Report of Committee on Dust Explosion Hazards

Correlating Committee

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Technical Committee on Metal Dusts

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Joseph B. Scheier, Silberline Manufacturing Co.
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Alternates

Harry W. Cooley, Aluminum Co. of America
(Alternate to R. W. Andrews, Jr.)
J. P. Gillis, Fenwal Inc.
(Alternate to Parker Peterson)

This list represents the membership at the time the Committee was balloted on the two-part Technical Committee Report. Since that time, changes in membership may have occurred.

Part I, prepared by the Technical Committee on Metal Dusts, proposes for adoption a complete revision of NFPA 65, Standard for the Processing and Finishing of Aluminum. NFPA 65 is published in Volume 5 of the 1979 National Fire Codes and in separate pamphlet form.

Part I has been submitted to letter ballot of the Technical Committee on Metal Dusts which consists of 8 voting members. Of these, 6 voted affirmatively, 1 abstained (Mr. Furnas), and 1 did not return a ballot (Mr. Tibbetts).

Part I has also been submitted to letter ballot of the Correlating Committee on Dust Explosion Hazards which consists of 7 voting members, all of whom voted affirmatively.

Part II, also prepared by the Technical Committee on Metal Dusts, proposes for adoption a complete revision of NFPA 651, Standard for the Manufacture of Aluminum and Magnesium Powder. NFPA 651 is published in Volume 5 of the 1979 National Fire Codes and in separate pamphlet form.

Part II has been submitted to letter ballot of the Technical Committee on Metal Dusts which consists of 8 voting members. Of these 6 voted affirmatively, 1 abstained (Mr. Furnas), and 1 did not return a ballot (Mr. Tibbetts).

Part II has also been submitted to letter ballot of the Correlating Committee on Dust Explosion Hazards which consists of 7 voting members, all of whom voted affirmatively.
Chapter 1 General

1-1 Scope.

1-1.1 This standard shall apply to industrial operations where aluminum or aluminum alloys are subjected to processing or finishing operations which produce fine metallic powder or dust. Such operations include, but are not limited to, grinding, buffing, and polishing.

1-1.2 This standard shall also apply to the handling and storage of aluminum powder by users of such material. This standard shall not, however, apply to the manufacture of such powder. (See Standard for the Manufacture of Aluminum and Magnesium Powders, NFPA 651.)

1-2 Purpose. The purpose of this standard is to minimize the occurrence of and resulting damage from fire and explosion in areas where aluminum dust is produced or handled.

1-3 Retrospectivity.

1-3.1 Unless otherwise stated, the requirements of this standard shall not be applied retrospectively.

1-3.2 Existing plants, equipment, structures, and installations which do not comply strictly with the requirements of this standard shall be considered to be in compliance if it can be shown that equivalent protection has been provided or that no specific hazard will be created or continued through noncompliance.

Chapter 2 Dust Collection

2-1 General.

2-1.1 Machines which produce fine particles of aluminum shall be provided with hoods or enclosures connected to a dust collection system having sufficient 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 them in the direction of airflow.

2-1.2* Special attention shall be given to the location of all dust-producing machines with respect to the location of the dustcollection system to ensure that the connecting ducts will be as straight and as short as possible.

2-1.3 Grinding operations shall not be served by the same duct collection system as buffing and polishing operations.

2-1.4 Grindings, polishing, or finishing operations shall not be located within 20 ft (6.1 m) of washing or cleaning facilities which employ combustible or flammable solvents.

2-1.5 Dry-type dust collectors shall be located outside of buildings.

2-1.6 All dust collection systems shall be installed in accordance with Standard for the Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying, NFPA 91.

2-2 Ducts and Ductwork.

2-2.1 Ducts shall be designed to handle a volumetric flow rate sufficient to maintain a dust loading safety below the lower explosive limit.

2-2.2* Ducts shall be designed to handle a volumetric flow rate sufficient to ensure re-entrainment if, for any reason, the particles should fall out before delivery to the collector (for example, in the event of power failure).

2-2.3* Ducts shall be as short and as straight as possible.

2-2.4 Ducts shall have as few bends and irregularities as possible so that free airflow is not interfered with.

2-2.5 Ducts shall be of substantial metal construction and shall be carefully fabricated and assembled with smooth interior surfaces and with internal lap joints facing the direction of airflow. There shall be no unused capped outlets, pockets, or other dead-end spaces which might allow accumulations of dust. Duct seams shall be oriented in a direction away from normal working personnel.

2-2.6 Duct systems, duct collectors, and dust-producing machinery shall be bonded and grounded to minimize accumulation of static electric charge (see Recommended Practice on Static Electricity, NFPA 77).

2-3 Wet-Type Dust Collectors.

2-3.1 Where tests prove that the collector's efficiency is great enough to provide both personnel and property safety, the cleaned air may be allowed to return to the work area. (See NFPA 68.)

2-3.2* If an exhaust vent is provided to the outside of the building, it shall be securely fastened, be as short and as straight as possible, and shall be designed to withstand internal explosion pressure of 100 psig (689 kPa).

Exception: Where explosion venting to outdoors, designed according to information in the Guide for Explosion Venting, NFPA 68, is provided, a lower design pressure may be used.

2-3.2.1* The exhaust vent shall be inspected and cleaned at least once per week to prevent buildup of highly combustible deposits of metal dusts on the interior surfaces of the duct.

2-3.3 The dust collector shall be arranged so that contact between dust particles and parts moving at high speeds is prevented. The blower for drawing the dust laden air into the collector shall be located on the clean air side of the collector.

2-3.4 The dust duct system shall be arranged so that the dust laden air stream will be thoroughly scrubbed by the liquid to achieve the desired efficiency.

2-3.5 Sludge shall be removed from the collector on a regular schedule to insure proper and safe operation of the equipment. Sludge shall be disposed of in accordance with the requirements of Section 2-5.

2-3.6* The sump of water wet-type dust collectors shall be ventilated at all times. When the dust collector is not in operation, this ventilation shall be provided by an independent blower or by an unimpeded gravity vent. Gravity vents shall be provided with means to automatically open when the dust collector is shut down.

2-4 Dry-Type Dust Collectors.

2-4.1 Fabric or filter media-type collectors or electrostatic collectors shall not be used.

2-4.2 Cyclone separators or improved cyclone separators or centrifugal separators shall preferably have exit velocities no greater than 500 ft/min (152.5 m/min).

2-4.3 Special care shall be taken to ensure the internal cleanliness of dry dust collection systems at all times and to avoid the accumulation of material except in the discharge hoppers of the dust collectors. Accumulation or condensation of water shall be prevented.

2-4.4 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 which shall be promptly and tightly covered to avoid the creation of airborne "fugitive dust." Waste material shall be mixed with an inert material, such as dry sand, in a ratio of 6 parts inert material to 1 part metal dust, and then deposited in a licensed landfill where it shall be immediately covered.

2-4.5* Dry dust collectors and other equipment where an explosion hazard exists shall be provided with explosion relief wherever practical. 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. Explosion vents shall be positioned so that a potential blast will not be directed towards any combustible or frangible structure. (For information on design of explosion vents, see the Guide for Explosion Venting, NFPA 68.)

2-4.6 When repairs on dry dust collectors are necessary, the collectors shall be emptied and residual accumulations of dust thoroughly removed (see Section 3-1). Duct work leading into the collector shall be disconnected and blanked off before repair work is started.

2-4.7 The interior of hoods and ducts shall be regularly cleaned wherever there is a possibility of buildup of wax or lint.

2-5 Disposal of Sludge from Water Wet Collectors.

2-5.1 Sludge from water wet-type dust collectors shall be removed at least once each day or more frequently if conditions warrant.

2-5.2 Covered, vented metal containers, preferably holding not more than 50 lbs (22.7 kg) each, shall be used to transport the collected sludge for disposal. (See A-2-3.5.)

2-5.3 Sludge shall be disposed of in one of the following methods:

2-5.3.1 Sludge may be mixed with sand in a ratio of 5 parts sand to 1 part sludge, and then shall be discarded in a protected dump.

2-5.3.2* Sludge may be dumped in an open pit. The pit shall be fenced or guarded from public access.

2-5.4* Smoking or open flames shall be prohibited in the disposal area and throughout the disposal process.

Chapter 3 Fire Safe Practices

3-1 Housekeeping.

3-1.1 Good housekeeping shall be practiced in the entire work area. Dust shall not be allowed to accumulate on floors, exposed building structural members, piping, conduit, or ductwork.

3-1.2 Cleaning shall be done with a soft brush or squeegee and pickup shall be done with nonsparking conductive scoops. Synthetic fiber bristle brushes and plastic or other nonconductive scoops shall not be used because of their tendency to accumulate static electric charges.

3-1.3 Only vacuum cleaners specifically approved for use with reactive combustible metal dusts shall be used to pick up small quantities of loose dust. Standard commercial industrial vacuum cleaners shall not be used, as they are not safe for use with combustible metals.

3-1.3.1 All spills shall first be cleaned by scooping and mild brushing.

3-1.4 The vacuum cleaner, its piping, suction hose, and tools shall be electrically conductive and shall be grounded to prevent static electric sparks. The vacuum cleaning tools shall be made of conductive nonsparking materials. (See Recommended Practice on Static Electricity, NFPA 77.)

3-2 Electrical Equipment.

3-2.1 All electrical equipment and wiring exposed to dust or dust-laden atmospheres shall be approved for use in Class II, Group E, Division 1 locations. Installation of such electrical equipment and wiring shall comply with the provisions of Article 502 of the National Electrical Code, NFPA 70.

Exception: Control equipment meeting the requirements of the Standard for Purged and Pressurized Electrical Equipment, NFPA 496, or of the Standard for Intrinsically Safe Apparatus for Use in Class I, II, and III, Division I Hazardous Locations, NFPA 493, need not comply with 3-2.1.

3-2.2 All electrical equipment and wiring not exposed to dust or dust-laden atmospheres shall be installed in accordance with applicable requirements of the National Electrical Code, NFPA 70.

3-2.3 All electrical equipment shall be inspected and cleaned at regular intervals.

3-2.4 Extension cords, lamps, and pendant lighting fixtures shall be of a type approved for the intended use.

3-2.5 All electrical equipment shall be adequately grounded by permanent ground wires to minimize accumulation of static electric charges. (See Recommended Practice on Static Electricity, NFPA 77.)

3-3 Solvent Cleaning.

3-3.1 Cleaning solvents shall not be recovered on the site unless approval is obtained from the authority having jurisdiction.

3-3.2 Operations which may produce sparks shall be separated from any cleaning equipment using flammable solvents.

3-4 Elimination of Ignition Sources.

3-4.1 No open flames shall be allowed in buildings where aluminum dust is produced. No smoking shall be allowed in such buildings.

3-4.2 Grinding wheels shall not be dressed while on a spindle protected by an aluminum dust collection system.

3-4.3 Powder actuated tools shall not be used in buildings where aluminum dust is created or handled.

Exception: If the use of powder actuated tools becomes absolutely necessary, the same precautions as outlined in 3-4.4 shall be taken.

3-4.4 Electric or gas welding or cutting or maintenance operations which could produce hot particles, such as drilling, sawing, or chipping, shall not be permitted in areas where an aluminum dust hazard exists unless the following precautions are taken:

3-4.4.1 All machinery in the area where such operations are to be performed shall be shut down.

3-4.4.2 All ductwork of dust collection systems shall be cleaned and the dust collectors shall be emptied and cleaned.

3-4.4.3 All accumulations of aluminum dust shall be thoroughly cleaned and removed from the area. The area shall also be free of all solvents and solvent vapors.

Chapter 4 Process Handling and Storage of Aluminum Powder and Paste

4-1 Scope. The requirements of this chapter shall apply to both regular and "nondusting" grades of aluminum powder.

4-2 Handling of Powder and Paste.

4-2.1 Where aluminum powder or paste is used or handled, good housekeeping practices shall be maintained.

4-2.2 Aluminum powder and paste shall be handled so as to avoid spillage and the creation of airborne dust.

4-2.3 Scoops, shovels, and scrapers used in the handling of aluminum powder and paste shall be electrically conductive and shall be grounded when necessary. Tools shall be made of nonsparking materials.

4-2.4 Vehicles used in areas where aluminum powder or paste is handled shall have nonsparking wheels.

4-3 Storage of Powder and Paste.

4-3.1 When aluminum powder or paste is stored in sealed containers of a type approved by the U.S. Department of Transportation (DOT), the practices listed below shall be followed.

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

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

(c) Aluminum powder or paste packed in sealed containers of a type approved by DOT shall be shipped in accordance with applicable regulations of the U.S. Department of Transportation.

(d) Aluminum powder or paste packed in sealed containers of a type approved by DOT may be stored in commercial or public warehouses if they are of fire-resistant, noncombustible, or limited-combustible construction.

(e)* Aluminum powder or paste shall not be stored in the same area as oxidizing agents or combustible material.

(f) When storing aluminum powder or paste in sealed containers, care shall be exercised to assure secure piling. Appropriate aisle space shall be provided around stored aluminum powder or paste.

(g) Leakage or condensation from roof, steam or water lines, or radiators shall be avoided.

(h) Smoking and open flames shall be prohibited in areas where aluminum powder or paste is stored.
Chapter 5: Fire Protection

5-1 Portable Fire Extinguishers.

5-1.1 Only fire extinguishers approved for Class D fires shall be permitted in areas where metal dusts are present.

5-1.2 Only extinguishers approved for Class B and C fires shall be provided in areas where solvent cleaning and washing is performed. Only extinguishers shall be provided at the wet-type collector complying with 2-3.4 is preferred.

5-2 Bulk Extinguishing Materials.

5-2.1 Metal dust fires on reasonably flat surfaces may be controlled by placing a ring dam of dry sand or approved dry extinguishing material around the burning area. This shall be done with great care to insure that not even a small dust cloud is created.

5-2.2 Long-handled shovels or scoops of nonsparking material shall be provided for the application of dry extinguishing agents.

5-3 Equipment Shutdown.

In the event of fire, all fans and machinery, including dust collection systems, shall be shut down. Drafts shall be avoided wherever possible.

5-4 Work Clothing. Work clothing shall be made of smooth, hard-finished, closely woven fabric and shall not be made of synthetic fabrics which tend to accumulate static electric charges. Trouser shall have no cuffs where dust might accumulate.

Appendix A

This Appendix is not a part of the requirements (recommendations) of this NFPA document ... but is included for information purposes only.

A-2-1.2 Often, individual wet-type dust collectors can be provided for each dust-producing machine so that dust work connecting the hood or enclosure of the machine to the collector is as short as possible.

A-2-2.2 The U.S. Bureau of Mines Report of Investigation RI-6516, Explosibility of Metal Powders, reports the results of tests conducted on 89 different samples of aluminum powders of various grades and sizes. In general, the explosibility index was found to be greater than 10, the highest reference value used. Minimum ignition energies for dust clouds ranged upwards from 15 millijoules, while minimum ignition energies for dust layers ranged upwards from 2 millijoules. Ignition temperatures ranged upwards from 370°C. Minimum explosive concentrations ranged upwards from 0.040 oz per cu ft (40 g/m³). Rate of pressure rise can be as high as 20,000 psi/sec (137 800 kPa/sec) and maximum explosion pressures can exceed 90 psi (620 kPa).

A-2-2.3 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 readily seen and more easily removed.

A-2-2.3(c) The humid air of the wet-type dust collector wets the fine particles which pass through the collector so that the particles agglomerate and tend to build up a crust of aluminum oxide which excludes oxygen and causes the fire to self-extinguish.

A-2-2.3.1(e) This requirement is to protect the aluminum powder from inadvertent exposure fire.

A-4-1 Certain "nondusting" grades of aluminum flake powder are being produced. These tend to reduce the hazards of inadvertently-caused dust clouds. They are as combustible as regular grades of flake powder and, once levigated into a cloud, exhibit the same explosion characteristics. For these reasons, the same precautions must be observed as for normal grades of powder.

A-5 The use of fine dry sand, preferably less than 20 mesh, or other approved powder is an effective method of isolating incidental fires in 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 material shall be provided at one such receptacle to afford a ready means of laying the material around the perimeter of the fire.

A-5-1.1 Since these extinguishers project a dry powder under the impulse of a gaseous propellant, extreme care must be taken in their use to avoid creating even a small dust cloud, where possible, the stream of powder should be directed above the fire, allowing the powder to settle down on the burning material by gravity.

A-5-1.2 Certain grades of aluminum dust will greatly accelerate metal dust fires and may cause the burning metal to explode.

A-5-2.2 Under certain circumstances, principally impact with rusted iron or steel, where a minor thermite reaction can be initiated, aluminum cannot safely be considered to be nonsparking. For details, refer to:


A-5-4 Work clothing without external pockets is preferred.

56-2-2 (Entire standard): Reject

SUBMITTER: Edward S. Naidu, APC Corporation and Fire Equipment Manufacturers Assoc.

RECOMMENDATION: 1. All required explosion relief vents and associated components shall be of an approved type. Approval by the official having jurisdiction shall be based on acceptable performance tests and standards (for the entire assembled device and not only unassembled components) by a qualified testing organization such as Fenwal Laboratories, Ashland, Massachusetts, Factory Mutual Laboratories, Norwood, Massachusetts, or others.

2. Tests shall include both pressure and time measurements expressed as average maximum pressure (at the instant of release) in lbs/sq ft (kg/sqm.) and as average time (milliseconds) to release (from ignition time to release time). The integrated product of "maximum pressure" multiplied by "release time" is called "impulse" and should range below 10% of the estimated "impulse" load resistance of the building. (Example: most buildings of conventional steel and masonry block can resist an "impulse" of 100 lbs/sq ft for 0.5 seconds.) The vents should open fully at not over 30 lb/sq ft, in not over 20 milliseconds.

3. Unit vents shall not be used for access and when in closed position shall not have fixed openings (to the outside) in the unit greater than 1% of the vent area.

4. Unit vents mounted in a roof shall have provisions for restraining a 200 pound person from falling through the vent in the nonactivated condition.

5. Materials of construction shall be durable and functional (without frequent inspection and maintenance) in the expected

Chlorinated Hydrocarbons, U. L. Bulletin of Research No. 34, available from Underwriters Laboratories Inc., 333 Pfiftenstien Road, Northbrook, IL, 60062. For these reasons halogenated extinguishing agents must not be used on a fire involving combustible metals.
environment of weather, corrosion, temperature, ignition sources and mechanical loading as well as any known special hazards. The releasable portions of the vent shall be tethered to minimize "flying object" hazards and shall not give rise to projectile hazards or shards that may cause injury. Substantiation: Standards for explosion venting have been expressed in ratios of vent area to building volume in NFPA standards and various model code provisions. However, details as to explosion vent performance have not usually been stated and the approving official has been forced to rely on general principles. In recent years, standards and test performance have been developed to the point where basic engineering information can now be furnished to architects, builders, engineers and code officials. (See References)

Ref:
1. Accidental Explosions - H. A. Streblew Nova Cr 13479 - June, 1975
2. Factory Mutual System - Gast Prevention Data 7-76 (August, 1976) p. 16

It is now known that damage to buildings or large structures by internal pressure waves depends on a characteristic time of the building. When the pressure wave moves more rapidly (most explosions) than the building can redistribute the energy of the pressure wave (the building is too rigid or not flexible enough) then a portion or all of the building collapses. The purpose of an explosion vent is to reduce the total energy on the building before the building reaches the force x time impulse that will cause damage. The characteristic time response decreases with increasing rigidity but for conventional masonry, steel or timbered structures, the time constant will range close to 1/2 second. Therefore, venting must occur well before 1/2 second after ignition to be of value. Use of vents for uses other than primary emergency explosion relief may cause excessive wear, damage or other performance impairment.

Current safety objectives for construction, maintenance or emergency personnel are met by providing a safety structure around or over the vent. For specialized structures, such as ducts over 6' in diameter or 4' x 4' in area, exhaust vents, elevator legs, conveyor throughways, etc., unit vents should be placed on all exterior faces and the vents should extend the full width of the structure. The vents should have a smallest dimension of 3' (1 meter) and a dimension ratio of not over 2. Structures with LD 1/2 greater than 3 require higher vent ratios than near-cubical buildings. (Example: Elevator legs should have vents no less than 20' on center.) Committee Action: Reject.

Committee Comment: The proposed material is more properly aimed at the scope of guidance for explosion venting, NFPA. Additionally, the proposal would rule out other proven effective methods of explosion venting.

65-3 - (2-2.5): Accept
Submitter: Technical Committee on Metal Dusts
Recommendation: Add the following requirement to 2-2.5: “Duct seams shall be oriented in a direction away from normal working personnel.”
Substantiation: This requirement will ensure that the force of an explosion which ruptures the duct work will be directed in a direction away from areas occupied by normal operating personnel.
Committee Action: Accept.

65-4 - (2-3.2): Accept
Submitter: Technical Committee on Metal Dusts
Recommendation: Increase the design pressure from 75 psig to 100 psig.
Substantiation: This requirement establishes an exhaust vent more able to withstand internal explosion.
Committee Action: Accept.

65-5 - (2-4.4): Accept
Submitter: Technical Committee on Metal Dusts
Recommendation: Include a recommended ratio of 5 parts inert material to 1 part metal dust for disposal of waste metal dust.
Substantiation: This provides guidance as to the amount of inert material needed for safe disposal.
Committee Action: Accept.

65-6 - (2-5.3): Accept
Submitter: Technical Committee on Metal Dusts
Recommendation: Delete old 252(3), which reads: “(Sludge) can be stored on the ground in an isolated area, where it will oxidize. An area used for this purpose shall be fenced or guarded from public access.”
Substantiation: This procedure is considered too hazardous for sludge disposal.
Committee Action: Accept.

65-7 - (2-5.4): Accept
Submitter: Technical Committee on Metal Dusts
Recommendation: Add new subsection 2-5.4 to read: “Smoking or open flames shall be prohibited in the disposal area and throughout the disposal process.”
Substantiation: This requirement increases the safety of the sludge disposal procedure.
Committee Action: Accept.

65-8 - (3-2.1): Accept
Submitter: Technical Committee on Metal Dusts
Recommendation: Add an exception to allow use of intrinsically safe electrical equipment and purged/pressured electrical equipment.
Substantiation: This recognizes the violent reaction between burning aluminum and halogenated agents.
Committee Action: Accept.

65-9 - (3-1.2): Accept
Submitter: Technical Committee on Metal Dusts
Recommendation: Add an appendix item to explain that aluminum reacts with water to produce hydrogen.
Substantiation: This explains the requirement for venting of the sump of water-wet dust collectors.
Committee Action: Accept.

65-10 - (A-2.3.6): Accept
Submitter: Technical Committee on Metal Dusts
Recommendation: Add an appendix item to 4-1 to read as shown in the reprinted draft of NFPA 65.
Substantiation: This appendix item explains the reason for storing aluminum powder and paste separately from combustible or oxidizers.
Committee Action: Accept.

65-11 - (A-4.1): Accept
Submitter: Technical Committee on Metal Dusts
Recommendation: Add an appendix item to 4-1 to read as shown in the reprinted draft of NFPA 65.
Substantiation: This appendix item explains the reason for storing aluminum powder and paste separately from combustible or oxidizers.
Committee Action: Accept.

65-12 - (A-4.3.1(e)): Accept
Submitter: Technical Committee on Metal Dusts
Recommendation: Add the following appendix item: “This requirement is to protect the aluminum oxidizer or paste from ignition by an exposure fire.”
Substantiation: This appendix item explains the reason for storing aluminum powder and paste separately from combustible or oxidizers.
Committee Action: Accept.

65-13 - (A-5.1.1): Accept
Submitter: Technical Committee on Metal Dusts
Recommendation: Add an appendix item A-5-1.1 to read as shown in the reprinted draft of NFPA 65.
Substantiation: This appendix item provides guidance on the use of dry powder extinguishments.
Committee Action: Accept.
II. Standard for the Manufacture of Aluminum and Magnesium Powder
NFPA 651-1980

Chapter 1 General

1-1 Scope.

1-1.1 This standard shall apply to manufacturing facilities which produce light metal flake powder, or paste, atomized light metal granules, or the dust of any light metal alloy that is explosive in an environmental atmosphere.

1-1.2 This standard shall not apply to the production of waste metal dust by operations such as grinding, buffing, and polishing of semi-finished light metal products. (See NFPA 65, Standard for the Processing and Finishing of Aluminum, and NFPA 48, Standard for the Storage, Handling, and Processing of Magnesium.)

1-2 Purpose. The objective of this standard is to minimize the occurrence of and resulting damage from fire and explosion in areas where light metal powder products are manufactured.

1-3 Retroactivity.

1-3.1 Unless otherwise stated, the requirements of this standard shall not be applied retroactively.

1-3.2 Existing plants, equipment, structures, and installations which do not comply strictly with the requirements of this standard shall be considered to be in compliance if it can be shown that equivalent protection has been provided or that no specific hazard will be created or continued through noncompliance.

1-4 Definitions.

1-4.1 The term “light metal powder,” as used in this standard, shall mean aluminum and magnesium powders only.

Chapter 2 Location and Construction of Light Metal Powder Production Plants

2-1 Location.

2-1.1 Light metal powder production plants shall be located on a site large enough so that the buildings in which powder is manufactured will be at least 300 ft (91.4 m) from any occupied structure, such as public buildings, dwellings, business or manufacturing establishments, other than those buildings which are a part of the light metal powder production plant.

2-1.2 Different production operations shall be located in separate buildings located at least 50 ft (15.24 m) from each other.

Exception: Where two buildings are less than 50 ft (15.24 m) apart, one of the facing walls shall be capable of resisting a blast pressure of 2.0 psig (13.8 kPa) and shall be nonload-bearing, noncombustible, dust-tight, and without openings. (See also 2-5.3.)

2-1.3 Electric or steam power generators shall be housed in a separate building (or buildings) located at least 100 ft (30.5 m) from any building containing a dust explosion hazard.

2-2 Security.

2-2.1 The site on which the powder production plant is located shall be surrounded by strong fencing at least 6 ft (2 m) high with suitable entrance gates.

2-2.2 All gates that are not kept locked shall be under the supervision of a guard.

2-3 Building Construction.

2-3.1 All buildings used for the manufacture, packing, or loading for shipment of light metal powders shall, where practical, be single story, without basements, constructed of noncombustible materials throughout, and have nonload-bearing walls. The buildings shall be designed so that all internal surfaces are readily accessible to facilitate cleaning.

2-3.2 All buildings used for the manufacture of light metal powders shall be subdivided into as many small units as practical by blast resistant, nonload-bearing, noncombustible, dust-tight walls having no openings.

2-3.3 All walls of areas where dust may be produced which are not of monolithic construction shall have all masonry joints thoroughly slushed with mortar and trowelled smooth so as to leave no interior or exterior voids where light metal powder may infiltrate and accumulate.

2-4 Doors and Windows.

2-4.1 All door and window frames shall be metal.

2-4.2 Each room shall have at least two widely separated exits to exit corridors or to the outside. All doors in interior openings shall be approved self-closing fire doors, installed in accordance with NFPA 80, Standard for Fire Doors and Windows. Hardware for emergency exit doors shall conform to requirements of NFPA 80 and of NFPA 101, Life Safety Code.

2-4.2.1 Emergency exit doors shall be provided from all areas, including balconies and elevated platforms.

2-4.3 Windows shall be installed so that they automatically open in case of internal explosion. They shall be hinged at the top and shall open outward, and shall be held in place by friction latches. (See Guide for Explosion Venting, NFPA 68.)

2-5 Communication Between Buildings.

2-5.1 Buildings separated by not less than 50 ft (15.24 m) or smaller units of one major process section may communicate through enclosed passageways of noncombustible construction.

2-5.2 Enclosed passageways, leading from production or storage areas shall be specifically designed to relieve internal pressure from an explosion and shall be protected by automatic self-closing Class A fire doors.

2-5.3 When two buildings are less than 50 ft (15.24 m) apart, only one of the facing walls shall have windows and doors. (See also Exception to 2-1.2)

2-5.4 All enclosed passageways shall be provided with an exit door leading to the outside.

2-6 Grounding and Lightning Protection.

2-6.1 All steel process equipment and all building steel shall be bonded and grounded to a suitable ground connection outside the building in accordance with NFPA 78, Lightning Protection Code.

2-6.2 Lightning rods shall be provided for all boiler stacks and chimneys and for the high points of all buildings.

2-6.3 Power lines shall be adequately protected against lightning (See NFPA 78, Lightning Protection Code.)

2-6.4 A lightning arrester system shall be provided around or within the building area of such capacity as to fully protect all buildings from lightning.

2-7 Electrical Power.

2-7.1 All electrical equipment and wiring shall be installed in accordance with NFPA 70, National Electrical Code.

2-7.2 All parts of manufacturing buildings shall be considered
Class II, Group E, Division 1 locations, as described in Articles 500 and 502 of NFPA 70, National Electrical Code.

Exception No. 1: Offices and similar areas so occupied and segregated as to be reasonably free from dust and so classified by the authority having jurisdiction.

Exception No. 2: Control equipment meeting the requirements of NFPA 496, Standard for Purged and pressurized Electrical Equipment, or NFPA 493, Standard for Intrinsically Safe Apparatus for Use in Class I, II and III, Division 1 Hazardous Locations.

2-7.3 Electrical equipment that is not suitable for Class II, Group E atmospheres shall be located in a dust-free area.

2-7.4* Each building shall be provided with remote manual cutoff of all electrical power. The remote manual cutoff shall be located at least 10 ft (3.05 m) from the nearest opening in the affected building.

2-7.4.1 Provisions shall also be made for remote manual cutoff of all electrical power to manufacturing areas from one or more central locations, such as offices, watchmen’s booth, or other appropriate locations.

2-7.5 All manufacturing buildings shall be provided with low voltage (24 to 32 volts) emergency lighting systems capable of providing 1 ft-candle (10.7 lux) of illumination for all aisles leading to emergency exits. The emergency lighting systems shall be energized automatically on loss of electrical power to the building. (See 10-2-9 of Life Safety Code, NFPA 101.)

2-7.6 Electrical equipment shall be inspected and cleaned at least once each year or more frequently if conditions warrant.

2-7.7 Flashlights and storage battery lamps may be used if approved for the locations in which they are used.

Chapter 3 Machinery and Operations

3-1 General Precautions.

3-1.1 In powder handling or manufacturing buildings and in the operation of dust conveying systems, every precaution shall be taken to avoid the production of sparks from static electricity, electrical faults, or impact (e.g., iron or steel articles on stones, on each other, or on concrete).

3-1.2 Water leakage in or into any building where it can contact light metal powder shall be prevented to avoid possible spontaneous heating and ignition.

3-1.3 Electrical heating to a high temperature of any wire or resistance element or load in an area containing a dust hazard shall be prevented.

3-1.4* Serious local friction heating in any machine located in an area containing a dust hazard shall be prevented.

3-2 Requirements for Machinery.

3-2.1 All dust-producing machines and conveyors shall be constructed so that escape of dust is minimized.

3-2.2 All machinery shall be bonded and grounded to minimize accumulation of static electric charge. (See Recommended Practice on Static Electricity, NFPA 77.) This requirement shall be applicable to stamp mortars, mills, fans and conveyors in all areas where dust is produced or handled, finishing and polishing equipment, filters, drawers, dust screens, fixed storage bins, and dust collection and transport systems of all types. (See also 2-6.1.)

3-2.3* Ball or roller bearings, properly sealed against dust, shall be used for shafts and high speed equipment. Where exposed bearings must be used, they shall be protected as well as possible to prevent ingress of light metal dust.

3-2.4 Internal machine clearances shall be maintained to prevent internal rubbing or jamming.

3-2.5 Approved magnetic separators or approved 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 may be introduced into the manufacturing operation.

3-2.5.1 Electromagnets shall be approved for use in Class II, Group E, Division 1 atmospheres.

3-3 Heating of Light Metal Powder Production Buildings.

3-3.1 Heating of buildings shall be done by hot air heating systems or by direct pipe heating systems using steam or hot water as the heat transfer medium. The air may be heated by steam or hot water coils located in a dust-free area adjacent to the room or building where heated air is required.

3-3.2 Fans or blowers used to convey the heated air shall also be located in a dust-free location. The air supply shall be taken from outside or from a dust-free location.

3-3.3 Make-up air for building heating shall have a dew point low enough to insure that no free moisture can condense at any point where the air is in contact with light metal dust or powder.

3-3.4 The requirements of 3-3.1, 3-3.2, and 3-3.3 shall not apply to areas where metal is melted for purposes of atomization.

3-4 Start-Up Operations. All machines shall be thoroughly cleaned and absolutely dry before they are charged with metal and placed in operation.

3-5 Charging and Discharging Light Metal Powders.

3-5.1 All containers shall be sealed with metallic, waterproof covers while in storage or transit.

3-5.2 When charging light metal powders to machines (or discharging from), the containers shall be positively grounded by a conducting cable from the container to a suitable ground connection.

3-5.6 Packing and Storage. Light metal powder shall be packed into steel drums or other closed containers acceptable to the U.S. Department of Transportation (DOT). The containers shall be tightly sealed and stored in a dry location until ready for shipment or repacking.

3-5.2 Light metal powder product shall be shipped as soon as possible.

3-7.4 Wet Milling of Light Metal Powder.

3-7.1 Where light metal is milled or comminuted in the presence of an inert liquid, the oxygen content shall be maintained at no less than 8 percent.

3-7.2 Where light metal is slurried in tanks or processed in blenders or other equipment in the presence of an inert liquid, the oxygen content shall be maintained at no less than 4 percent.

3-7.3 The dew point of the controlled oxygen atmosphere in 3-7.1 and 3-7.2 shall be maintained substantially below the point where condensation could occur.

3-7.4 Bearings of wet mills shall be grounded across the lubricating film by use of current collector brushes.

3-7.5 Adequate ventilation, forced or natural, shall be maintained in areas where solvents are handled.

3-7.6 Solvent or slurry pumps shall be installed with proper controls to insure that they are shut down should they run dry.

3-7.7 All alarms and electrical equipment shall be installed in accordance with appropriate provisions of the National Electrical Code, NFPA 70.

Chapter 4 In-Plant Conveying of Light Metal Powder

4-1 Wheeled Containers.

4-1.1 Movable containers for in-plant transportation of light metal powders shall be constructed entirely of nonferrous minimum-sparking metal or of nonmagnetic minimum-sparking stainless steel.

4-1.2 Drums approved by the U.S. Department of Transportation (DOT) for shipment of light metal powders may be used when moved on 2- or 4-wheeled trucks or when moved on pallets by lift trucks.

4-1.3 All wheeled containers, hand trucks, and lift trucks shall have nonsparking, static conductive tires and wheels which have been bonded through or around the lubricating film in the bearings.

4-2 Pneumatic Conveying.

4-2.1 Conveyor ducts shall be fabricated of nonferrous minimum-sparking metal or of nonmagnetic minimum-sparking stainless steel.

4-2.2 Ducts shall be electrically bonded and grounded to minimize accumulation of static electric charge. (See Recommended Practice on Static Electricity, NFPA 77.)

4-2.3 Plastics or other nonconductive ducts or duct liners shall not be used.

4-2.4* Inert gas explosion prevention systems shall be used in any pneumatic conveying system where the concentration of light metal powder is or may be within the explosive range. (See Standard on Explosion Prevention Systems, NFPA 68.)
4-2.4.1* The inert gas used shall be based on such gases as nitrogen, argon, or helium, and shall have an oxygen concentration appropriate to the inerting gas and the particle size of the metal dust, but in no case less than 1 percent.

4-2.4.2 The inert gas shall contain no carbon monoxide.

4-2.4.3 The inert gas shall have a dew point such that no free moisture can condense or accumulate at any point in the system.

4-2.4.4 The inert gas stream shall be continuously monitored for oxygen content and shall be arranged to sound an alarm if the oxygen content is not within the prescribed range.

4-2.4.5 The inert gas for magnesium dust shall not contain carbon dioxide or nitrogen.

4-2.5 Where the conveying duct is exposed to weather or moisture, it shall be moisture tight.

4-2.6 A minimum conveying velocity of 4500 ft/min (1371 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 may drop out during an unscheduled system stoppage.

4-2.7 If the conveying gas is inducted into the system in a relatively warm environment and the ducts and collectors are relatively cold, the ducts and the collectors shall be either insulated or provided with heating so that the gas temperature does not fall below the dew point, causing condensation.

4-2.8* If the conveying gas is air, the metal dust-to-air ratio throughout the conveying system shall be held safely below the minimum explosive concentration of the metal dust.

4-2.8.1* If the dust is collected in a liquid, such as in a spray tower, any liquid used shall not have a flashpoint below 100°F (37.8°C) and shall be nonreactive with metal dust or reactive at a controlled rate under favorable operating conditions. The liquid remaining in or on the product shall be compatible with subsequent processing requirements.

4-3 Ductwork For Conveying Systems.

4-3.1 Wherever practical, explosion vents, openings protected by antiflashback swing valves, or rupture diaphragms shall be provided on ductwork. Relief shall be to the outside of the building. (See Guide for Explosion Venting, NFPA 68.)

4-3.1.1 The inertia of swing valves shall be limited to the minimum required.

4-3.2 Wherever damage to other property or injury to personnel may result from the rupture of the ductwork or where explosion relief vents cannot provide sufficient pressure relief, the ductwork shall be designed to withstand a suddenly applied internal pressure of at least 100 psig (689 kPa).

4-3.2.1 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 may be of light construction so as to intentionally fail, thereby acting as an auxiliary explosion vent for the system.

4-4 Fan Construction and Arrangement.

4-4.1 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.

4-4.2 In no case shall the design allow the transported dust or powder to pass through the fan while it is operating. No maintenance shall be performed on the fan until it is shut down.

4-4.3 Personnel shall not be permitted within 50 ft (15.5 m) of the fan while it is operating. No maintenance shall be performed on the fan until it is shut down.

4-4.3.1 If personnel must approach the fan while it is operating, such as for a pressure test, it shall be done under the direct supervision of competent technical personnel and with the knowledge and approval of operating management.

4-4.4* Fans shall be located outside of all manufacturing buildings and so located that entrance of dust is minimized.

4-4.5* Fans shall be equipped with ball or roller bearings. Bearings shall be equipped with suitable temperature-indicating devices and shall be arranged to sound an alarm in case of over-temperature.

4-4.6 Fans shall be electrically interlocked with dust-producing machinery so that the machines are shut down if the fan stops.

4-5 High Temperature Warning.

4-5.3.3 All such instruments shall be removed at once, using conductive, nonsparking scoops and soft brushes or brushes having natural fiber bristles. Final cleanup may be accomplished using a vacuum cleaning system.

4-5.3.4* Dust Collecting Filter Medium. Dust collecting filter medium made from synthetic fabrics which accumulate high static electric charges shall not be used.

Chapter 6 Prevention of Dust Accumulations

6-1 General.

6-1.2 The use of water for cleaning shall not be allowed in manufacturing areas unless the following requirements are met:

(a) It has been ascertained by competent technical personnel that the use of water will be the safest method of cleaning in the shortest exposure time.

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

(c) Adequate ventilation, either natural or forced, is available to maintain the hydrogen concentration safely below the lower explosive limit.

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

6-2 Vacuum Cleaning Systems.

6-2.1 Vacuum cleaning systems shall be used for removal of dust accumulations too small or too dispersed to be thoroughly removed by hand-brushing.

6-2.2 Vacuum cleaning systems shall be used for removal of dust accumulations too small or too dispersed to be thoroughly removed by hand-brushing.

6-2.3 If located in a dust-producing building or in an area where dust can accumulate, the vacuum cleaning system's electrical equipment shall be suitable for Class II, Group E, Division 1 locations.

6-2.4 Vacuum cleaner hoses shall be conductive and nozzles or fittings shall be made of conductive, nonsparking material.

6-2.5 Dust picked up by the vacuum cleaning system shall be discharged in a suitable receptacle or collector located outside the building.
manufacturing buildings shall be provided. All machinery shall be carefully removed for disposal. It shall be covered with dry sand or with other suitable dry extinguishing materials which could cause a dust cloud.

7-1 Dry Powders.

7-1.1 An incipient fire shall be ringed with a dam of dry sand, dry inert granular material or powder, or approved dry powder extinguishing agent. Extreme care shall be exercised during application to avoid any disturbance of the light metal powder which could cause a dust cloud.

7-1.2 The dry material shall be carefully applied with a nonsparking metal scoop or shovel.

7-1.3 Care shall be exercised to eliminate drafts by shutting off fans and machinery and by closing doors and windows.

7-1.4 Areas where dry light metal powders are produced or handled shall not have fire extinguishers rated for Class A, B, or C fires. An ample and readily available supply of dry materials suitable for use with combustible metals, such as Class D extinguishing agent) shall be provided and suitable tools for application shall be kept in the same locations. The dry extinguishing material shall be stored in such a manner that it remains clean and dry.

7-1.5 In cases of fires involving magnesium powder or dust, it is permissible to use dry magnesium foundry flux as the extinguishing agent. The procedures stated in 7-1.1 through 7-1.3 shall apply to such use.

7-2 Solvent-Wetted Powders.

7-2.1 A fire occurring while the light metal powder is in slurry form may be fought using Class B extinguishing agents. Exception: Halogenated extinguishing agents shall not be used.

7-2.2 A fire occurring in semi-wet material or filter-cake shall be fought using suitable dry extinguishing material.

7-2.3 Carbon dioxide or nitrogen shall not be used on fires involving magnesium in any form.

7-2.4 Where carbon dioxide is used to extinguish fires involving aluminum, the residual material shall be immediately covered with dry sand or with other suitable dry extinguishing material 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 (11.4 dm³) each in 5-gal (19.0 dm³) containers.

7-2.5 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. Extreme care shall be exercised 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.

7-2.5.1 After extinguishment, the area shall be immediately cleaned of all wetted powder, paste, or slurry.

7-2.5.2 Adequate ventilation shall be provided during cleanup to avoid concentrations of hydrogen from the exothermic reaction of the light metal with water.

7-2.5.3 Suitable drainage provisions to a safe area away from manufacturing buildings shall be provided.

7-3 Automatic Sprinkler Protection.

7-3.1 Automatic sprinkler protection may be used in areas where solvents are stored or used or where light metal powders are stored in sealed metal containers.

7-3.2 Automatic sprinkler systems shall be designed and installed in accordance with NFPA 13, the Standard for the Installation of Sprinkler Systems.

7-3.2.1 The selection, design, and installation of automatic sprinkler systems shall be made only with the guidance of experts who have knowledge of the special hazards of the particular light metal powder involved.

7-3.3 Attention shall be given to employee training and organizational planning to insure safe and proper evacuation of the protected area within the time limits of the system operation.

7-4 Fire Fighting Organization.

7-4.1 Work assignments shall be so planned that an organized crew, trained in fire fighting, is in or close to the hazardous area at all times during operation.

7-4.2 Only trained personnel shall be permitted to engage in fire control activity. All others shall be evacuated from the area.

7-4.3 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.

7-4.4 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.

Chapter 8 Safety Requirements

8-1 Protective Clothing for Workers.

8-1.1 Outer clothing shall be clean, flame resistant, nonstatic-generating and shall be designed to be easily removable. Tightly woven, smooth fabrics treated with a flame retardant chemical, if necessary, shall be used.

8-1.2 Work clothing shall have no external pockets. Trousers shall not have cuffs.

8-1.3 Metallic fasteners shall be avoided where possible.

8-1.4 Safety shoes meeting the following requirements shall be worn by all operating personnel except those persons who are required to work on electrical circuits or equipment.

(a) Soles shall be resistant to embedding particles and to petroleum solvents, if used.
(b) Soles and heels shall be attached by sewing or pegging.
(c) Nails, metal cleats, or metal plates shall not be used.
(d) Safety toe caps shall be completely covered with a nonstatic-generating material.
(e) Soles and heels shall be static conductive.

8-2 Smoking and Matches.

8-2.1 Smoking materials, matches, and lighters shall only be allowed in the "change house" at the building entrance.

8-2.2 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 light metal powder is produced, handled, or loaded for shipment.

8-2.3 The "change house" building shall be of fire-resistant construction, shall be normally accessible only from a single entrance, and shall be located at or near the entrance to the premises.

8-3 Open Flames, Cutting and Welding Equipment, Powder-Operated Tools.

8-3.1 Maintenance workers and furnace or boiler operators shall be furnished such safe ignition tools as their duties require.

8-3.2 Cutting, welding, soldering, or brazing shall not be permitted in buildings housing powder-producing or handling machinery unless operations are completely shut down.

8-3.2.1 All machinery in the area where the hot work is to be done shall be completely shut down.

8-3.2.2 The entire area and machinery located in the area shall be thoroughly cleaned.

8-3.3 Powder-operated tools shall not be used in areas where a dust explosion hazard may exist unless the procedures of 8-3.2.1 and 8-3.2.2 are followed. After use of such tools, a careful check shall be made to insure that no cartridges or charges are left in the area, where they could enter equipment or be accidentally discharged after operations have resumed.

8-3.4 Aluminum, copper, or bronze metal tools, including shovels and scoops, shall be used in all buildings where a dust explosion hazard exists. Iron, steel, or other spark-producing tools shall not be used.
overheating. Outboard bearings are used where practical because machine stop switches may be employed for locations where excessive vibration, or other pertinent factors being action can be taken.

buildings when one or more safety sensing devices are activated electrical power and lighting circuits in manufacturing

light metal powder fires.

The hazards involved in causing dust clouds and the danger of applying liquids onto an incipient fire shall be explained.

Strict discipline and scrupulous housekeeping shall be maintained at all times.

A thorough systematic inspection shall be made at regular intervals not to exceed 1 month.

Two or more competent persons shall conduct each inspection and the record of their findings and recommendations shall be permanently recorded in the principal plant office.

The inspection shall include the following: (a) general safety precautions; (b) fire-fighting equipment; (c) first aid equipment; (d) housekeeping; (e) electrical and mechanical equipment; (f) procedures.

Indicating and recording instruments and alarm devices shall be checked daily and the results recorded. Instruments shall be calibrated every 6 months.

Deluge Showers. Deluge showers actuated by hinged floor valves shall be installed at strategic locations immediately outside critical working areas to immediately douse clothing fires.

Safety Blankets. Safety blankets shall be provided throughout the plant area.

Appendix A

This Appendix is not a part of the requirements (recommendations) of this NFPA document...but is included for information purposes only.

A-1.1 Certain "mounding" grades of aluminum flake powder are being produced. These tend to reduce the hazards from inadvertently-caused dust clouds. However, they are as combustible as regular grades of flake powder. Although they exhibit less tendency to be dispersed into a dust cloud, the same precautions described in this standard should be observed.

A-2.7.4 Provisions may also be made to automatically cut off electrical power and lighting circuits in manufacturing buildings when one or more safety sensing devices are activated by high pressure, low airflow, abnormal oxygen content, excessive vibration, or other pertinent factors being monitored. Alternatively, these sensing devices may be arranged to sound an alarm in those locations where prompt corrective action can be taken.

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

A-3.2.1 Plain bearings must not be used because of the difficulty of maintaining proper lubrication to prevent overheating. Outboard bearings are used where practical because it is easier to check for overheating. In those instances where dust tends to penetrate bearings a continuous flow of inert gas (1/2 to 5 percent oxygen) can be employed to pressurize the bearings and seals, or a compatible liquid may be used in the same manner.

A-3.6 Open bin storage is not desirable. Storage bins can be sealed and they can be purged with inert gas prior to filling. Once filled, the bins can be maintained inert by a suitable gas as detailed in A-2.4.

A-3.7 When light metal is milled in the presence of a liquid which 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 may 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-4.2.4 Light metal and light metal alloy powders are produced by various mechanical means of particle size degradation. 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 which forms a protective coating of metal oxide. The metal oxide thwarts further oxidation. In some cases, the oxide layer may be thick and impervious enough 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 cannot be used as an inerting medium since the metal 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-4.2.4.1 Oxygen limits of 3 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 Inflammability and Explosibility of Metal Powders, RI 3722, U.S. Bureau of Mines, 4800 Forbes Ave., Pittsburgh, PA.

A-4.2.5 Any moisture entering the system can react with the light metal dust, generating heat and serving as a potential source of ignition.

A-4.2.8 These minimum explosive concentrations are published in Explosibility of Metal Powders, RI 3722, U.S. Bureau of Mines, 4800 Forbes Ave., Pittsburgh, PA. Although the metal dust-air suspension may be held below the explosive concentration in the containment vessel, the explosion will pass through the explosive range in the collector at the end of the system unless the dust is collected in liquid, such as in a spray tower.

A-4.2.8.1 Such wet collection is not always possible or desirable.

A-4.4.4 Ultimately, all fans in dust collector systems accumulate sufficient dust to become a potential explosion hazard.

A-4.4.5 Fans may also be provided with vibration-indicating devices, arranged to sound an alarm or to provide shutdown or both in event of blade or rotor imbalance or bearing or drive problems.

A-5.1 A high efficiency cyclone-type collector presents less hazard than a bag-type collector and, except for extremely fine powders, will usually operate with fairly high collection efficiency. When cyclone collectors are employed, it may be necessary to recharge to atmosphere away from other operations. It should be recognized that there will be some instances in which a centrifugal-type collector may be followed by a fabric or bag collector or by a scrubber-type collector where particulate emissions must be kept at a low level. The hazards of each collector must be recognized and protected against. In each instance, the fan will be the last element downstream in the system. Because of the initial capital cost of an efficient bag collector maintenance expenses are high, and the extreme hazard involved, a realistic evaluation of the losses from a multiple series cyclone with a liquid final stage should be seriously considered. Industry experience has clearly demonstrated that an eventual explosion can be expected when a bag collector is used to collect aluminum or magnesium fines. Seldom, it ever, can the source of ignition be positively identified. In those unusual instances when it becomes necessary to collect extreme fines for a specific commercial product, it is customary for the producer to employ a bag collector. With the knowledge that strong
explosive potential is present, he will locate the bag collector 3 to 5 feet for Class A fires, and 5 to 10 feet from the point of ignition when he is able to observe the fire. An operator who surrounds the collector with a strong steel plate barricade to confine the fire within the dust collecting equipment may use water or dry inert granular material used. A fire in aluminum powder slurry is primarily a solvent fire and can be fought using Class B extinguishing agents, except for halogenated compounds. Water will self-extinguish. It is customary practice, after dispensing the extinguishing material, to leave the area, closing all doors and windows. A-4-5 Some collector bags or screens have fine, noninsulated wire meshed into or woven with the cloth or otherwise fastened to it. These are also 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.

A-4-6 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 at least 50 feet (15.24 m) away. If the collector is located closer than 50 feet (15.24 m), it is usually surrounded by a strong steel shield, cylindrical in shape and open at the top, or closed with an unfastened cover. The shield is closed at the bottom and designed to withstand a blast pressure of 200 psig (1378 kPa). Such a protective barrier will direct an explosion harmlessly upward and away. If the collector is located closer than 50 ft (15.24 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 Explosion Venting. Care is customarily exercised in locating the vents because of the possibility of blast damage to personnel or adjacent structures.

A-4-7 Since it is almost impossible to extinguish a massive fire in aluminum powder, the fire problem resolves itself into the control of fires in the incipient stage. The requirements of Section A-7-1 must 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 extinguished fire will develop a hard crust of metal oxide which will ultimately extinguish the fire and prevent re-entert by dust accumulation in the area. This minimum resistance value should be provided with explosion vents and anti-flashback valves.

A-4-8 Milling of aluminum with combustible solvents is practiced in the manufacture of aluminum flake used in pigments and powders. The material is handled using a slurry during the milling and processing. Some of the product is marketed as a paste; other portions are filtered, dried, sometimes polished, and sold as dry flake powders. The solvents employed are generally moderately high flash point naphthas. A fire in an aluminum powder slurry is primarily a solvent fire and can be fought using Class B extinguishing agents, except for halogenated extinguishing agents. Major producers usually employ fixed extinguishing systems of carbon dioxide or foam in this area. Some Class B portable extinguishers are provided also. Obviously, judgment must be used in determining whether Class B extinguishing agents can be safely used. The extinguishing agent is carefully applied to the fire; it will be very evident if it accelerates the fire. If it does, its use should be discontinued and a Class D extinguishing agent or water used. A fire in a filter cake of a solvent-wetted but dry powder material containing aluminum, may be a solvent fire or may at some point exhibit the characteristics of a powder fire at which time it must be treated as such. If the aluminum metal has ignited, it may continue to burn under a crust without flames.

A-7-2.4 Carbon dioxide may be used to extinguish fires involving solvent-wetted aluminum. However, reignition may occur due to high localized heat or spontaneous heating. To avoid reignition, the residual material must be immediately smothered.

A-7-2.4 Professional or volunteer fire fighters from outside the plant cannot be expected to be trained for the specific fire and life hazards associated with light metal powder manufacturing. The requirement that they be directed by the plant's fire fighting officer is in the interest of their own safety.

A-8-2.1 Employees may bring smoking materials in their street clothes provided they remain in the "change house."

A-8-3.1 Ignition tools will generally be the flint-and-file type used for lighting torches or furnace burners.

A-8-3.2 Attention is called to the hazardous conditions that may exist both inside and outside the plant if cutting torches are used to dismantle dust collectors or powder-producing machinery before all dust accumulations have been removed. It is a commonly recognized practice that operators of cutting or welding torches must be provided with proper and approved helmets and that gas is fed to it. These expenditures are not suitable.

A-6-2 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 at least 50 feet (15.24 m) away. If the collector is located closer than 50 feet (15.24 m), it is usually surrounded by a strong steel shield, cylindrical in shape and open at the top, or closed with an unfastened cover. The shield is closed at the bottom and designed to withstand a blast pressure of 200 psig (1378 kPa). Such a protective barrier will direct an explosion harmlessly upward and away. If the collector is located closer than 50 ft (15.24 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 Explosion Venting. Care is customarily exercised in locating the vents because of the possibility of blast damage to personnel or adjacent structures.
B-2.5 For compliance with the minimum resistance limit, no individual measurement should be less than 10,000 ohms and the average of not less than five measurements should be greater than 74,000 ohms.

B-2.6 Where resistance to ground is measured, two measurements are customarily made at each location, with the test leads interchanged at the instruments between the two measurements. The average of the two measurements is taken as the resistance to ground at that location. Measurements are customarily taken with the electrods or electrodes more than 3 ft (0.9 m) from any ground connection or grounded object resting on the floor.

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651-1. (Entire Standard): Reject
SUBMITTER: Edward S. Nords, APC Corp. & Fire Equipment Manufacturers Assoc.
RECOMMENDATION: 1. All required explosion relief vents and associated components shall be of an approved type. Approval by the official having jurisdiction shall be based on acceptable performance tests and standards (for the entire assembled device and not only unassembled components) by a qualified testing organization such as Fenwal Laboratories, Ashland, Massachusetts, Factory Mutual Laboratories, Norwood, Massachusetts, or others.
2. Tests shall include both pressure and time measurements expressed as average maximum pressure (at the instant of release) in pounds/sq. ft. (kg/sq.m.) and as average time (milliseconds) to release (from ignition time to release time). The integrated product of “maximum pressure” multiplied by “release time” is called “impulse” and should range below 10% of the estimated “impulse” load resistance of the building. (Example: most buildings of conventional steel and masonry block can resist an “impulse” of 100 lb/sq. ft. for 0.5 seconds.)
3. The vents shall open fully at not over 30 lb/sq. ft. in not over 50 milliseconds.
4. Unit vents shall not be used for access and when in closed position shall not have fixed openings (to the outside) in the unit greater than 1% of the vent area.
5. Unit vents mounted on a roof shall have provisions for restraining a 200 pound person from falling through the vent in the non-activated condition.
6. Materials of construction shall be durable and functional (without frequent inspection and maintenance) in the expected environment of weather, corrosion, temperature, ignition sources and mechanical loading as well as any known special hazards. The releasable portions of the vent shall be tethered to minimize “flying object” hazards and shall not give rise to projectiles or shards that may cause injury.
7. Substantiation: Standards for explosion venting have been expressed in ratios of vent area to building volume in NFPA standards and various model code provisions. However, details as to explosion vent performance have not usually been stated and the approving official has been forced to rely on general principles. In recent years, standards and test performance have been developed to the point where basic engineering information can now be furnished to architects, builders, engineers and code officials. (See references)

Ref: 1. Accidental Explosions - H. A. Strehlow Nasa Cr 34775 - June, 1975
2. Factory Mutual System - Loss Prevention Data 7-76 (August, 1976) p. 16
4. It is now known that damage to buildings or large structures by internal pressure waves depends on a characteristic time response of the building. When the pressure wave moves more rapidly (most explosions) than the building can redistribute the energy of the pressure wave (the building is too rigid or not flexible enough) then a portion or all of the building collapses. The purpose of an explosion vent is to reduce the total energy on the building before the building reaches the force x time impulse that will cause damage. The characteristic time response decreases with increasing rigidity but for conventional masonry, steel or timbered structures, the time constant will range close to 1/2 second. Therefore, venting must occur well below 1/2 second after ignition to be of value. Use of vents for uses other than primary emergency explosion relief may cause excessive wear, damage or other performance impairment.

Current safety objectives for construction, maintenance or emergency personnel are met by providing a safety structure around or over the vent. For specialized structures, such as ducts over 6' in diameter or 4' x 4' in area, elevator legs, conveyor throughways, etc., unit vents should be placed on all exterior faces and the vents should extend the full width of the structure. The vents should have a smallest dimension of 3' (1 meter) and a dimension ratio of not over 2. Structures with L/D greater than 3 require higher vent ratios than near-cubical buildings. (Example: Elevator legs should have vents no less than 20' on center).

COMMITTEE ACTION: Rejected.