) of containing volume, the equipment shall be protected from the effects of a deflagration. [652:9.7.3.1]

N 9.7.3.2 Explosion protection systems shall incorporate one or more of the following methods of protection:

- (1) Oxidant concentration reduction in accordance with NFPA 69
 - (2) Deflagration venting in accordance with NFPA 68
 - (3) Deflagration venting through listed flame-arresting devices in accordance with NFPA 68
 - (4) Deflagration pressure containment in accordance with NFPA 69
 - (5) Deflagration suppression system in accordance with NFPA 69
 - (6) Dilution with a noncombustible dust to render the mixture noncombustible
- [652:9.7.3.2]

N 9.7.3.3* For legacy metals, including niobium, and similar alloys or mixtures with adiabatic flame temperatures higher than 3300°C, explosion protection systems such as venting, flameless venting, suppression, and isolation systems shall be tested and certified under realistic deflagration conditions with a representative metal dust and at a test vessel volume representative of the actual application.

N 9.7.3.4 Enclosures and all interconnections protected in accordance with 9.7.3.2 shall be designed to withstand the resultant pressures produced during the deflagration event. [652:9.7.3.3]

N 9.7.4* Equipment Isolation.

N 9.7.4.1 Where a dust explosion hazard exists, isolation devices shall be provided in accordance with NFPA 69 to prevent deflagration propagation between connected equipment. [652:9.7.4.1]

N 9.7.4.2 Isolation devices shall not be required where oxidant concentration has been reduced in accordance with 9.7.3.2(1) or where the dust has been rendered noncombustible in accordance with 9.7.3.2(6). [652:9.7.4.2]

N 9.7.4.3 Where a dust explosion hazard exists, isolation devices shall be provided in accordance with NFPA 69 to prevent deflagration propagation from equipment through ductwork to the work areas. [652:9.7.4.3]

N 9.8 Fire Protection.

N 9.8.1 General. In addition to the requirements in Section 9.8, the requirements in Chapter 10 shall also apply.

N 9.8.2 Fire Extinguishers.

N 9.8.2.1 Portable fire extinguishers shall be provided throughout all buildings in accordance with the requirements of NFPA 10. [652:9.8.3.1]

N 9.8.2.2* Personnel designated to use portable fire extinguishers shall be trained to use them in a manner that minimizes the generation of dust clouds during discharge. [652:9.8.3.2]

N 9.8.3 Hose, Standpipes, Hydrants, and Water Supply. The requirements in 9.8.3 shall apply where water has been deemed an acceptable extinguishing agent.

N 9.8.3.1 Standpipes and hose, where provided, shall comply with NFPA 14. [652:9.8.4.1]

N 9.8.3.2 Nozzles.

N 9.8.3.2.1* Portable spray hose nozzles that are listed or approved for use on Class C fires shall be provided in areas that contain dust, to limit the potential for generating unnecessary airborne dust during fire-fighting operations. [652:9.8.4.2.1]

N 9.8.3.2.2* Straight-stream nozzles and combination nozzles on the straight-stream setting shall not be used on fires in areas where dust clouds can be generated. [652:9.8.4.2.2]

N 9.8.3.2.3 It shall be permitted to use straight stream nozzles or combination nozzles to reach fires in locations that are otherwise inaccessible with nozzles specified in 9.8.3.2.1. [652:9.8.4.2.3]

N 9.8.3.3 Water Supply.

N 9.8.3.3.1 Private hydrants and underground mains, where provided, shall comply with NFPA 24. [652:9.8.4.3.1]

N 9.8.3.3.2 Fire pumps, where provided, shall comply with NFPA 20. [652:9.8.4.3.2]

N 9.8.3.3.3 Fire protection water tanks, where provided, shall comply with NFPA 22. [652:9.8.4.3.3]

N 9.8.4 Spark/Ember Detection and Extinguishing Systems. Where provided, spark/ember detection and extinguishing

systems shall be designed, installed, and maintained in accordance with NFPA 15, NFPA 69, and NFPA 72. [652:9.8.6]

N 9.8.5 Special Fire Protection Systems.

N 9.8.5.1 Automatic extinguishing systems or special hazard extinguishing systems, where provided, shall be designed, installed, and maintained in accordance with the following standards, as applicable:

- (1) NFPA 11
 - (2) NFPA 12
 - (3) NFPA 12A
 - (4) NFPA 15
 - (5) NFPA 16
 - (6) NFPA 17
 - (7) NFPA 25
 - (8) NFPA 750
 - (9) NFPA 2001
- [652:9.8.7.1]

N 9.8.5.2 The extinguishing systems shall be designed and used in a manner that minimizes the generation of dust clouds during their discharge. [652:9.8.7.2]

Chapter 10 Fire Prevention, Fire Protection, and Emergency Response

10.1 Retroactivity. The requirements of this chapter shall apply retroactively.

N 10.2 General. The procedures and training in this chapter shall be delivered in a language that the participants can understand. [652:8.2]

N 10.2.1 Documentation shall be maintained in compliance with Section 8.13.

N 10.3 Operating Procedures and Practices.

N 10.3.1* The owner/operator shall establish written procedures for operating its facility and equipment to prevent or mitigate fires, deflagrations, and explosions from combustible particulate solids. [652:8.3.1]

N 10.3.2* The owner/operator shall establish safe work practices to address hazards associated with maintenance and servicing operations. [652:8.3.2]

N 10.3.2.1 The safe work practices shall apply to employees and contractors. [652:8.3.2.1]

10.4 Fire Prevention.

10.4.1 Inspection, Testing, and Maintenance.

10.4.1.1 An inspection, testing, and maintenance program for equipment affecting the prevention, control, and mitigation of fires, combustible dust fires, deflagrations, and explosions shall be implemented that ensures that process controls and equipment perform as designed and that a change in process or equipment does not increase the hazard.

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

- (1) Fire and explosion protection and prevention equipment in accordance with the applicable NFPA codes and standards
- (2) Dust control equipment

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

N 10.4.1.3 The owner/operator shall establish procedures and schedules for maintaining safe operating conditions for its facility and equipment in regard to the prevention, control, and mitigation of combustible dust fires and explosions. [652:8.7.3]

10.4.1.4 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.

10.4.1.4.1 The inspection shall be conducted at least quarterly.

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

N 10.4.1.4.3* Where equipment deficiencies that affect the prevention, control, and mitigation of dust fires, deflagrations, and explosions are identified or become known, the owner/operator shall establish and implement a corrective action plan with an explicit deadline. [652:8.7.4]

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

N 10.4.1.6 Document retention shall be in compliance with Section 8.13.

10.4.2 Control of Combustible Materials.

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

10.4.2.1.1 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).

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

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

10.4.2.2 Ordinary Combustible Storage.

10.4.2.2.1 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.

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

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

10.4.2.3.1 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.

10.4.2.3.2 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.

10.4.3* Molten Metal.

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

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

10.5 Fire Protection.

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

10.5.1.1* Automatic sprinkler protection shall not be permitted in areas where combustible metals are produced or handled unless allowed by 10.5.1.2, 10.5.1.3, and 10.5.1.4.

10.5.1.2* 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.

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

10.5.1.4 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.

10.5.1.5 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 10.5.4.

10.5.1.6* 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

10.5.2 Sprinkler Protection for Alkali Metals.

10.5.2.1* 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.

10.5.2.2 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.

10.5.2.3 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.

10.5.2.4 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.

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

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

10.5.3* Extinguishing Agents and Application Techniques.

10.5.3.1* 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.

10.5.3.1.1 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.

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

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

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

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

10.5.3.5 The following agents shall not be used as extinguishing agents on a combustible-metal fire because of adverse reactions or ineffectiveness unless they are compatible with the metal and are an effective extinguishing agent (*see* 10.5.3):

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

10.5.3.6 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.

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

10.5.3.8 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.”

10.5.3.9* Solvent-Wetted Powders. Incipient fires in solvent-wetted powders shall be handled according to 10.5.3.9.1 or 10.5.3.9.2.

10.5.3.9.1 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.

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

10.5.3.9.2.1* 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.

10.5.3.9.2.2* 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.

10.5.3.9.2.3 The material shall be handled in covered containers.

10.5.3.10 Applications of Extinguishing Agents. Applications of extinguishing agents shall be handled according to 10.5.3.10.1 through 10.5.3.10.4.

10.5.3.10.1* 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.

10.5.3.10.2 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.

10.5.3.10.3* 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.

10.5.3.10.4 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.

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

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

10.5.4 Fire-Fighting Activities.

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

10.5.4.2 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.

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

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

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

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

10.5.4.7 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.

10.5.4.8 Processing Equipment.

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

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

10.5.4.9 Alkali Metals Fire-Fighting Procedures.

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

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

10.5.5 Fire-Fighting Organization.

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

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

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

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

10.5.5.2.1 Training shall include all possible contingencies.

10.5.5.2.2* 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.

10.6 Training and Hazard Awareness.

10.6.1* Employees, contractors, temporary workers, and visitors shall be included in a training program according to the potential exposure to combustible dust hazards and the potential risks to which they might be exposed or could cause. [652:8.8.1]

10.6.1.1 Contractors shall also meet the requirements of Section 8.9.

N 10.6.2* General safety training and hazard awareness training for combustible metal fire hazards shall be provided to all affected employees.

N 10.6.2.1* Job-specific training shall ensure that employees are knowledgeable about fire and explosion hazards of combustible metals, dusts, and particulate solids in their work environment.

N 10.6.2.2 Employees shall be trained before taking responsibility for a task. [652:8.8.2.2]

N 10.6.2.3* Where explosion protection systems or emergency shutdown systems are installed, training of affected personnel shall include the operations and potential hazards presented by such systems.

10.6.3* 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.

N 10.6.4 Personnel assigned to fire control activities shall be trained in accordance with 10.5.5.

N 10.6.5 Refresher training shall be provided as required by the AHJ and as required by other relevant industry- or commodity-specific NFPA standards. [652:8.8.3]

N 10.6.6 The training shall be documented. [652:8.8.4]

10.7 Emergency Planning/Preparedness and Response.

10.7.1 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.

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

N 10.7.2.1* The plan shall be developed to prepare for and respond to work-related emergencies including, but not limited to, fire and explosion.

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

N 10.7.2.3 The emergency response plan shall be reviewed and validated at least annually, highlighting specific actions in the event of a combustible metal fire.

Δ 10.7.2.4 The plan shall be coordinated with the facility management and emergency responders.

10.7.2.5* Clothing Fires.

10.7.2.5.1 Emergency procedures for handling clothing fires shall be established as part of the plan.

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

10.7.2.6 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

10.7.2.7 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 10.5.3.)
- (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 10.5.3.)
- (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 10.5.3.)
- (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.

• **10.7.3** 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.

10.7.4 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.

10.8* Emergency Response.

10.8.1 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 10.5.3.)
- (12) Use extinguishing agents for containment of small and incipient fires. (See 10.5.3.)
- (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.

N 10.9 Incident Investigation. Incident investigation shall comply with Section 8.11.

Chapter 11 Housekeeping

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

11.2 Applicability. The requirements of this chapter shall not apply to nanometals (see Chapter 14).

11.3* Housekeeping Plan.

11.3.1 A documented housekeeping program shall be established.

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

11.3.3* 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.

11.4 Cleanup Procedures for Fugitive Dust Accumulations.

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

11.4.2* 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.

11.4.3 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 11.6

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

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

11.4.5.1 The cleaning shall include machinery.

11.4.5.2 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.

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

11.4.5.4 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.

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

11.5 Cleanup of Spilled Dust, Fine or Powder.

11.5.1 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.

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

11.5.3 Compressed-air blowdown shall be permitted as a method for cleaning only when done in accordance with Section 11.7.

11.6* Vacuum Cleaning.

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

Δ 11.6.2* When being used for combustible metal powder, portable vacuum cleaners shall be used only if identified for the material being vacuumed with the following conditions:

- (1) They shall be permitted only for the 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

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

11.6.3.1* If the system is moved, grounding and bonding shall be verified.

N 11.6.3.2 For compressed air-operated systems, the air supply hose shall comply with the manufacturer's specifications.

• **11.6.4** Vacuum cleaner hose shall be conductive or static dissipative and nozzles or fittings shall be made of conductive, nonsparking material.

11.6.5 Assembled components shall be conductive or static dissipative and bonded where necessary.

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

Δ 11.6.7 Combustible metal dust picked up by a centralized vacuum cleaning system shall be discharged into a container located outside the building.

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

11.7 Compressed Air Cleaning Requirements.

11.7.1 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.

▲ **11.7.1.1** 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.

11.7.2 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.

11.8 Water-Cleaning Requirements.

11.8.1 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

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

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

11.9 Cleaning Frequency.

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

11.9.2 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.

11.9.3* 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.

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

11.10 General Precautions.

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

11.10.2 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.

11.10.3 Oil spills shall be cleaned up promptly.

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

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

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

11.10.7 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 12 Control of Ignition Sources

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

12.2 Hot Work. See Section 8.5.

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

12.3.1 Bearings.

12.3.1.1 Ball or roller bearings shall be sealed against dust.

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

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

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

12.3.1.5 Grounded and bonded bearings shall be used.

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

12.3.2 Fan and Blower Construction.

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

12.3.2.2* 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.

12.3.2.3 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.

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

12.3.2.4.1 Bearings shall be equipped with temperature indicating devices.

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

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

12.3.3* Grinding Wheels.

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

12.3.3.2 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.

12.4 Electrical Area Classification.

12.4.1* 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*.

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

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

12.4.4* 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.

N 12.5* Portable Electrical and Electronic Equipment. Portable electrical and electronic equipment used in hazardous (classified) locations shall be identified for use in such locations. (See *NFPA 70*.)

Δ Chapter 13 Pneumatic Conveying, Dust Collection, and Centralized Vacuum Cleaning Systems

13.1 Retroactivity. Paragraphs **13.2.4.2.2**, **13.2.4.4.6**, **13.2.4.4.12**, **13.2.4.4.15.3**, **13.2.4.5.9**, and Section **13.4** shall be applied retroactively.

13.2* Dust Collection.

13.2.1* 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.

13.2.2 Powder conveying and collection for combustible metal powder production operations shall follow the requirements of Section **13.5**, **13.2.4.4**, and **13.2.4.5** for wet and dry AMS.

13.2.3 General Requirements.

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

13.2.3.2* 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]

13.2.3.3* 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 **8.12**.

13.2.3.4* 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.

13.2.3.5 Restrictions on Collected Materials.

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

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

13.2.3.5.1.2 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.

13.2.3.6 Operations.

13.2.3.6.1 Sequence of Operation. Dust collection systems shall be designed with the operating logic, sequencing, and timing outlined in **13.2.3.6.1.1** and **13.2.3.6.1.2**.

13.2.3.6.1.1 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.

13.2.3.6.1.2 Shutdown.

(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.

(B) The requirements of **13.2.3.6.1.2(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.

13.2.3.6.2* 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]

13.2.3.6.3* 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]

13.2.3.6.4* 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]

13.2.3.6.5* 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]

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

13.2.3.6.7* 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 unless protected from explosion, fire, and sparks

and isolated to prevent the propagation of flame and pressure between interconnected equipment and upstream work areas in accordance with 9.7.3.3, NFPA 68, and NFPA 69.

13.2.3.6.8* 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]

13.2.3.6.9* 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.

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

13.2.3.6.11* 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.

13.2.3.6.12* 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.

13.2.3.7* 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.

13.2.3.7.1 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

13.2.4 Specific Requirements.

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

13.2.4.2* Prevention of Static Discharge.

13.2.4.2.1 Prevention of ignition due to static discharge shall be in accordance with subsection 9.4.7.1 in addition to the requirements of this chapter.

13.2.4.2.2 Bonding and Grounding.

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

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

13.2.4.2.2.3* 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.

13.2.4.3 Ducts, Ductwork, and Flex Connections.

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

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

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

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

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

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

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

13.2.4.4.1* 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.

▲ **13.2.4.4.2** Media dust collectors shall be provided with all the following ignition prevention measures:

- (1)* Where conductive combustible dusts having an MIE less than 30 mJ are handled, the filter media shall be static-dissipative and shall be effectively bonded to the conductive filter frame unless supported by a risk assessment that includes an evaluation of filter electrostatic charge accumulation and the electrostatic discharge ignition properties of the collected dust.
- (2)* Accumulation levels during the operation shall be monitored across the media using a pressure drop or equivalent sensor. If the accumulation exceeds the predetermined limits, a controlled shutdown of the collector and dust generation equipment shall be implemented.
- (3) Periodic inspections and the replacement of media shall be based on intervals determined by the pressure drop across the filter media or via indication of self-heating detection equipment based on oxidative self-heating and moisture reactivity.

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

13.2.4.4.4 Dry-Type AMS Limitations.

13.2.4.4.4.1* Electrostatic collectors shall be prohibited.

13.2.4.4.4.2 Enclosureless dry-type AMS shall be prohibited.

▲ **13.2.4.4.4.3*** Self-contained, dry-type AMS, downdraft benches, and environmental control booths with integral filter media in the wall shall be prohibited unless complying with 13.2.4.4.4.4.

▲ **13.2.4.4.4.4*** Self-contained, dry-type AMS, downdraft benches, and environmental control 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 contained in the collector at any given time.

13.2.4.4.5* 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.

13.2.4.4.6 Repairs.

13.2.4.4.6.1 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.

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

13.2.4.4.7 Cyclone Construction.

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

13.2.4.4.7.2* Cyclone dry-type AMS shall be constructed with smooth internal seams to minimize material accumulation.

13.2.4.4.8 Temperature Monitoring Requirements.

13.2.4.4.8.1* Dry-type AMS shall be equipped with fire detection and alarm devices.

13.2.4.4.8.2 The detection device shall interlock and deenergize the system and provide an audible and visual alarm at normally attended stations.

13.2.4.4.8.3 Where the AMS contains filter media, detection shall be designed so that all filter locations are monitored.

13.2.4.4.9* 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.

13.2.4.4.10 Filter Media Properties.

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

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

13.2.4.4.11 Explosion Protection.

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

13.2.4.4.11.2* 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 requirement to maintain a minimum concentration of oxygen to control pyrophoricity depending on the chemical properties of the material being conveyed

- (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

13.2.4.4.11.3 If the method in 13.2.4.4.11.2(5) is used, test data for specific dust and diluent combinations shall be provided and shall be acceptable to the authority having jurisdiction.

13.2.4.4.11.4 Where an explosion hazard exists and is not protected by 13.2.4.4.11.2(2) or 13.2.4.4.11.2(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.

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

(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.

13.2.4.4.11.5 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.

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

13.2.4.4.11.7 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.

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

WARNING:

EXPLOSION RELIEF DEVICE

13.2.4.4.12 Collected Material.

13.2.4.4.12.1* Discharge containers for collectors shall be emptied before or when 100 percent of the storage capacity of the container is attained, or more frequently as determined by the DHA.

13.2.4.4.12.2 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.

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

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

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

13.2.4.4.13* Requirements for the Clean Air Exhaust.

13.2.4.4.13.1 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 11.
- (10) Recycled-air ducts are inspected and cleaned at least annually.

Δ **13.2.4.4.13.2** Air shall be permitted to be recirculated for materials not meeting items 13.2.4.4.13.1(1) and 13.2.4.4.13.1(2) if the AMS has a collection capacity meeting the requirements of 13.2.4.4.15.8.

13.2.4.4.14 Dry-type dust collectors shall be located outside of buildings unless permitted by 13.2.4.4.15.

13.2.4.4.15* Indoor Dry-Type Air-Material Separator (AMS). All portions of 13.2.4.4 on dry-type AMS requirements shall apply to indoor dry-type AMS in addition to this section.

13.2.4.4.15.1 A hazards analysis shall be conducted in accordance with Section 5.3 and Chapter 7 to ensure that the risk to personnel and operations is minimized for both new and existing systems.

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

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

(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.

(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.

(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.

(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).

(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.

Δ **13.2.4.4.15.4*** Exhaust ducts from the fan discharge exiting the building shall be as straight and short as is practicable.

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

Δ **13.2.4.4.15.6** The exhaust duct from an AMS located inside the building that traverses the building and discharges outside shall be protected by one of the following deflagration protection methods:

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

13.2.4.4.15.7* If the material meets either of the following criteria, the additional requirements in 13.2.4.4.15.7(A), 13.2.4.4.15.7(B), and 13.2.4.4.15.7(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.10.5.3).

(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.

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

THIS COLLECTOR CONTAINS COMBUSTIBLE METAL DUST.

DO NOT EXTINGUISH WITH WATER.

(C) The emergency response plan required in Section 10.8 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

Δ 13.2.4.4.15.8 Indoor dry-type dust collectors shall be permitted for legacy metals covered by Chapter 17, 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 AMS has a dirty volume less than 0.2 m³ (8 ft³) or an airflow less than 850 m³/hr (500 ft³/min), and the discharge container is emptied in accordance with 13.2.4.4.12.

13.2.4.4.15.9 Indoor dry-type dust collectors shall be permitted for metals covered by Chapter 18, 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 13.2.4.4.15.10 Where an entire dust collection and AMS system, including the material collection container, is protected from fire and explosion in accordance with 13.2.4.4.11.2(2), the quantity of collected material shall be permitted to be increased to 227 kg (500 lb), or a value determined by a DHA.

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

13.2.4.4.16.1 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 13.2.4.4.16.

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

13.2.4.4.16.3 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.

(A)* The portable dust collector shall not be used in an identified deflagration hazard area until appropriate housekeeping

methods in Chapter 11 have been used to remove hazardous quantities of dust.

(B)* Portable dry AMS with a dirty side volume less than or equal to 0.2 m³ (8 ft³) shall not be required to be protected against explosion in accordance with NFPA 69.

13.2.4.4.16.4 Personal protective clothing shall comply with Section 8.6.

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

13.2.4.4.16.6 Grounding of personnel operating portable indoor dust collectors shall comply with 9.4.7.1.6.

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

13.2.4.4.16.8 Hazards associated with static discharge shall be mitigated in accordance with subsection 9.4.7.1.

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

13.2.4.4.16.10* 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.

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

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

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

13.2.4.4.17 Operations Generating Hot Particles.

13.2.4.4.17.1* Grinding, sanding, polishing, cutting/sawing, plasma spray, or other operations generating hot metal particles shall have a spark arrester system upstream of the AMS.

13.2.4.4.17.2* Dust collection systems for hot metallic nanoparticles shall be inerted unless combustibility testing of nanoparticle dust samples demonstrate that the particles are not pyrophoric.

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

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

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

13.2.4.5.1 The exhaust vent shall terminate to a safe location outside the building and shall be securely fastened except as provided in 13.2.4.5.3.

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

13.2.4.5.3 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.

13.2.4.5.4 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.

13.2.4.5.5* 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.

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

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

13.2.4.5.7.1 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

13.2.4.5.8 Operational Safeguards.

13.2.4.5.8.1* 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.

13.2.4.5.8.2 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.

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

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

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

13.2.4.5.9.1* 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.

13.2.4.5.9.2 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.

13.2.4.5.9.3 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.

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

13.2.4.5.9.5 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.

13.2.4.5.9.6 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.

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

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

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

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

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

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

13.2.4.5.11 Additional Requirements for Water-Based Wet-Type AMS.

13.2.4.5.11.1 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.

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

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

13.2.4.5.11.4 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.

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

13.2.4.5.12 Additional Requirements for Non-Water-Based Wet-Type AMS.

13.2.4.5.12.1 The liquid used shall be limited to nonaqueous Class IIIB or noncombustible liquids.

13.2.4.5.12.2 Possible vapor generation due to metal reaction with the liquid shall be evaluated and addressed as part of the DHA required in Chapter 7.

13.2.4.5.12.3 Class IIIB liquids shall be handled in accordance with NFPA 30.

13.2.4.5.12.4 Pressurized transfer of liquid shall be prohibited.

13.2.4.5.12.5 Formation of liquid residue in the vicinity of the operating unit shall be minimized.

13.2.4.5.13 Portable Indoor Wet-Type Immersion Air-Material Separators (AMS).

13.2.4.5.13.1 Portable indoor wet-type immersion AMS shall comply with 13.2.3.5 and 13.2.4.5.10.1 through 13.2.4.5.10.5, in addition to this section.

13.2.4.5.13.2 Personal protective clothing shall comply with Section 8.6.

13.2.4.5.13.3 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.

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

13.2.4.5.13.5 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.

13.2.4.5.13.6 The maximum capacity shall not exceed 20 lb (9 kg) of sludge.

13.3* Centralized Vacuum Cleaning System.

13.3.1 General Requirements.

13.3.1.1* 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.

13.3.1.2* 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.

13.3.1.3* 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.

13.3.2* Specific Requirements for Centralized Vacuum Cleaning Systems.

13.3.2.1* 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.

13.3.2.2* The hose length and diameter shall be sized for the application and operation.

13.3.2.3* Vacuum cleaning tools shall be constructed of metal or shall be static dissipative and provide proper grounding and bonding to the hose.

13.3.2.4* Vacuum cleaning hose shall be static dissipative or conductive and shall be grounded.

13.3.2.5 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.

13.3.2.6* The entire centralized vacuum cleaning system shall be effectively bonded and grounded to minimize the accumulation of static electrical charge.

13.3.2.7* The tubing, piping, or both used in the system shall be metal and properly grounded and bonded.

13.3.2.8* The dry or wet AMS used in the system must comply with the requirements for dust collectors found in 13.2.4.4 for dry-type AMS and 13.2.4.5 for wet-type AMS.

13.3.2.9* 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.

13.4 Portable Vacuum Cleaners.

13.4.1 The use of portable vacuum cleaners shall comply with Section 11.6.

N 13.4.2* Due to the inherent hazards associated with the use of portable electrical vacuum cleaning systems, the equipment used for cleaning shall be identified for use in a Class II, Group E atmosphere. (See also Section 13.3.)

N 13.4.3 Portable vacuum cleaning systems shall be effectively bonded and grounded to minimize the accumulation of static electric charge.

N 13.4.4 Vacuum cleaner hose shall be conductive or static dissipative and nozzles or fittings shall be made of conductive, nonsparking material.

N 13.4.5 Assembled components shall be conductive or static dissipative and bonded where necessary.

13.5 Pneumatic Conveying of Powder.

13.5.1 Ductwork for Pneumatic Conveying Systems.

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

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

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

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

13.5.1.5* 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.

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

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

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

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

Δ 13.5.1.6.1.3 Where ducts are provided with deflagration vents, vent closures shall be clearly marked as follows:

WARNING:

EXPLOSION RELIEF DEVICE