NFPA 651

Standard for the Machining and Finishing of Aluminum and the Production and Handling of Aluminum Powders

1998 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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Machining and Finishing of Aluminum and the Production and Handling of Aluminum Powders

1998 Edition

This edition of NFPA 651, *Standard for the Machining and Finishing of Aluminum and the Production and Handling of Aluminum Powders,* was prepared by the Technical Committee on Combustible Metals and Metal Dusts and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 18–21, 1998, in Cincinnati, OH. It was issued by the Standards Council on July 16, 1998, with an effective date of August 5, 1998, and supersedes all previous editions.

This edition of NFPA 651 was approved as an American National Standard on August 6, 1998.

Origin and Development of NFPA 651

NFPA 651, *Manufacture of Aluminum Powder,* was originally prepared by the Committee on Dust Explosion Hazards in 1938 and 1939. It was first adopted in 1939, and revised in 1946, 1952, 1959, 1963, 1967, and 1972. The 1967 edition was approved by the American National Standards Institute in 1967 and designated ANSI Z12.11.

NFPA 652, *Plants Producing or Handling Magnesium Powder*, was originally prepared by the Committee on Dust Explosion Hazards in 1942 and was first adopted in 1944. Amendments were adopted in 1945, 1946, 1952, 1959, and 1968. The 1968 edition was approved by the American National Standards Institute in 1968 and designated ANSI Z12.15.

In 1973, NFPA 651 and 652 were combined into a single standard, NFPA 651-T, and tentatively adopted at the 1973 Annual Meeting and officially adopted at the 1974 Annual Meeting. Revisions were adopted in 1980 and 1987.

For the 1993 edition, the Committee added definitions; clarified the requirements for the location of aluminum powder production plants; and revised the requirements for electrical power, machinery, and operations, and for in-plant conveying of aluminum powder including the provisions for inert conveying. The requirements for explosion venting, manual fire fighting, and automatic sprinkler protection were also updated. This included the change in terminology from "light metal powder" to "aluminum powder" to emphasize that the requirements for the manufacture of magnesium powder were incorporated into the 1993 edition of NFPA 480, *Standard for the Storage, Handling, and Processing of Magnesium Solids and Powders*. The Committee also incorporated various style and editorial revisions to comply with the NFPA *Manual of Style* and to assist in making the document more usable, adoptable, and enforceable.

This edition of NFPA 651 represents a complete revision that incorporates the requirements of NFPA 65 and 651 into a combined document. This new edition reduces redundancy and ensures that a consistent approach is applied to protecting against similar hazards. The new format also provides users with a single reference source for requirements in these operations.

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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.

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

Information on referenced publications can be found in Chapter 8 and Appendix C.

Chapter 1 General

1-1 Scope.

1-1.1* This standard shall apply to manufacturing facilities that produce aluminum flake powder, aluminum paste, atomized aluminum powder or aluminum granules, or any aluminum alloy powder that is combustible or explosible in an ambient atmosphere.

1-1.2 This standard also shall apply to operations where aluminum or aluminum alloys are subjected to processing or finishing operations that produce fine metallic powder or dust. Such operations include, but are not limited to, machining, sawing, grinding, buffing, and polishing.

1-1.3 This standard also shall apply to the handling and storage of combustible aluminum dusts, aluminum powders, or aluminum pastes by users of such material.

1-1.4 This standard does not apply to the transportation of combustible aluminum dusts, aluminum powders, or aluminum pastes on public highways, waterways, or by air or rail.

1-1.5 This standard does not apply to the primary production of aluminum metal.

1-2 Purpose. The objective of this standard is to minimize the occurrence of and resulting damage from fire and explosion in areas where combustible aluminum dusts, aluminum powders, or aluminum pastes are manufactured, produced, handled, and stored.

1-3 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.

1-4 Applicability.

1-4.1 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. They reflect situations and the state-of-the-art prevalent at the time the standard was issued. Unless otherwise noted, it shall not be intended that the provisions of this document be applied to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of the document, except in those cases where it is determined by the authority having jurisdiction that the existing situation involves a distinct hazard to life or adjacent property.

1-4.2 Existing plants, equipment, structures, and installations that do not comply strictly with the requirements of this standard shall be considered to be in compliance if it can be shown that an equivalent level of protection has been provided or that no specific hazard will be created or continued through noncompliance.

1-4.3 This standard is not intended to prevent use of systems, methods, or devices that provide equivalent protection from fire and explosion. NFPA 69, *Standard on Explosion Prevention Systems,* shall be referred to when considering the use of optional systems.

1-5 Definitions.

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

Aluminum Flake. See Aluminum Powder.

Aluminum Granules. Aluminum powders, generally larger than 200 mesh (i.e., material not passing a U.S. No. 200 Standard Sieve, 75 microns).

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.

Aluminum Powder. Aluminum powder can be divided into three broad classifications: atomized, flake, and granules. The length, width, and thickness of an atomized particle or granule are all of approximately the same order; the length dimension probably not exceeding two or three times the thickness dimension. The length or width of a flake particle can be several hundred times its thickness. Granules are generally powders larger than 75 μm (microns) (i.e., 200 mesh).

Aluminum Powder Production Plant. Facilities or buildings in which the primary product is aluminum powder. Facilities or buildings in which aluminum powder or combustible aluminum dust is produced incidental to operations shall not be considered a powder production plant.

Approved.* Acceptable to the authority having jurisdiction.

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

Combustible Aluminum Dust.* Any finely divided aluminum material 420 μm (microns) or smaller in diameter (i.e., material passing a U.S. No. 40 Standard Sieve) that presents a fire or explosion hazard when dispersed and ignited in air.

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

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

Shall. Indicates a mandatory requirement.

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

Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

Chapter 2 Aluminum Powder Production Plants

2-1 Location.

2-1.1 Aluminum powder production plants shall be located on a site large enough so that the buildings in which powder is manufactured are at least 300 ft (90.9 m) from public roads and from any occupied structure, such as public buildings, dwellings, business or manufacturing establishments, other than those buildings that are a part of the aluminum powder production plant.

2-1.2 A hazard analysis shall be conducted to determine the minimum separation distance for individual buildings and operations within aluminum powder production plants.

2-2 Building Construction.

2-2.1 All buildings used for the manufacture, packing, or loading for shipment of aluminum powders shall be constructed of noncombustible materials throughout and shall have nonload-bearing walls. The buildings shall be designed so that all internal surfaces are readily accessible to facilitate cleaning.

2-2.2 All walls of areas where fugitive dust can be produced shall have a smooth finish and be sealed so as to leave no interior or exterior voids where aluminum powder can infiltrate and accumulate. The annulus of all pipe, conduit, and ventilation penetrations shall be sealed.

2-2.3 Floors shall be hard-surfaced and installed with a minimum number of joints in which aluminum powder or dust can collect. The requirements of this section shall also apply to elevated platforms, balconies, floors, or gratings. *(See Appendix B.)*

2-2.4 Roofs of buildings that house combustible aluminum dust–producing operations shall be supported on girders or structural members designed to minimize surfaces on which dust can collect. Where such surfaces are unavoidably present, they shall be covered by a smooth concrete, plaster, or noncombustible mastic fillet having a minimum slope of 55 degrees to the horizontal.

2-2.5 Roof decks and basements shall be watertight.

2-2.6* Explosion venting shall be provided for buildings where aluminum powder is processed.

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

2-2.7 Doors and Windows.

2-2.7.1 All doors in interior fire-rated partitions shall be listed, self-closing fire doors, installed in accordance with NFPA 80, *Standard for Fire Doors and Fire Windows.*

2-2.7.2 Emergency exits shall be provided in compliance with NFPA *101®, Life Safety Code®. (See Section 5-11 and Chapter 28 of NFPA 101.)*

2-2.8 Enclosed Passageways.

2-2.8.1* Where buildings or process areas are interconnected by enclosed passageways, the passageways shall be designed to prevent propagation of an explosion or fire from one unit to another.

2-2.8.2 All enclosed passageways that can be occupied and that connect with one or more processing areas shall be provided with means of egress in accordance with NFPA *101, Life Safety Code.*

2-2.9 Grounding and Lightning Protection.

2-2.9.1* All process equipment and all building steel shall be bonded and grounded in accordance with NFPA 70, *National Electrical Code®.*

2-2.9.2 All buildings shall be provided with a lightning protection system in accordance with NFPA 780, *Standard for the Installation of Lightning Protection Systems.*

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

2-2.10 Electrical Power and Control.

2-2.10.1 All electrical equipment and wiring shall be installed in accordance with NFPA 70, *National Electrical Code.*

2-2.10.1.1* Powder-manufacturing areas shall be classified, where applicable, in accordance with Article 500 of NFPA 70.

Exception No. 1: Offices and similar areas within the aluminum powder–manufacturing building that are segregated and reasonably free from dust shall not be classified.

Exception No. 2: Control equipment meeting the requirements of NFPA 496, Standard for Purged and Pressurized Enclosures for Electrical Equipment, shall be permitted.

2-2.10.2 One or more remotely located control stations shall be provided to allow the safe and selective shutdown of process equipment in an emergency.

2-2.10.3 All manufacturing buildings shall be provided with emergency lighting systems in accordance with Section 5-9 of NFPA *101, Life Safety Code.*

2-2.10.4 Preventative maintenance for electrical equipment shall be established commensurate with environment and conditions. Electrical equipment shall be inspected and cleaned at least once each year or more frequently if conditions warrant it.

2-2.10.5 Flashlights and other portable electrical equipment shall be listed for the locations where they are used.

2-2.11 Heating and Cooling of Aluminum Powder Production Buildings.

2-2.11.1 Buildings shall be permitted to be heated by indirect hot air heating systems or by bare pipe heating systems using steam or hot water as the heat transfer medium, or by listed electric heaters. Indirect hot air shall be permitted if the heating unit is located in a combustible aluminum dust–free area, adjacent to the room or area where heated air is required.

2-2.11.2 Fans or blowers used to convey the heated or cooled air shall also be located in a combustible aluminum dust–free location. The air supply shall be taken from outside or from a location that is free of combustible aluminum dust.

2-2.11.3 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 aluminum dust or powder.

2-2.11.4 The requirements of 2-2.11.1, 2-2.11.2, and 2-2.11.3 shall not apply to areas where aluminum metal is melted.

2-3 Machinery and Operations.

2-3.1 General Precautions.

2-3.1.1 This section shall be applied to new and existing facilities where aluminum powder is produced or handled.

2-3.1.2 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, or impact (e.g., iron or steel articles on stones, on each other, or on concrete), or other energy sources.

2-3.1.3 Water leakage inside or into any building where the water can contact aluminum powder shall be prevented to avoid possible spontaneous heating.

2-3.1.4* Frictional heating shall be minimized by the use of lubrication, inspection programs, and maintenance programs and techniques set forth by the equipment manufacturer's recommendation.

2-3.2 Requirements for Machinery.

2-3.2.1 All combustible aluminum dust–producing machines and conveyors shall be designed, constructed, and operated so that fugitive dust is minimized.

2-3.2.2 All machinery and equipment shall be installed in accordance with NFPA 70, *National Electrical Code*.

2-3.2.3* All machinery shall be bonded and grounded to minimize accumulation of static electric charge.

2-3.2.4 Bearings.

2-3.2.4.1* Ball or roller bearings shall be sealed against dust.

2-3.2.4.2 Where exposed bearings are used, the bearings shall be protected to prevent ingress of combustible aluminum dust and shall have a lubrication program.

2-3.2.5 Clearances between moving surfaces that are exposed to paste, powder, or dust shall be maintained to prevent rubbing or jamming.

2-3.2.6 Permanent magnetic separators, pneumatic separators, or screens shall be installed ahead of mills, stamps, or pulverizers wherever there is any possibility that tramp metal or other foreign objects can be introduced into the manufacturing operation.

2-3.3 Start-Up Operations. All areas of processing machinery that will be in contact with aluminum powder shall be free of foreign material and water before being placed into operation.

2-4 Handling and Conveying of Aluminum Powder.

2-4.1 Where aluminum powder is present, good housekeeping practices shall be maintained.

2-4.2 Aluminum powder shall be handled so as to avoid spillage and the creation of airborne dust.

2-4.3 Scoops, shovels, and scrapers used in the handling of aluminum powder shall be electrically conductive and shall be grounded when necessary. Hand tools shall be made of spark-resistant materials.

2-4.4 Each container for aluminum powders shall be conductive and covered while in storage or transit.

2-4.5 When charging aluminum powders to (or discharging from) machines, the containers shall be bonded to the grounded machine.

2-4.6 When transferring aluminum powder between containers, the containers shall be bonded and at least one of the containers shall be grounded.

2-4.7 Portable Containers.

2-4.7.1 Transport of aluminum powders shall be done in covered conductive containers as described in 2-4.4.

2-4.7.2 Powered industrial trucks shall be selected in accordance with NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation*.

2-4.8 Ductwork for Pneumatic Conveying Systems.

2-4.8.1 Conveyor ducts shall be fabricated of nonferrous spark-resistant metal or spark-resistant stainless steel. Plastics or other nonconductive ducts or duct liners shall not be used.

2-4.8.2* Ducts shall be electrically bonded and grounded to minimize accumulation of static electric charge.

2-4.8.3* Where the conveying duct is exposed to weather or moisture, it shall be moisture-tight.

2-4.8.4 A minimum conveying velocity of 4500 ft/min (1364 m/min) shall be maintained throughout the conveying system to prevent the accumulation of dust at any point and to pick up any dust or powder that can drop out during unscheduled system stoppages.

2-4.8.5* If the conveying gas is air, the aluminum-to-air ratio throughout the conveying system shall be held below the minimum explosible concentration (MEC) of the combustible aluminum dust at normal operating conditions.

2-4.8.6* Deflagration venting (e.g., rupture diaphragms) shall be provided on ductwork. Deflagration vents shall relieve to a safe location outside of the building.

Exception: Ductwork provided with explosion isolation systems identified in NFPA 69, Standard on Explosion Prevention Systems, that can prevent propagation of a deflagration into other parts of the process.

2-4.8.7 Whenever damage to other property or injury to personnel can result from the rupture of the ductwork, or where deflagration relief vents cannot provide sufficient pressure relief, the ductwork shall be designed to withstand a suddenly applied pressure of at least 100 psig (690 kPa gauge).

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

2-4.9 Conveying Using an Inert Medium.

2-4.9.1* Inert gas–conveying systems shall be permitted, if designed in accordance with Chapter 2 of NFPA 69, *Standard on Explosion Prevention Systems.*

2-4.9.2* The inert gas used shall be based on such gases as argon, carbon dioxide, helium, nitrogen, or flue gas and shall have a limiting oxygen concentration determined by test to be appropriate to the inert gas.

Exception: Where the aluminum powder is never exposed to air, the oxygen content can be zero.*

2-4.9.3 The inert gas shall have a dew point such that no free moisture can condense or accumulate at any point in the system.

2-4.9.4 The inert gas stream shall be continuously monitored for oxygen content and shall be arranged to sound an alarm if the oxygen content is not within the prescribed range.

2-4.9.5 A minimum conveying velocity of 4500 ft/min (1364 m/min) shall be maintained throughout the conveying system to prevent the accumulation of dust at any point and to pick up any dust or powder that can drop out during an unscheduled system stoppage.

2-4.9.6 If the conveying gas is inducted into the system in a relatively warm environment and the ducts and collectors are relatively cold, the ducts and collectors shall be either insulated or provided with heating so that the gas temperature does not fall below the dew point, causing condensation.

2-4.10 Fan and Blower Construction and Arrangement.

2-4.10.1* Blades and housings of fans used to move air or inert gas in conveying ducts shall be constructed of conductive, nonsparking metal such as bronze, nonmagnetic stainless steel, or aluminum.

2-4.10.2 The design of the fan or blower shall not allow the transported aluminum powder to pass through the fan before entering the final collector.

Exception: Where the aluminum powder–conveying system is inerted, the aluminum powder shall be permitted to pass through the fan.

2-4.10.3 Personnel shall not be permitted within 50 ft (15 m) of the fan or blower while it is operating. No maintenance shall be performed on the fan until it is shut down.

Exception No. 1: If personnel approach the fan or blower while it is operating, such as for a pressure test, the test shall be done under the direct supervision of competent technical personnel and with the knowledge and approval of operating management and with the flow of aluminum powder cut off.

Exception No. 2: Where the aluminum powder–conveying system is inerted, personnel shall be permitted to be closer than 50 ft (15 m).

2-4.10.4* Fans or blowers shall be located outside of all manufacturing buildings and shall be located so that entrance of dust into the building from the fan exhaust shall be minimized.

2-4.10.5* Fans or blowers shall be equipped with ball or roller bearings. Bearings shall be equipped with temperature-indicating devices and shall be arranged to sound an alarm in case of overheating.

2-4.10.6 Fans or blowers shall be electrically interlocked with powder-producing machinery so that the machines are shut down if the fan stops.

2-5 Powder Collection.

2-5.1* Collectors.

2-5.1.1 Dry-type collectors shall be located outside in a safe location and shall be provided with barriers or other means for protection of personnel.

2-5.1.2* The area around the collector shall be posted with a sign as follows:

CAUTION

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

2-5.1.3 Collectors shall be constructed of metal to allow dissipation of static electricity.

2-5.1.4 Ductwork shall comply with the provisions of 2-4.8.

2-5.1.5* The entire collection system, including the collector, shall be completely bonded and grounded to minimize accumulation of static electric charge.

2-5.1.6 Recycling of air from powder collectors into buildings shall be prohibited.

2-5.1.7* Where an explosion hazard exists, dry dust collectors shall be provided with deflagration vents. Extreme care shall be taken in the selection of the type and location of vents or weak sections of the collector to minimize injury to personnel and blast damage to nearby equipment or structures. Deflagration vents shall be positioned so that a potential blast shall not be directed towards any combustible or frangible structure.

2-5.1.8 Where repairs on dry dust collectors are necessary, the collectors shall be emptied and residual accumulations of dust thoroughly removed. *(See Section 5-2.)* Ductwork leading into the collector shall be disconnected and blanked off before repair work shall be permitted to be started.

2-5.2 High Temperature Warning.

2-5.2.1 Cyclone or other dry-type collectors shall be equipped with instruments for recording the surface temperature. An overheating alarm or warning device shall be included, and the limit setting shall be below the maximum service temperature of the filter medium or 90°F (32°C) below the ignition temperature of the powder cloud, whichever is lower.

2-5.2.2 All such instruments shall give audible and visual alarms at normally attended locations.

2-5.3* Collector Filter Medium. Collector filter medium made from synthetic fabrics that accumulate static electric charges shall not be used.

2-6 Storage of Aluminum Powder. When aluminum powder is stored in sealed containers, the following procedures shall apply.

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

(b) Containers shall be kept free of contact with water or moisture.

(c) Aluminum powder packed in sealed containers shall be permitted to be stored in commercial or public warehouses if they are of fire-resistive, noncombustible, or limited-combustible construction as defined in NFPA 220, *Standard on Types of Building Construction,* or other construction types protected with an automatic sprinkler system.

(d)* Aluminum powder shall be segregated from incompatible materials and combustible materials.

(e) When storing aluminum powder in sealed containers, storage shall be limited to one drum tiers per pallet with a height of no more than four pallet loads. Stacked storage shall be arranged to ensure stability. Aisles shall be provided for maneuverability of material handling equipment, for ready accessibility, and to facilitate incipient fire-fighting operations.

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

(g) Smoking and open flames shall be prohibited in areas where aluminum powder is stored.

Chapter 3 Aluminum Powder Handling and Use

3-1 Scope. The provisions of this chapter shall apply to operations including, but not limited to, the use of aluminum powder in the production of paste, flake powders, powdered metallurgy component manufacturing, fireworks, and pyrotechnics, propellants, plasma spray coating, chemical processing, and refractories.

3-2 Storage. Dry aluminum powder and aluminum paste shall be stored in accordance with the provisions of Section 2-6.

3-3* Handling. The requirements of this chapter shall apply to both regular and "nondusting" grades of aluminum powder, as well as aluminum paste.

3-3.1 Where aluminum powder or paste is used or handled, good housekeeping practices shall be maintained.

3-3.2 Aluminum powder and paste shall be handled so as to avoid spillage and the creation of airborne dust.

3-3.3 Scoops, shovels, and scrapers used in the handling of aluminum powder and paste shall be electrically conductive and shall be grounded when necessary. Hand tools shall be made of spark-resistant materials.

3-3.4 Powered industrial trucks shall be selected in accordance with NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation.*

3-4 Machinery and Operations.

3-4.1* Wet Milling of Aluminum Powder.

3-4.1.1 This section shall not apply to machining and rolling operations.

3-4.1.2* Where aluminum is added to a mill in the presence of a liquid that is chemically inert with respect to the metal, the milling shall be done in air in a vented mill or in an inerting atmosphere containing sufficient oxygen to oxidize any newly exposed surfaces as they are formed.

3-4.1.3* Where aluminum is slurried in tanks or processed in blenders or other similar equipment in the presence of a liquid that is chemically inert with respect to the metal, the operation shall be carried out in air or in an inerting atmosphere containing sufficient oxygen to oxidize any newly exposed surfaces as they are formed.

3-4.1.4 The dew point of the atmospheres in 3-4.1.2 and 3-4.1.3 shall be maintained below the point where condensation occurs.

3-4.1.5 Bearings of wet mills shall be grounded across the lubricating film by use of current collector brushes, a conductive lubricant, or other applicable means.

3-4.1.6* Ventilation in accordance with NFPA 30, *Flammable and Combustible Liquids Code,* shall be maintained in areas where flammable or combustible solvents are handled, particularly in areas where combustible aluminum dusts or powders are present.

3-4.1.7 Solvent or slurry pumps shall be installed with controls that ensure that a flow exists and that ensure the pumps run with safe operating temperatures.

3-4.2 Electrical Equipment.

3-4.2.1 All electrical wiring and equipment shall conform to the provisions of NFPA 70, *National Electrical Code.*

3-4.2.2* All components of collector systems shall be electrically bonded and grounded in an acceptable manner. When continuous contact is interrupted, metallic jumpers shall be installed for effective bonding.

3-4.2.3* Wet solvent milling areas shall be classified where applicable, in accordance with Article 500 of NFPA 70.

Exception No. 1: Offices and similar areas so occupied and segregated as to be reasonably free from solvent vapors.

Exception No. 2: Control equipment meeting the requirements of NFPA 496, Standard for Purged and Pressurized Enclosures for Electrical Equipment.

3-4.3 Plasma Spray Operations.

3-4.3.1 For plasma spray operations, media collectors, if used, shall be located at a distance from the point of collection to eliminate the possibility of hot metal particles igniting the filter medium in the collector.

3-4.3.2 Metal overspray temperatures at the dust collector shall be compatible with the limiting temperature of the filter medium element.

3-5* Transfer Operations. Operations involving the transfer of combustible aluminum dusts or powders from one container to another shall be designed and operated to protect personnel, equipment, or buildings from the fire or dust explosion hazard produced by airborne suspensions of combustible aluminum dusts or powders.

3-6 Prevention of Fugitive Dust Accumulations. See Chapter 5.

Chapter 4 Processing and Finishing Operations

4-1* Scope. This chapter shall apply to operations where aluminum or aluminum alloys are subjected to processing or finishing operations. Such operations include, but are not limited to, grinding, buffing, polishing, sawing, and machining of solids.

4-2 Dust-Producing Operations.

4-2.1* Machines that produce fine particles of aluminum shall be provided with hoods, capture devices, or enclosures that are connected to a dust collection system having suction and capture velocity to collect and transport all the dust produced. Hoods and enclosures shall be designed and maintained so that the fine particles will either fall or be projected into the hoods and enclosures in the direction of airflow. Dust shall be collected by means of suitable hoods or enclosures at each operation.

4-2.2* Special attention shall be given to the location of all dust-producing machines with respect to the location of the dust collection system to ensure that the connecting ducts will be as straight and as short as possible.

4-2.3 Grinding operations shall not be served by the same dust collection system as buffing and polishing operations.

4-2.4* Dry-type dust collectors shall be located outside of buildings.

Exception: * *Individual machines with portable dust collection capability shall be permitted to be used indoors when the object being processed or finished is incapable of being moved to a properly arranged fixed hood or enclosure.*

The following safeguards shall be incorporated:

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

(b) Personnel protective clothing shall comply with Section 7-2.

(c) The collector shall be designed to dissipate static electricity.

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

4-2.4.1* Dry-type collectors shall be provided with barriers or other means for protection of personnel.

4-2.4.2* The area around the collector shall be posted with a sign as follows:

CAUTION

This dust collector can contain explosible dust.

4-2.5* Dust collection systems shall be dedicated to collection of aluminum or aluminum alloy dust only. Grinders, buffers, and associated equipment with dust collectors utilized for processing aluminum shall be provided with a placard as follows:

WARNING

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

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

4-3 Dust Collection Ducts and Ductwork.

4-3.1 All dust collection systems shall be installed in accordance with NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials.*

4-3.2 Ducts shall be designed to maintain a velocity of not less than 4500 ft/min (1364 m/min) to ensure the transport of both coarse and fine particles and to ensure re-entrainment if, for any reason, the particles can fall out before delivery to the collector (e.g., in the event of a power failure).

4-3.3* Ducts shall be designed to handle a volumetric flow rate that maintains dust loading safely below the minimum explosible concentration (MEC).

4-3.4* Ducts shall be as short as possible and shall have as few bends and irregularities as possible to prevent interference with free airflow.

4-3.5 Duct Construction.

4-3.5.1 Ducts shall be constructed of conductive material and shall be carefully fabricated and assembled with smooth interior surfaces and with internal lap joints facing the direction of airflow.

4-3.5.2 There shall be no unused capped outlets, pockets, or other dead-end spaces that might allow accumulations of dust.

4-3.5.3 Duct seams shall be oriented in a direction away from personnel.

4-3.5.4 Additional branch ducts shall not be added to an existing system without redesign of the system. Branch ducts shall not be disconnected nor unused portions of the system be blanked off without providing means to maintain required airflow.

4-3.6* Duct systems, dust collectors, and dust-producing machinery shall be bonded and grounded to minimize accumulation of static electric charge.

4-4 Wet-Type Dust Collectors.

4-4.1* The exhaust vent shall terminate outside the building and be securely fastened. The duct shall be as short and straight as possible and shall be designed to withstand the same explosion pressure as the wet-type dust collector.

Exception: The cleaned air shall be permitted to be returned to the work area where tests conducted by an approved testing organization prove the collector's efficiency is great enough to provide both personnel and property safety in the particular installation, with regard to particulate matter in the cleaned air and accumulations of particulate matter and hydrogen in the work area. (See 5-2.1.)

4-4.2* The exhaust vent shall be inspected and cleaned frequently to prevent buildup of highly combustible deposits of metal dusts on the interior surfaces of the duct.

4-4.3 The dust collector shall be arranged so that contact between dust particles and parts moving at high speed is prevented. The blower for drawing the dust-laden air into the collector shall be located on the clean air side of the collector.

4-4.4* The dust collector shall be arranged so that the dust-laden air stream shall be thoroughly scrubbed by the liquid to achieve the desired efficiency. *[See Figures A-4-4.4(a) through A-4-4.4(c).]* The use of additional dry filter medium either downstream or combined with a wet collector shall not be permitted.

4-4.5* Sludge shall be removed from the collector on a regular schedule to ensure proper and safe operation of the equipment. Sludge shall be disposed of in accordance with the requirements of Section 4-4.8.

4-4.6 Collector Sump Venting.

4-4.6.1* The sump of water wet-type dust collectors shall be ventilated at all times.

4-4.6.2 Vents shall remain open and unobstructed when the machine is shut down.

4-4.6.3 When the dust collector is not in operation, ventilation shall be permitted to be provided by an independent blower or by an unimpeded vent.

4-4.7 The power supply to the dust-producing equipment shall be interlocked with the airflow from the exhaust blower and the liquid level controller of the separator so that improper functioning of the dust collection system will shut down the equipment it serves. A time delay switch or equivalent device shall be provided on the dust-producing equipment to prevent starting of its motor drive until the separator is in complete operation.

4-4.8 Disposal of Sludge from Water Wet-Type Dust Collectors.

4-4.8.1 Sludge from water wet-type dust collectors shall be removed at least once each day or more frequently if conditions warrant.

4-4.8.2 Covered, vented metal containers, preferably holding not more than 50 lb (23 kg) each, shall be used to transport the collected sludge for disposal.

4-4.8.3 Sludge shall be permitted to be mixed with inert materials in a ratio of at least 5 parts inert material to 1 part sludge and then shall be recycled or discarded in accordance with local, state, and federal requirements.

4-4.8.4 Smoking or open flames shall be prohibited in the disposal area and throughout the disposal process.

4-5 Dry-Type Dust Collectors.

4-5.1 Electrostatic collectors shall not be used.

4-5.2* Dust-collecting filter medium shall be designed to be conductive so as to dissipate static electric charges.

4-5.3 Dry dust collection systems shall be designed and maintained so that internal cleanliness is ensured. The accumulation of material inside any area of the collector other than in the discharge containers designed for that purpose shall not be permitted.

4-5.4 Accumulation or condensation of water at any point in the dry dust collection system shall be prevented.

4-5.5 Dust shall be removed from dry collectors at least once each day and at more frequent intervals if conditions warrant. Extreme care shall be taken in removing dust from the collectors to avoid creating dust clouds. The material shall be discharged into metal containers that shall be promptly and tightly covered to avoid the creation of airborne fugitive dust. Waste material shall be mixed with an inert material in a volume ratio of 5 parts inert material to 1 part metal dust and shall be recycled or disposed of in accordance with local, state, and federal regulations.

4-5.6* Dry collectors used for combustible aluminum dust shall be provided with deflagration vents. 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.

4-5.7 Where repairs on dry dust collectors are necessary, the collectors shall be emptied and residual accumulations of dust thoroughly removed. *(See Section 5-2.)* Ductwork leading into the collector shall be disconnected and blanked off before repair work shall be permitted to be started.

4-5.8 The interior of hoods and ducts shall be regularly cleaned wherever there is the possibility of buildup of wax, lint, aluminum fines, or other combustible material.

4-5.9 The dust collector shall be arranged so that contact between dust particles and parts moving at high speeds shall be prevented. The blower for drawing the dust-laden air into the collector shall be located on the clean air side of the collector.

4-6 Recycling of Exhaust Air. Recycling of air from dry dust collectors into buildings shall be prohibited.

4-7 Machining and Sawing Operations.

4-7.1* Cutting tools shall be of proper design and shall be kept sharp for satisfactory work with aluminum.

4-7.2* Sawing, grinding, and cutting equipment shall be grounded.

4-7.3 All aluminum chips, oily crushed lathe turnings, raw turnings, and swarf shall be collected in closed-top containers and removed daily, at a minimum, to a safe storage or disposal area.

4-7.4 Nonflammable coolants shall be used for wet grinding, cutting, or sawing operations. The coolant shall be filtered on a continuous basis, and the collected solids shall not be permitted to accumulate in quantities greater than 5 gal (19 L) and shall be removed to a safe storage or disposal area.

4-8 Electrical Equipment.

4-8.1 All electrical wiring and equipment shall conform to the provisions of NFPA 70, *National Electrical Code*.

4-8.2* All components of the dust collection systems shall be electrically bonded and grounded in an acceptable manner. When continuous contact is interrupted, metallic jumpers shall be installed for effective bonding.

Chapter 5 Housekeeping

5-1 Scope. This chapter shall apply to new and existing facilities where combustible aluminum dusts, pastes, and powders are present.

5-2 Cleanup Procedures for Fugitive Dust Accumulations.

5-2.1* Fugitive dust shall not be permitted to accumulate.

5-2.2 Periodic cleanup of fugitive dusts shall be accomplished by using conductive, nonsparking scoops and soft brooms, brushes that have natural fiber bristles, or vacuum-cleaning systems designed for handling combustible metal powders in accordance with Section 5-3.

5-2.3 Cleanup of Spilled Aluminum Powder.

5-2.3.1 Preliminary cleanup of the bulk of the powder shall be accomplished by using conductive, nonsparking scoops and soft brooms, as well as brushes that have natural fiber bristles.

5-2.3.2 Vacuum cleaners shall be permitted to be used only for small amounts of residual material remaining after preliminary cleanup.

5-3* Vacuum-Cleaning Systems.

5-3.1 Vacuum-cleaning systems shall only be used for removal of dust accumulations too small, too dispersed, or inaccessible to be thoroughly removed by hand brushing.

5-3.2* Vacuum-cleaning systems shall be effectively bonded and grounded to minimize accumulation of static electric charge.

5-3.3 Due to the inherent hazards associated with the use of fixed and portable vacuum-cleaning systems for finely divided combustible aluminum dust, special engineering considerations shall be given to the design, installation, maintenance, and use of such systems.

5-3.4* Portable vacuum cleaners shall only be used if listed or approved for use with combustible aluminum dust.

5-3.5 Vacuum cleaner hose shall be conductive, and nozzles or fittings shall be made of conductive, nonsparking material. Assembled components shall be conductive and bonded where necessary. Periodic tests for continuity shall be performed.

5-3.6 Combustible aluminum dust picked up by a fixed vacuum-cleaning system shall be discharged into a container or collector located outside the building.

5-4 Compressed Air Cleaning Requirements. Compressed air blowdown shall not be permitted.

Exception: In certain areas, impossible to clean otherwise, compressed air blowdown shall be done under carefully controlled conditions with all potential ignition sources prohibited in or near the area and with all equipment shut down.

5-5 Water Cleaning Requirements. The use of water for cleaning shall not be allowed in manufacturing areas unless the following requirements are met:

(a) Competent technical personnel have determined that the use of water will be the safest method of cleaning in the shortest exposure time.

(b) Operating management has full knowledge of and has granted approval of its use.

(c) Ventilation, either natural or forced, is available to maintain the hydrogen concentration safely below the lower flammable limit (LFL).

(d) Complete drainage of all water and powder to a safe, remote area is available.

5-6 Cleaning Frequency.

5-6.1 The accumulation of excessive dust on any portions of buildings or machinery not regularly cleaned in daily operations shall be minimized.

5-6.2 Regular periodic cleaning of buildings and machinery, with all machinery idle and power off, shall be carried out as frequently as conditions warrant.

Chapter 6 Fire Prevention, Protection, and Procedures

6-1* Scope. This section shall apply to new and existing facilities where combustible aluminum dusts, pastes, and powders are present.

6-2 Extinguishing Agents and Application Techniques for Use on Combustible Aluminum Dusts.

6-2.1* An incipient fire shall be ringed with a dam of dry sand, dry inert granular material, or a listed Class D extinguishing powder in accordance with the manufacturer's instructions. Application of dry extinguishing agent shall be conducted in such a manner so as to avoid any disturbance of the combustible aluminum dust, which could cause a dust cloud.

6-2.2 The dry extinguishing agent shall be stored in such a manner that it remains clean and dry.

6-2.3* The dry extinguishing agent shall be carefully applied with a nonsparking metal scoop or shovel or applied from a listed Class D fire extinguisher equipped with a low-velocity nozzle.

6-2.4 Drafts shall be eliminated by shutting off fans and machinery and by closing doors and windows.

6-2.5 Portable or wheeled fire extinguishers shall be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*. Areas where dry combustible aluminum dust is present shall not have fire extinguishers rated for Class A, B, or C fires.

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

6-2.6* Extinguishers listed for use on Class B fires shall be provided in areas where solvent cleaning and washing is performed. Conspicuous signs shall be placed adjacent to such extinguishers stating that these extinguishers shall not be used for combustible aluminum dust fires.

Exception: Halogenated extinguishing agents shall not be used.

6-3* Solvent-Wetted Powders.

6-3.1 An incipient fire occurring while the aluminum powder is in slurry form shall be permitted to be fought using listed Class B extinguishing agents.

Exception: Halogenated extinguishing agents shall not be used.

6-3.2* An incipient fire occurring in semi-wet material or filter-cake shall be fought using a listed Class B extinguishing agent.

6-3.3* Where carbon dioxide is used to extinguish fires involving solvent-wetted aluminum, the residual material shall be immediately covered with dry sand, dry inert granular material, or with other listed Class D extinguishing agent, and the entire mass shall be allowed to cool until it reaches ambient temperature. 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. It shall be handled in small quantities in covered containers, preferably not more than 3 gal (11 L) each in 5-gal (19-L) containers.

6-3.4 Manual water application shall only be used on a solvent–metal powder fire as a last resort, when other methods of control have failed and the fire shows evidence of going out of control. Only low-velocity spray or fog nozzles shall be used. Manual application of water shall be conducted in such a manner so as to avoid creating a dust cloud. Once water is used, its use shall be continued until the fire is extinguished or until the area becomes untenable.

6-3.4.1 After extinguishment, the area shall be immediately cleaned of all wetted powder, paste, or slurry.

6-3.4.2 Ventilation shall be provided during cleanup to avoid concentrations of hydrogen from the exothermic reaction of the aluminum with water.

6-3.4.3* Fire flow containment shall be provided for new facilities.

6-4 Automatic Sprinkler Protection.

6-4.1 Automatic sprinkler protection shall not be permitted in areas where dry aluminum powders are produced or handled.

*Exception:** *Where both dry aluminum and other combustibles (e.g., solvents) are present, automatic sprinkler protection shall be permitted if a hazard analysis acceptable to the authority having jurisdiction indicates that automatic sprinkler systems could reduce the risk to life and damage to property. The hazard analysis shall consider the possibility of fires and explosions involving both dry aluminum and the other combustibles.*

6-4.2 The special hazards associated with aluminum powder in contact with water shall be considered in the selection, design, and installation of automatic sprinkler systems.

6-4.3 Automatic sprinkler systems shall be designed and installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems,* and where applicable NFPA 231C, *Standard for Rack Storage of Materials.*

6-4.4 Employee training and organizational planning shall be provided to ensure safe evacuation of the sprinkler protected area in case of fire.

6-5 Fire-Fighting Organization.

6-5.1 Only trained personnel shall be permitted to engage in fire control activity. All others shall be evacuated from the area. Training shall emphasize the different types of fires anticipated and the appropriate agents and techniques to be used.

6-5.2 Fire-fighting personnel shall be given regular and consistent training in the extinguishment of test fires set in a safe location away from manufacturing buildings. Training shall include all possible contingencies.

6-5.3* If professional or volunteer fire fighters are admitted onto the property in the event of a fire emergency, their activity shall be directed by the on-site ranking officer of the trained plant fire fighters.

6-6* Employee Training Program. Training programs shall be instituted to properly inform employees about the hazards involved in the manufacture of aluminum powder, paste, or granules, and the hazards involved in processing or finishing operations that generate fine combustible aluminum dust, as appropriate to the operation.

6-7 Control of Ignition Sources.

6-7.1* No smoking, open flames, electric or gas cutting or welding equipment, or spark-producing operations shall be permitted in the section of the building where combustible aluminum dust is produced or handled. This type of work shall be allowed only in the areas where all machinery is shut down, and the area is thoroughly cleaned and inspected to ensure the removal of all accumulations of combustible aluminum dust. Lockout/tagout procedures shall be followed for the shutdown of machinery. Hotwork operations in facilities covered by this standard shall comply with the requirements of NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes.*

6-7.2 Smoking materials, matches, and lighters shall not be carried or used by employees or visitors about the premises adjacent to or within any building in which combustible aluminum dust is present.

6-7.3 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.

6-7.4* Nonsparking tools shall be used when making repairs or adjustments on or around any machinery or apparatus where combustible aluminum dust is present.

6-7.5 Dressing of grinding wheels shall not be conducted when the airflow across the grinding wheel is entering a combustible aluminum dust collection system.

6-7.6 Spark-producing operations shall be separated from any cleaning equipment using flammable or combustible solvents and shall comply with NFPA 30, *Flammable and Combustible Liquids Code.*

6-7.7 Brooms and brushes used for cleaning shall have natural fiber bristles. Synthetic bristles shall not be used. Scoops, dustpans, and so forth used for collecting sweepings shall be made of nonsparking, conductive material.

6-7.8 Dry aluminum sweepings shall not be returned to the main process stream for processing.

6-8 Compressed Air Fittings. To prevent potential explosions caused by inadvertently using compressed air in place of inert gas, fittings used on compressed air and inert gasline outlets shall not be interchangeable.

Chapter 7 Safety Procedures

7-1 Scope. This section shall apply to new and existing facilities where combustible aluminum dusts, pastes, and powders are present.

7-2 Personal Protective Equipment.

7-2.1 Outer clothing shall be clean, flame retardant, and nonstatic–generating where combustible aluminum dust is present and shall be designed to be easily removable. Tightly woven, smooth fabrics treated with a flame-retardant chemical, and from which dust can readily be brushed, shall be used, if necessary. Woolen, silk, or synthetic fabrics that can accumulate high static electric charges shall not be used.

7-2.2 Work clothing shall be designed to minimize the accumulations of combustible aluminum dust (e.g., trousers shall not have cuffs).

7-2.3* Safety shoes shall be static dissipating, where necessary, shall have no exposed metal, and shall be appropriate for the type of operation taking place.

7-2.4* Emergency procedures for handling clothing fires shall be established. If deluge showers are installed, they shall be located away from dry aluminum powder processing and handling areas.

7-3* Emergency Procedures. Emergency procedures to be followed in case of fire or explosion shall be established. All employees shall be trained in these procedures.

7-4 Safety Inspection. A thorough inspection of the operating area shall take place on an as needed basis to help ensure that the equipment is in good condition and that proper work practices are being followed. This inspection shall be conducted at least quarterly but shall be permitted to be done more often. The inspection shall be conducted by a person(s) knowledgeable in the proper practices, who shall record the findings and recommendations.

7-5 Maintenance. Regular and periodic maintenance checks and calibration on equipment critical to employee safety and plant operation shall be performed.

Chapter 8 Referenced Publications

8-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix C.

8-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers,* 1998 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 1996 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 1996 edition.

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

NFPA 69, *Standard on Explosion Prevention Systems,* 1997 edition.

NFPA 70, *National Electrical Code®,* 1999 edition.

NFPA 80, *Standard for Fire Doors and Fire Windows,* 1995 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials,* 1995 edition.

NFPA *101®, Life Safety Code®,* 1997 edition.

NFPA 220, *Standard on Types of Building Construction,* 1995 edition.

NFPA 231C, *Standard for Rack Storage of Materials,* 1998 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment,* 1998 edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation,* 1996 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems,* 1997 edition.

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

A-1-1.1 Certain "nondusting" grades of aluminum flake powder are being produced. Although they exhibit less tendency to be dispersed into a dust cloud, the same precautions described in this standard should be observed.

A-1-5 Aluminum Chips. Aluminum chips vary in ease of ignition and rapidity of burning, depending on their size and geometry. A light, fluffy chip can ignite easily and burn vigorously, whereas a heavy, compact chip ignites with difficulty and burns quite slowly.

A-1-5 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-5 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-1-5 Combustible Aluminum Dust. Any time a combustible dust is processed or handled, a potential for explosion exists. The degree of explosion hazard will vary depending on the type of combustible dust and processing methods used.

A dust explosion has four requirements:

(a) The dust is combustible. One method of determining combustibility of dusts is testing in accordance with ASTM E 1226, *Standard Test Method for Pressure and Rate of Pressure Rise for Combustible Dusts.*

(b) The dust particles form a cloud at or exceeding the minimum explosible concentration (MEC).

(c) A source of ignition is present.

(d) Oxygen is present in sufficient quantities to support combustion.

Evaluation of a combustible dust explosion hazard and the prevention techniques employed should be determined by means of actual test data. All combustible dusts that can produce a dust explosion should be tested so as to determine the following data:

(a) Particle size distribution
(b) Moisture content as received and dried
(c) Minimum dust concentration to ignite
(d) Minimum energy required for ignition (joules)
(e) Maximum rate of pressure rise at various concentrations
(f) Layer ignition temperature
(g) Maximum explosion pressure at optimum concentration

The following data can be determined by optional testing:

(a) Dust cloud ignition temperature
(b) Maximum permissible oxygen content to prevent ignition
(c) Electrical resistivity measurement

Samples to be submitted for testing should not be allowed to oxidize significantly more than their degree of oxidation would be where the hazard exists. This usually involves taking samples as soon as possible after the aluminum dust is produced, and then storing and shipping the samples in an airtight container purged with an inert gas.

A-1-5 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-2-2.6 For information on deflagration venting, see NFPA 68, *Guide for Venting of Deflagrations*.

A-2-2.8.1 For information on deflagration venting, see NFPA 68, *Guide for Venting of Deflagrations*.

A-2-2.9.1 For information on static electricity, see NFPA 77, *Recommended Practice on Static Electricity*.

A-2-2.10.1.1 For additional information on classification of dusty locations, see NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

A-2-3.1.4 Temperature-sensing elements connected to alarms or machine stop switches should be employed for locations where overheating of bearings or other elements could be anticipated.

A-2-3.2.3 This requirement shall be applicable to stamp mortars, mills, fans, and conveyors in all areas where dust is produced or handled, such as in finishing and polishing equipment, filters, driers, dust screens, fixed storage bins, and dust collection and transport systems of all types. For further information on bonding and grounding, see NFPA 77, *Recommended Practice on Static Electricity*.

A-2-3.2.4.1 Journal bearings should not be used because of the difficulty of maintaining proper lubrication to prevent overheating. Outboard bearings are used where practicable because it is easier to check for overheating. In those instances where dust tends to penetrate bearings, a continuous flow of inert gas ($1^1/_2$ percent to 5 percent oxygen) can be employed to pressurize the bearings and seals.

A-2-4.8.2 For information on static electricity, see NFPA 77, *Recommended Practice on Static Electricity*.

A-2-4.8.3 Any moisture entering the system can react with the aluminum powder, generating heat and hydrogen. Hydrogen is extremely flammable and very easy to ignite. It should not be trapped in nonventilated areas of buildings, equipment, or enclosures.

A-2-4.8.5 Typical margins of safety used for pneumatic dust handling are 25 percent to 50 percent of the MEC. Published data indicates an MEC of 45 g/m^3 (0.045 oz/ft^3) for atomized aluminum powder. MEC data for aluminum with varying particle size distributions can be found in U.S. Bureau of Mines, RI 6516, "Explosibility of Metal Powders." Although the aluminum powder–air suspension can be held below 25 percent to 50 percent of the MEC in the conveying system, the suspension will necessarily pass through the explosible range in the collector at the end of the system unless the dust is collected in liquid, such as in a spray tower. Also, the powder in the conveying line from the atomizer to the collector will, of necessity, approach the MEC.

A-2-4.8.6 For information on spacing and sizing of ductwork deflagration vents, see NFPA 68, *Guide for Venting of Deflagrations*.

A-2-4.9.1 Aluminum and aluminum alloy powders are produced by various means. These processes, as well as certain finishing and transporting operations, tend to expose a continuously increasing area of new metal surface. Most metals immediately undergo a surface reaction with available atmospheric oxygen that forms a protective coating of metal oxide that serves as an impervious layer to inhibit further oxidation. This reaction is exothermic. If a fine or thin lightweight particle having a large surface area of "new" metal is suddenly exposed to the atmosphere, sufficient heat will be generated to raise its temperature to the ignition point.

Completely inert gas generally cannot be used as an inerting medium since the aluminum powder would eventually, at some point in the process, be exposed to the atmosphere, at which time the unreacted surfaces would be oxidized; enough heat would be produced to initiate either a fire or an explosion. To provide maximum safety, a means for the controlled oxidation of newly exposed surfaces is provided by regulating the oxygen concentration in the inert gas. The mixture serves to control the rate of oxidation, while materially reducing the fire and explosion hazard.

A completely inert gas can be used if the powder so produced will not be exposed to air.

A-2-4.9.2 Oxygen limits of 3 percent to 5 percent have been maintained in aluminum powder systems using a controlled flue gas. Other limits are applicable where other inert gases are used. Refer to U.S. Bureau of Mines, RI 3722, "Inflammability and Explosibility of Metal Powders."

A-2-4.9.2 Exception. A completely inert gas can be used if the powder so produced will not be exposed to air. Aluminum powder produced without oxygen is more highly reactive than aluminum powder produced by conventional means.

A-2-4.10.1 Information on spark-resistant fans and blowers can be found in Air Movement and Control Association (AMCA) Standard No. 99-0401-91.

A-2-4.10.4 Ultimately, all fans or blowers in dust collection systems accumulate sufficient powder to become a potential explosion hazard.

A-2-4.10.5 Fans or blowers can also be provided with vibration-indicating devices, arranged to sound an alarm or to provide shutdown, or both, in the event of blade or rotor imbalance, or bearing or drive problems.

A-2-5.1 A high-efficiency cyclone-type collector presents less hazard than a bag- or media-type collector and, except for extremely fine powders, will usually operate with fairly high collection efficiency. Where cyclones are used, the exhaust fan discharges to atmosphere away from other operations. It should be recognized that there will be some instances in which a cyclone collector can be followed by a fabric- or bag-type, or media-type collector or by a scrubber-type collector where particulate emissions are kept at a low level. The hazards of each type of collector should be recognized and protected against. In each instance, the fan will be the last element downstream in the system. Because of the extreme hazard involved with a bag- or media-type collector, consideration should be given to a multiple-series cyclone with a liquid final stage.

Industry experience has clearly demonstrated that an eventual explosion can be expected where a bag- or media-type collector is used to collect aluminum fines. Seldom, if ever, can the source of ignition be positively identified. In those unusual instances when it becomes necessary to collect very small fines for a specific commercial product, it is customary for the producer to employ a bag- or media-type collector. With the knowledge that strong explosive potential is present, the producer will locate the bag- or media-type collector a safe distance from buildings and personnel.

If a bag- or media-type collector is used, the shaking system or dust removal system can be such as to minimize sparking due to frictional contact or impact. Pneumatic- or pulse-type cleaning is more desirable because no mechanical moving parts are involved in the dusty atmosphere. If the bags are provided with grounding wires, they can be positively grounded through a low-resistance path to ground. Where bags are used, it is customary that the baghouse be protected by an alarm to indicate excessive pressure drop across the bags. An excess air temperature alarm is also frequently employed. A bag- or media-type collector is customarily located at least 50 ft (15 m) from any other building or operation. It is not customary to permit personnel to be within 50 ft (15 m) of the collector during operation or when shaking bags. Explosion vents are usually built into the system, as described in NFPA 68, *Guide for Venting of Deflagrations*. Care is customarily exercised in locating the vents because of the possibility of blast damage to personnel or adjacent structures.

A-2-5.1.2 For the method to calculate the length of a fireball issuing from a vented collector, see NFPA 68, *Guide for Venting of Deflagrations*.

A-2-5.1.5 For information on precautions for static electricity, see NFPA 77, *Recommended Practice on Static Electricity*.

A-2-5.1.7 Explosion venting is especially important for combustible aluminum dust, due to the high maximum explosion pressures reached and the extremely high rate of pressure rise. For information on design of explosion vents and predicting the size of the fireball, see NFPA 68, *Guide for Venting of Deflagrations*. Dust collectors, when provided by a manufacturer, seldom have properly sized venting to handle a combustible aluminum dust explosion.

A-2-5.3 Some collector bags or other types of media or screens have fine, noninsulated wire enmeshed into or woven with the cloth or otherwise fastened to it. These are always securely grounded. It should be pointed out that this is not a positive guarantee of static charge removal because there is no dependable force to cause the charges to move across the nonconducting area of the fabric to the grounded wires. Often, a substantial potential difference can be measured. Also, it is possible that a wire in the cloth could break in such a way that it is no longer grounded. Such a wire serves as a capacitor and could store a static charge.

A-2-6(d) Materials incompatible with aluminum powder include, but are not limited to, oxidizers, organic peroxides, inorganic acids, and materials identified in the Material Safety Data Sheet (MSDS).

A-3-3 Certain nondusting grades of aluminum flake powder are being produced. These tend to reduce the hazard of inadvertently caused dust clouds. They are as combustible as regular grades of flake powder, and once levitated into a cloud, exhibit the same explosibility characteristics. For these reasons, the same precautions must be observed as for normal grades of powder.

A-3-4.1 When aluminum is milled in a ball, rod, or similar type of mill, in the presence of a liquid that is chemically inert with respect to the metal, the air–dust explosion hazard is eliminated. When the resulting product is subsequently exposed to air, any unoxidized surfaces produced during milling will react and could generate enough heat to cause ignition. To prevent this, it is imperative that a controlled amount of oxygen be present in the milling operation and in slurries ahead of filters and blenders, so that new surfaces are oxidized as they are formed. The addition of a milling agent, such as stearic acid, does not eliminate the need for this added oxygen.

A-3-4.1.2 See A-3-4.1.

A-3-4.1.3 See A-3-4.1.

A-3-4.1.6 Of particular note in the aluminum paste–manufacturing process are the risks associated with hybrid mixtures. A hybrid mixture is a mixture of a dust with one or more flammable gases or vapors. The presence of the flammable gas or vapor, even at concentrations less than their lower flammable limit (LFL), will not only add to the violence of the dust–air combustion but will drastically reduce the ignition energy. In such cases, electrical equipment should be specified that is suitable for simultaneous exposure to both the Class I (flammable gas) and the Class II (combustible dust) hazards.

A-3-4.2.2 For information on bonding and grounding, see NFPA 77, *Recommended Practice on Static Electricity*.

A-3-4.2.3 For additional information on classification of areas containing solvent vapors, see NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

A-3-5 See Figures A-3-5(a) and A-3-5(b) for examples of bag dump-station dust collection.

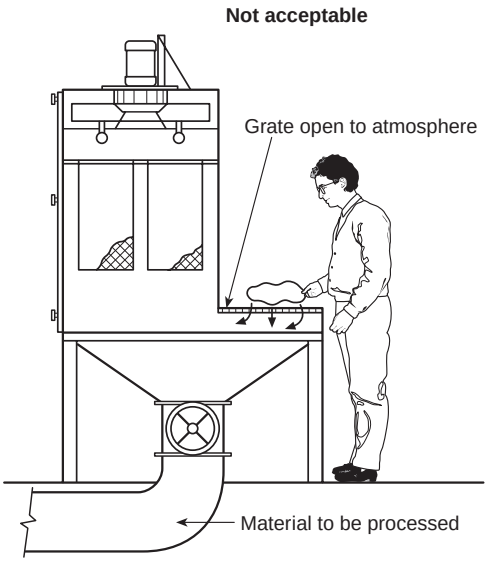

Figure A-3-5(a) Example of manual bag dump station. (Exposes operator to potential fire or explosion or both.)

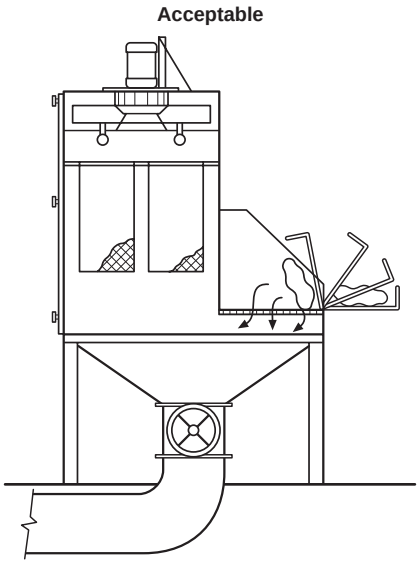

Figure A-3-5(b) Automated bag dump operation only.

A-4-1 There are two recognized methods of collecting aluminum dust in industrial operations. They are wet dust collectors, which can be located indoors near the point of dust generation, or dry-type collectors located outdoors, as close as possible to the point of dust generation.

A-4-2.1 The maximum concentration of less than 100-mesh magnesium dust should never exceed 0.03 oz/ft^3 (0.03 g/m^3) (air), which is the minimum explosible concentration.

Minimum explosible concentrations for magnesium dust in air are published in RI 6516, "Explosibility of Metal Powders." Although the metal dust–air suspension normally can be held below the minimum explosible concentration in the conveying system, the suspension can pass through the flammable range in the collector at the end of the system.

A-4-2.2 Often, individual wet-type dust collectors can be provided for each dust-producing machine so that ductwork connecting the hood or enclosure of the machine to the collector is as short as possible.

A-4-2.4 See Figure A-4-2.4.

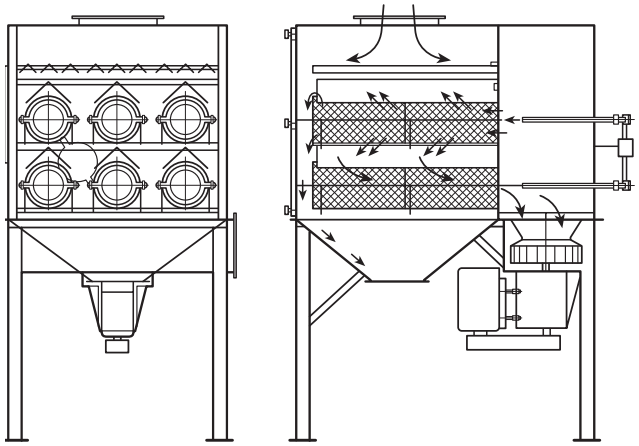

Figure A-4-2.4 Example of a fixed media-type dust collector.

A-4-2.4 Exception. See Figure A-4-2.4 Exception.

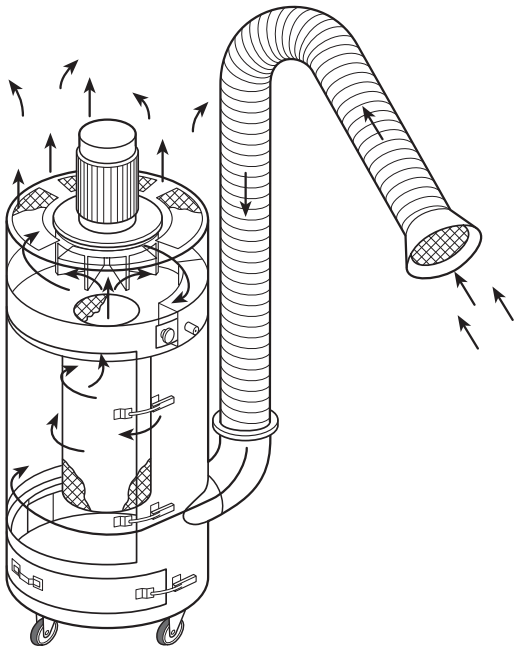

Figure A-4-2.4 Exception. Example of a portable media-type dust collector.

A-4-2.4.1 A high-efficiency cyclone-type collector presents less hazard than a bag- or media-type collector and, except for extremely fine powders, will usually operate with fairly high collection efficiency. Where cyclones are used, the exhaust fan discharges to atmosphere away from other operations. It should be recognized that there will be some instances in which a centrifugal-type collector can be followed by a fabric- or bag-type, or media-type collector or by a scrubber-type collector where particulate emissions are kept at a low level. The hazards of each collector should be recognized and protected against. In each instance, the fan will be the last element downstream in the system. Because of the extreme hazard involved with a bag- or media-type collector, consideration should be given to a multiple-series cyclone with a liquid final stage.

Industry experience has clearly demonstrated that an eventual explosion can be expected where a bag- or media-type collector is used to collect aluminum fines. Seldom, if ever, can the source of ignition be positively identified. In those unusual instances when it becomes necessary to collect very small fines for a specific commercial product, it is customary for the producer to employ a bag- or media-type collector. With the knowledge that strong explosive potential is present, the producer will locate the bag- or media-type collector a safe distance from buildings and personnel.

If a bag- or media-type collector is used, the shaking system or dust removal system can be such as to minimize sparking due to frictional contact or impact. Pneumatic- or pulse-type cleaning is more desirable because no mechanical moving parts are involved in the dusty atmosphere. If the bags are provided with grounding wires, they can be positively grounded through a low-resistance path to ground. Where bags are used, it is customary that the baghouse be protected by an alarm to indicate excessive pressure drop across the bags. An excess air temperature alarm is also frequently employed. A bag- or media-type collector is customarily located at least 50 ft (15 m) from any other building or operation. It is not customary to permit personnel to be within 50 ft (15 m) of the collector during operation or when shaking bags. Explosion vents are usually built into the system, as described in NFPA 68, *Guide for Venting of Deflagrations*. Care is customarily exercised in locating the vents because of the possibility of blast damage to personnel or adjacent structures.

A-4-2.4.2 For the method to calculate the length of a fireball issuing from a vented collector, see NFPA 68, *Guide for Venting of Deflagrations*.

A-4-2.5 Under certain circumstances, such as impact with rusted iron or steel, aluminum cannot safely be considered to be nonsparking, since a minor thermite reaction can be initiated. For details, refer to the article by H. S. Eisner, "Aluminum and the Gas Ignition Risk."

A-4-3.3 The U.S. Bureau of Mines Report of Investigations 6516, "Explosibility of Metal Powders," reports the results of tests conducted on 89 different samples of aluminum powders of various grades and sizes. Minimum ignition energies for dust clouds ranged upwards from 15 mJ, whereas minimum ignition energies for dust layers ranged upwards from 15 mJ. Ignition temperatures ranged upwards from 608°F (320°C). Minimum explosive concentrations ranged upwards from 0.040 oz/ft^3 (40 g/m^3). Maximum explosion pressures can exceed 90 psig (620 kPa gauge).

A-4-3.4 Short, straight ducts reduce the explosion hazard and minimize the likelihood of accumulations of dry dust. Also, accumulations of tallow, wax, or oil with metallic fines and lint can be seen readily and more easily removed.

A-4-3.6 For additional information, see NFPA 77, *Recommended Practice on Static Electricity*.

A-4-4.1 Hydrogen is extremely flammable and is very easy to ignite. It should not be trapped in nonventilated areas of buildings, equipment, or enclosures.

A-4-4.2 The humid air of the wet-type dust collector wets the fine particles that pass through the collector so that the particles agglomerate and tend to build up a cake or a spongelike deposit ("sludge"), which is highly combustible, on the inner wall of the exhaust duct.

A-4-4.4 Refer to Figures A-4-4.4(a) through A-4-4.4(c) for examples of liquid precipitation separators.

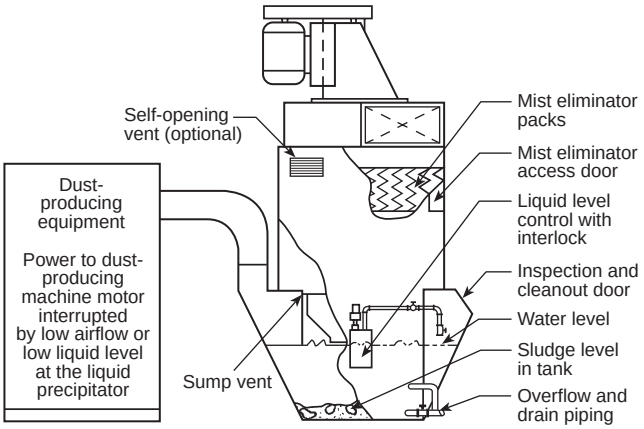

Figure A-4-4.4(a) Typical liquid precipitation separator for fixed dust-producing equipment.

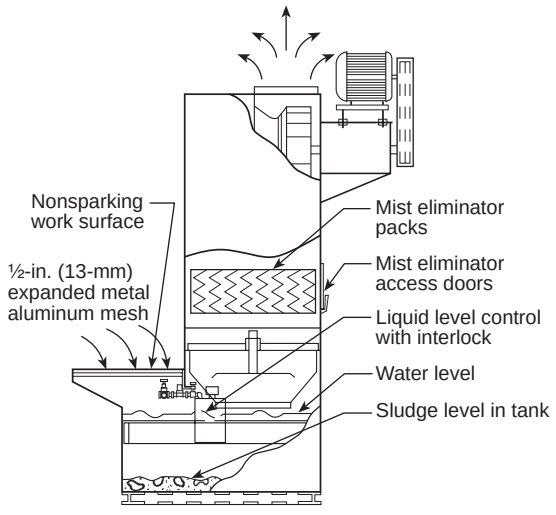

Figure A-4-4.4(b) Typical liquid precipitation separator for portable dust-producing equipment.

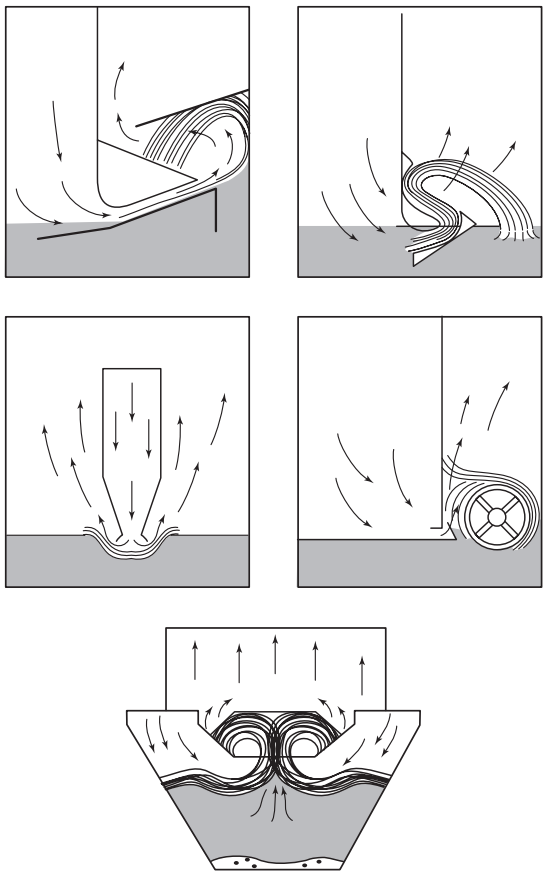

Figure A-4-4.4(c) Diagram of five methods of precipitating dust used in precipitators.

A-4-4.5 It should be remembered that wetted dust that is not submerged under a cover of water is highly flammable and very dangerous.

A-4-4.6.1 The reaction of aluminum with water produces hydrogen, which is highly flammable.

A-4-5.2 Some collector bags or other types of media or screens have fine, noninsulated wire enmeshed into or woven with the cloth or otherwise fastened to it. These are always securely grounded. It should be pointed out that this is not a positive guarantee of static charge removal because there is no dependable force to cause the charges to move across the nonconducting area of the fabric to the grounded wires. Often, a substantial potential difference can be measured. Also, it is possible that a wire in the cloth could break in such a way that it is no longer grounded. Such a wire serves as a capacitor and could store a static charge.

A-4-5.6 Explosion venting is especially important for combustible aluminum dust, due to the high maximum explosion pressures reached and the extremely high rate of pressure rise. For information on design of explosion vents and predicting the size of the fireball, see NFPA 68, *Guide for Venting of Deflagrations*. Dust collectors, when provided by a manufacturer, seldom have properly sized venting to handle a combustible aluminum dust explosion.

A-4-7.1 If a sufficient coolant flow is not used, improperly designed or dull tools can produce high temperatures at the tool/workpiece interface, potentially causing ignition of the turnings.

A-4-7.2 For information on bonding and grounding, see NFPA 77, *Recommended Practice on Static Electricity*.

A-4-8.2 For information on bonding and grounding, see NFPA 77, *Recommended Practice on Static Electricity*.

A-5-2.1 Once ignition has occurred either in a cloud suspension or a layer, an explosion is likely. Often the initial explosion is followed by another much more violent explosion, fueled by the dust from accumulations on structural beams and equipment surfaces that is thrown into suspension by the initial blast. For this reason, good housekeeping in all areas that handle dust is vitally important.

A-5-3 Permanently installed vacuum-cleaning systems provide the maximum safety because the dust-collecting device and the exhaust blower can be located in a safe location outside the dust-producing area. The dust collector should be located outside the building, preferably more than 50 ft (15 m) away. If the collector is located closer than 50 ft (15 m), it should be surrounded by a strong steel shield, cylindrical in shape and open at the top, or closed with a light, unfastened cover. The shield is closed at the bottom and designed to withstand a blast pressure of 200 psig (1380 kPa gauge). Such a protective barricade will direct an explosion upward and could protect both property and personnel. All suction lines should be provided with explosion vents and antiflashback valves.

A-5-3.2 For information on static electricity, see NFPA 77, *Recommended Practice on Static Electricity*.

A-5-3.4 Improper use of vacuum cleaners for aluminum powder accumulations can result in fire or explosion. For information on static electricity, see NFPA 77, *Recommended Practice on Static Electricity*.

A-6-1 Since it is almost impossible to extinguish a massive fire in dry aluminum powder, the fire problem resolves itself into the control of fires in the incipient stage. The requirements of Section 6-2 should be followed if the fire is to be controlled quickly. This is especially true with regard to the application of the extinguishing material, as even a minor dust cloud can explode violently.

A properly ringed fire will develop a hard crust of metal oxide that will ultimately exclude enough oxygen to cause self-extinguishment. It is customary practice, after dispensing the extinguishing material, to leave the area, closing all doors leading to the area and sealing them with sand. The area should not be re-entered until combustion has stopped and the material has cooled.

A-6-2.1 The use of fine, dry sand, preferably less than 20 mesh, or other approved powder is an effective method of isolating incipient fires in combustible aluminum dust. An ample supply of such material should be kept in covered bins or receptacles located in the operating areas where they can be reached at all times. A long-handled shovel of nonsparking metal should be provided at each such receptacle to afford a ready means of laying the material around the perimeter of the fire.

Nearly all vaporizing liquid fire extinguishing agents react violently with burning aluminum, usually serving to greatly intensify the fire and sometimes resulting in explosion *(see A-6-2.6)*.