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NFPA 654 Prevention of Fire and Dust Explosions in the Chemical, Dye, Pharmaceutical, and Plastics Industries 1988 Edition

National Fire Protection Association Batterymarch Park, Quincy, MA 02269

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

Statement on NFPA Procedures

This material has been developed under the published procedures of the National Fire Protection Association, which are designed to assure the appointment of technically competent Committees having balanced representation. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accepts any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

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NATIONAL FIRE PROTECTION ASSOCIATION

NFPA 654

Standard for the Prevention of Fire and Dust Explosions in the Chemical, Dye, Pharmaceutical, and Plastics Industries

1988 Edition

This edition of NFPA 654, *Standard for the Prevention of Fire and Dust Explosions in the Chemical, Dye, Pharmaceutical, and Plastics Industries*, was prepared by the Technical Committee on Fundamentals of Dust Explosion Prevention and Control, released by the Correlating Committee on Dust Explosion Hazards, and acted on by the National Fire Protection Association Inc. at its Annual Meeting held May 16-18, 1988, in Los Angeles, California. It was issued by the Standards Council on June 8, 1988, with an effective date of June 28, 1988, and supersedes all previous editions.

The 1988 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 654

NFPA 654 was initiated by the Committee on Dust Explosion Hazards in 1943 and originally applied only to the prevention of dust explosions in the plastics industry. As such, it was tentatively adopted in 1944 and officially adopted in 1945. Amendments were adopted in 1946, 1959, 1963, and 1970. The 1970 edition was reconfirmed in 1975.

In 1976, responsibility for NFPA 654 was transferred to the Technical Committee on Fundamentals of Dust Explosion Prevention and Control. The Committee, in completely revising the document, also expanded its scope to include chemical, dye, and pharmaceutical dusts, since the fire and explosion hazards of these dusts are generally the same as for plastic dusts.

The 1982 edition of this standard consisted of a complete rewrite of the 1975 edition. Due to limited technological changes in this area since 1982, the Committee voted to reconfirm the text as it appears in the 1982 version. Editorial changes and changes to allow the document to adhere more closely to the NFPA *Manual of Style* have been incorporated into the 1988 edition.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred

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.

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NFPA 654

Standard for the Prevention of Fire and Dust Explosions in the Chemical, Dye, Pharmaceutical, and Plastics Industries

1988 Edition

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

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

Chapter 1 General

1-1 Scope.

1-1.1 This standard shall apply to all phases of the manufacture and processing of industrial dusts including, but not limited to, chemicals, dyes, pharmaceuticals, and plastics where a fire or explosion hazard may exist due to the presence of combustible dusts.

1-1.2 This standard shall not apply to materials covered by the following:

NFPA 61A, *Standard for the Prevention of Fire and Dust Explosions in Facilities Manufacturing and Handling Starch*

NFPA 61B, *Standard for the Prevention of Fires and Explosions in Grain Elevators and Facilities Handling Bulk Raw Agricultural Commodities*

NFPA 61C, *Standard for the Prevention of Fire and Dust Explosions in Feed Mills*

NFPA 61D, *Standard for the Prevention of Fire and Dust Explosions in the Milling of Agricultural Commodities for Human Consumption*

NFPA 65, *Standard for the Processing and Finishing of Aluminum*

NFPA 85F, *Standard for the Installation and Operation of Pulverized Fuel Systems*

NFPA 490, *Code for the Storage of Ammonium Nitrate*

NFPA 651, *Standard for the Manufacture of Aluminum and Magnesium Powder*

NFPA 655, *Standard for the Prevention of Sulfur Fires and Explosions*

NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities.*

1-2 Purpose.

1-2.1 The purpose of this standard is to prescribe reasonable requirements for safety to life and property from fire and explosion and to minimize the resulting damage should a fire or explosion occur.

1-2.2 This standard is not intended to prevent the use of systems, methods, or devices which provide equivalent protection from fire and explosion, providing that suitable data is available to demonstrate equivalency.

1-3 Definitions. For the purpose of this standard, the following terms shall have the meanings given below.

Approved. Acceptable to the "authority having jurisdiction."

NOTE: 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 or 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 concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: 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, 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 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."

Chemical. A substance composed of an element or combination of elements.

Combustible Dust.* Any finely divided solid material 420 microns or smaller in diameter (material passing a U.S. No. 40 Standard Sieve) which presents a fire or explosion hazard when dispersed and ignited in air.

Detachment. In the open air or in a separate building.

Duct. Pipes, channels, or other enclosures, used for the purpose of conveying air, dust, or gas.

Dye. A solid or powdered coloring matter.

Explosion. The bursting of a building or container as a result of development of internal pressure beyond its confinement capacity.

Hybrid Mixture. A combination of combustible dust and flammable gas or vapor which form an explosive mixture.

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization 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 or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which 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.

Pharmaceutical. A natural or manufactured medicinal drug composed of various ingredients.

Plastic. A generic term referring to synthetic or natural resins with or without additives, which can be molded by heat and/or pressure. The term also refers to the finished products.

Separation. The interposing of distance between the combustible dust process and other operations which are in the same room.

Segregation. The interposing of a physical barrier between the combustible dust process and other operations.

Shall. Indicates a mandatory requirement.

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

Chapter 2 Plant Arrangement and Building Construction

2-1 Segregation, Separation or Detachment of Dust Handling and Processing Areas.

2-1.1 Areas in which combustible dusts are processed or handled shall be segregated, separated, or detached in such a manner as to minimize damage to other portions of the plant should an explosion or fire occur. (*See 3-3.2.4.*)

2-1.2* If physical barriers are erected to segregate dust explosion hazards, they shall be designed for sufficient explosion resistance to preclude failure of these barriers before the explosion pressure can be safely vented to the outside.

2-1.3 Separation may be used to limit the area considered hazardous provided that a dust collection system is installed to minimize accumulations of dust. Process equipment, including the dust collection system, shall be protected as required by Chapters 3 and 4.

2-2 Building Construction.

2-2.1 All buildings shall be of Type I or II construction, as defined in NFPA 220, *Standard on Types of Building Construction.* Where local, state, and national building codes require, modifications may be made to conform to these codes.

2-2.2* To facilitate cleaning and minimize combustible dust accumulation, interior surfaces shall be as smooth as possible, with fillets provided at floor and wall junctions wherever practical. Window ledges, girders, beams, and other horizontal projections or surfaces shall be designed to minimize the deposit of dust thereon.

2-2.3 Concealed spaces shall be sealed to prevent dust accumulation.

2-2.4 Interior walls erected as fire partitions shall be designed for a minimum fire endurance of one (1) hour.

2-2.5 Openings in fire walls shall be protected by automatic closing fire doors suitable for Class A openings and having a fire protection rating of three (3) hours. Fire doors shall be installed according to NFPA 80, *Standard for Fire Doors and Windows*, and shall normally be in the closed position.

2-2.6 Means of egress shall comply with NFPA *101®, Life Safety Code®*.

2-2.7 All penetrations of floors, walls, or partitions shall be dust-tight and, where structural assemblies have a fire endurance rating, the seal shall maintain that rating.

2-2.8 Interior stairs, elevators and manlifts shall be enclosed in dust-tight noncombustible shafts having a one (1) hour fire endurance rating. Doors of the automatic-closing or self-closing type, suitable for Class B openings and having a fire protection rating of one (1) hour, shall be provided at each landing.

Exception: Stairs, elevators, and manlifts serving only open-deck floors, mezzanines, and platforms need not be enclosed.

2-2.9* Floors and load bearing walls exposed to dust explosion hazards shall be designed to preclude failure during an explosion. (*See A-2-1.2.*)

2-3 Explosion Venting.

2-3.1 If a dust explosion hazard exists in rooms or buildings, such areas shall be provided with explosion venting to a safe outside location. The design of such explosion venting shall be based on information contained in NFPA 68, *Guide for Venting of Deflagrations.*

2-3.2 Explosion vents shall be restrained in such a way to prevent them blowing off uncontrollably and causing personnel injury or property damage.

2-3.3 Explosion vents shall be designed such that, once opened, they will remain open to prevent failure from the vacuum wave following the pressure wave.

Chapter 3 Process Equipment

3-1* General.

3-1.1 Equipment Explosion Protection.

3-1.1.1 In designing explosion protection for equipment, one of the following methods of protection shall be incorporated:

(a)* Equipment may be designed to contain the anticipated explosion pressure.

(b)* Explosion venting may be provided and, when used, design shall be based on information contained in NFPA 68, *Guide for Venting of Deflagrations*.

(c) An explosion suppression system may be provided and, when used, shall be designed in accordance with NFPA 69, *Standard on Explosion Prevention Systems*.

(d)* Inerting may be used to reduce oxygen content below the specific level for the material being handled. See NFPA 69, *Standard on Explosion Prevention Systems*.

3-1.2* Equipment Isolation. Major pieces of equipment shall be isolated to prevent explosion and flame propagation. The following methods may be used:

(a) Chokes.

(b) Rotary Valves.

(c) Fast Acting Dampers and Valves.

3-1.2.1* Rotary valves shall be designed to withstand the maximum anticipated explosion pressure.

3-1.2.2 Fast acting damper and valve systems shall be designed to fully close before passage of a dust explosion flame front.

3-1.3* Hybrid Mixtures. The presence of flammable gases and vapors, even at concentrations less than the lower explosive limit (LEL) of the flammable gases and vapors, will add to the violence of a dust-air combustion. The resulting dust/vapor mixture is called a hybrid mixture and is discussed in NFPA 68, *Guide for Venting of Deflagrations*.

3-2 Bulk Storage.

3-2.1 For the purpose of this section bulk storage includes such items as bins, tanks, hoppers, and silos.

3-2.2 Bulk storage containers, whether located inside or outside of buildings, shall be constructed of noncombustible material.

3-2.3 There shall be no intertank or interbin venting.

3-2.4 To facilitate cleaning and minimize combustible dust accumulation, interior surfaces shall be as smooth as possible, with fillets provided at floor and wall junctions wherever practical. Beams and other horizontal projections or surfaces shall be designed to minimize the deposit of dust thereon.

3-2.5 Access doors or openings shall be provided to permit inspection, cleaning, and maintenance. Access doors or openings shall be designed to prevent dust leaks and shall not be included in the required explosion relief area.

3-2.6 Bulk storage containers shall be provided with explosion protection as described in 3-1.1.

3-3 Material Transfer System.

3-3.1 Blowers. Blowers or exhaust fans shall be installed on proper foundations and secured in a substantial manner. Dust shall not pass through a fan or blower. For fans or blowers on the discharge side of dust collectors, it is permissible to pass product through a fan, provided that ample clearance shall be provided between the blades and the casing, and the normally expected dust concentration is below the minimum explosible concentration. All rotating elements shall be made of nonferrous material. The fan bearings shall not extend into the casings. Belt drives shall not be located inside the fan or blower housing. A clearance shall be provided between the shaft and casing.

3-3.2 Duct Systems.

3-3.2.1* Ducts handling combustible dust shall be constructed entirely of sheet metal or other noncombustible material, and of adequate strength and rigidity to meet the conditions of service and installation requirements, and shall be properly protected where subject to mechanical injury. All ducts, whether inside or outside of buildings, shall be thoroughly braced where required and substantially supported by metal hangers or brackets and shall be designed to afford strength and rigidity against disruption. All lap joints shall be made in the direction of the air flow.

3-3.2.2 All ducts shall be made reasonably dust-tight throughout and shall have no openings other than those required for the proper operation and maintenance of the system, i.e., clean-out panels, service access panels for explosion vents, etc.

3-3.2.3 Changes in size of ducts shall be by means of a taper transformation piece, the included angle of the taper being not more than 30^0.

3-3.2.4 The passing of ducts through a physical barrier for segregation shall be avoided.

3-3.3 Bucket Elevators.

3-3.3.1 Bucket elevators shall be provided with explosion protection as specified in 3-1.1. Bucket elevators, wherever possible, shall be located outside buildings. When explosion venting is provided, the bucket elevator shall be located as close as possible to exterior walls where explosion relief can be vented to the outside; if the distance between the head and boot exceeds 20 ft (6.1 m), explosion relief shall be provided at not more than 20 ft (6.1 m) intervals on the legs.

3-3.3.2 Elevator leg casings, head and boot sections, and connecting ducts shall be dust-tight and shall be constructed of noncombustible materials.

3-3.3.3 When provided, inlet and discharge hoppers shall be designed so that they are accessible for cleaning and inspection.

3-3.4 Conveyors.

3-3.4.1 All conveyors (i.e., screw, drag, pneumatic, etc.) shall be of substantial metal construction and designed to

prevent escape of combustible dusts. Coverings on clean-out, inspection, and other openings shall be securely fastened. This shall not prohibit the use of explosion relief vents.

3-3.4.2* Pneumatic systems shall be designed in accordance with NFPA 650, *Standard for Pneumatic Conveying Systems for Handling Combustible Materials.*

3-3.4.3 Conveyors shall be protected from explosion as specified in 3-1.1.

3-4 Size Reduction.

3-4.1 Size reduction equipment includes such items as mills, grinders, and pulverizers.

3-4.2 Before material is processed by size reduction equipment, foreign matter shall be removed as required by 5-1.1.

3-4.3 Size reduction equipment shall be isolated as required by 3-1.2.

3-4.4 Explosion protection shall be provided as specified in 3-1.1.

3-5 Particle Size Separation.

3-5.1* Screens, sieves, and similar devices shall have their reels or sieves in dust-tight enclosures. Connection ducts shall be of metal.

Exception: Where movement of the equipment is necessary, short flexible connections may be used. Such connectors shall be electrically conductive or bonded. (See 5-3.1.)

3-6 Mixers and Blenders.

3-6.1 Mixers and blenders shall be dust-tight. Foreign matter shall be removed as required by 5-1.1.

3-6.2 Explosion protection shall be provided as specified in 3-1.1.

3-6.3 Mixers and blenders shall be made of metal or other noncombustible material. Where provided, liners or interior coatings shall be of a conductive material.

3-7 Dryers.

3-7.1* A dryer, within the scope of this standard, is a piece of processing equipment used to reduce the moisture content of the material being handled.

3-7.2* Heating may be by direct or indirect means and shall be in accordance with 5-5.1.

3-7.3 Drying media which contacts material being processed shall not be discharged to the atmosphere or be recycled without passing through a filter, dust separator, or equivalent means of dust removal.

Exception: Drying media which contains combustible gases or vapors or hybrid mixtures shall not be recycled.

3-7.4 Dryers shall be isolated as required by 3-1.2.

3-7.5 Combustion controls on all heating mediums shall be provided in accordance with the following NFPA standards, as applicable:

NFPA 31, *Standard for the Installation of Oil Burning Equipment*

NFPA 85A, *Standard for Prevention of Furnace Explosions in Fuel Oil- and Natural Gas-Fired Single Burner Boiler-Furnaces*

NFPA 85B, *Standard for Prevention of Furnace Explosions in Natural Gas-Fired Multiple Burner Boiler-Furnaces*

NFPA 85D, *Standard for Prevention of Furnace Explosions in Fuel Oil-Fired Multiple Burner Boiler-Furnaces*

NFPA 85E, *Standard for Prevention of Furnace Explosions in Pulverized Coal-Fired Multiple Burner Boiler-Furnaces*

NFPA 86, *Standard for Ovens and Furnaces.*

3-7.6 Dryers shall be constructed of noncombustible materials.

3-7.7 Interior surfaces of dryers shall be designed so that accumulations of material are minimized and so that cleaning is facilitated.

3-7.8 Outward opening access doors or openings shall be provided in all parts of the dryer and connecting conveyors to permit inspection, cleaning, maintenance, and the effective use of portable extinguishers or hose streams.

3-7.9 Explosion protection shall be provided as specified in 3-1.1.

3-7.10 Dryer Operation.

3-7.10.1 Operating controls shall be designed, constructed, installed, and monitored so that required conditions of safety for operation of the air heater, the dryer, and the ventilation equipment will be maintained.

3-7.10.2 The drying chamber shall have an operating control arranged to maintain the temperature within the prescribed limits.

3-7.10.3 Extraneous material that would contribute to a fire hazard shall be removed from the commodity before it enters the dryer.

3-7.10.4 Operating personnel shall be fully instructed on the safe operation of the dryer, according to the manufacturer's operating instructions. Instruction shall include procedures to be followed in case of fire.

Chapter 4 Dust Control

4-1 Dust Collection.

4-1.1 Continuous suction shall be provided for processes where combustible dust is liberated in normal operation. The dust shall be conveyed to dust separators or collectors.

4-1.2 Dust collection systems shall comply with all requirements of NFPA 91, *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying.*

4-1.3 Dust collectors shall be located outside of buildings.

Exception No. 1: Dust collectors may be located inside of buildings if they are located adjacent to an exterior wall, are vented to the outside through straight ducts not exceeding 10 ft (3 m) in length, and have explosion vents designed according to information in NFPA 68, Guide for Venting of Deflagrations.

Exception No. 2: Dust collectors protected with an explosion suppression system meeting the requirements of NFPA 69, Standard on Explosion Prevention Systems, may be located inside buildings.

4-1.3.1 Dust collection equipment may be provided with other means of explosion protection, as specified in 3-1.1.

4-1.4 Manifolding of dust collection ducts shall not be permitted unless arranged in accordance with 4-1.4.1 and 4-1.4.2.

4-1.4.1 Dust collection ducts from a single piece of equipment or from multiple pieces not isolated from one another may be manifolded.

4-1.4.2 Dust collection ducts from single isolated pieces of equipment may be manifolded if each of the ducts is equipped with an isolation device just prior to manifolding.

4-1.5 Dust collectors shall be constructed of noncombustible materials. Cloth type collectors shall be provided with dust-tight metal enclosures or their equivalent.

4-1.6 Recycling of air from collectors to buildings shall be permitted if the system is designed to prevent both return of dust and transmission of energy from a fire or explosion to the building.

Exception: Recycling of air to the building shall not be permitted under any circumstances when hybrid mixtures or inert gases are involved.

4-2 Housekeeping. The requirements of 4-2.1 through 4-2.3 shall be applied retroactively.

4-2.1* Good housekeeping is of utmost importance. Equipment shall be designed, maintained, and operated in a manner which will minimize the escape of dust. Accumulations of dust shall not be tolerated. Horizontal surfaces such as ducts, pipes, hoods, ledges, and beams, on which quantities of dust may accumulate, shall be given particular attention.

4-2.2* Interior surfaces shall be cleaned in a manner that will minimize the generation of dust clouds. Vigorous sweeping, blowing down with steam or compressed air produces dust clouds and shall be permitted only if the requirements of 4-2.2.1 are met.

4-2.2.1 Blowdown with steam or compressed air may be performed if the following items are complied with:

(a) Area and equipment shall be vacuumed prior to blowdown.

(b) Electrical power and other sources of ignition shall be shut down or removed from the area.

(c) Only low pressure steam or compressed air shall be used.

4-2.3 When used, vacuum cleaners shall be approved for use in Class II hazardous locations, or shall be a fixed pipe suction system with remotely located exhauster and collector.

Chapter 5 Control of Ignition Sources

5-1 Friction.

5-1.1* Tramp Metal. Magnetic separators of the permanent magnet or self-cleaning electromagnetic type or pneumatic separators shall be installed to remove metal or foreign matter capable of igniting combustible material being processed. (*See figures in Appendix.*)

5-1.2 Drives and Transfer of Power. Transmission of power by direct drive shall be used where possible in preference to belt or chain drives. Where a belt drive is used, the drive train shall be designed to stall without slipping.

5-1.3 Bearings.

5-1.3.1 Roller or ball anti-friction bearings shall be used on all processing and transfer equipment. Lubrication inlets on all bearings shall be provided with dust caps or other tight closures.

5-1.3.2 Wherever possible, bearings shall be located outside the combustible dust stream where they will be less exposed to dust and more accessible for inspection and service.

5-1.4 Equipment.

5-1.4.1 Equipment shall be installed and maintained so that constant true alignment is maintained and adequate clearance provided to minimize friction.

5-1.4.2 Equipment such as screw conveyors or drag conveyors shall be arranged to vent or shut down if the discharge opening becomes plugged.

5-2 Electrical Equipment. All electrical equipment and installations shall comply with the requirements of NFPA 70, *National Electrical Code®* , NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, or NFPA 493, *Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous Locations*, as applicable.

5-3 Static Electricity. All machines and equipment, including duct work, storage bins, and permanently installed and portable vacuum cleaning systems, shall be bonded and grounded. Bonding minimizes the potential difference between metallic objects. Grounding minimizes the potential difference between objects and the ground. When belt drives are used, the belts shall be of electrically conductive material. Ionization methods shall be used to dissipate static electricity in nonconducting equipment. (NFPA 77, *Recommended Practice on Static Electricity*, provides information on this subject.)

5-4 Open Flames and Sparks. The requirements of 5-4.1 through 5-4.3 shall be applied retroactively.

5-4.1 Cutting and welding shall comply with the applicable requirements of NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes.*

5-4.2 A permit system shall be used for any process resulting in sparks or using open flames in areas where combustible dust is present. Precautions shall be similar to those required in 5-4.1 for cutting and welding operations.

5-4.3 Smoking shall only be permitted in designated areas.

5-5 Heating Systems.

5-5.1 Process Heating Systems.

5-5.1.1 Process heating systems using air, steam, or heat transfer fluids shall be provided with pressure relief valves where necessary. Relief valves on systems employing combustible heat transfer media shall be vented to a safe outside location.

5-5.1.2 Heaters for heat transfer media shall be located in a separate, dust-free room, building, or outdoors.

5-5.1.3 Air for combustion shall be taken from a clean outside source.

5-5.1.4 Heat exchangers shall be located and arranged in a manner which does not allow combustible dust to accumulate on coils, fins, or other heated surfaces.

5-5.2 Comfort Heating.

5-5.2.1 In areas containing combustible dust, comfort heating, if provided, shall be provided by indirect means or a means suitable for the location.

5-5.2.2 If used, hot water or low pressure steam (15 psig or less) shall be supplied by a boiler installed in accordance with 5-5.1.2.

5-5.2.3 Hot air heaters shall be installed in accordance with 5-5.1.2. Air containing combustible dust shall not be circulated back to the heater nor shall it be recirculated to nonhazardous areas of the building.

5-5.2.4 Steam and hot water supply pipes and hot air supply ducts in areas containing combustible dust shall be fitted with insulation having a continuous nonporous covering and having a thickness sufficient to keep the temperature of the outer surface below 80 percent of the minimum ignition temperature of the dust layer.

5-6 Hot Surfaces. The temperature of all exposed surfaces (engines, pipes, ducts, process equipment) within an area containing a combustible dust shall be maintained below 80 percent of the minimum ignition temperature of the dust layer.

5-7 Industrial Trucks. In areas containing a combustible dust hazard, only industrial trucks of a type suitable for the electrical classification of the area shall be used. (*See NFPA 505, Firesafety Standard for Powered Industrial Trucks, and Articles 500 and 502 of NFPA 70, National Electrical Code.*)

5-8 Powder Actuated Tools.

5-8.1 Powder actuated tools shall not be used in areas where combustible dust is present.

5-8.2 When the use of powder actuated tools becomes necessary, all dust producing machinery in the area shall be shut down, all equipment, floors, and walls shall be carefully cleaned and all dust accumulations removed.

5-8.3 A careful check shall be made after the work is completed to be sure that no cartridges or charges are left on the premises where they can enter equipment or be accidentally discharged after operation of the dust producing or handling machinery is resumed.

Chapter 6 Fire Protection

6-1 Fire Extinguishers. Portable fire extinguishers shall be provided throughout all buildings according to the requirements of NFPA 10, *Standard for Portable Fire Extinguishers.*

6-2 Hose, Standpipes and Hydrants.

6-2.1 Standpipes and hose, when provided, shall comply with NFPA 14, *Standard for the Installation of Standpipe and Hose Systems.*

6-2.1.1 Electrical (or equivalent) type spray nozzles shall be provided in areas containing dust in order to limit the potential for generating unnecessary airborne dust during fire fighting operations.

6-2.2 Private outside protection, including outside hydrants and hoses, when provided, shall comply with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*

6-3 Automatic Sprinklers. Automatic sprinklers, when provided, shall be installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

6-4 Special Fire Protection Systems. Automatic extinguishing systems or special hazard extinguishing systems, when provided, shall be designed, installed, and maintained in accordance with the following standards as applicable. The extinguishing system shall be designed to minimize the generation of dust clouds during their discharge.

(a) NFPA 11, *Standard for Low Expansion Foam and Combined Agent Systems*

(b) NFPA 11A, *Standard for Medium and High Expansion Foam Systems*

(c) NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*

(d) NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*

(e) NFPA 12B, *Standard on Halon 1211 Fire Extinguishing Systems*

(f) NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*

(g) NFPA 16, *Standard on Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*

(h) NFPA 17, *Standard for Dry Chemical Extinguishing Systems*

(i) NFPA 69, *Standard on Explosion Prevention Systems*

(j) NFPA 600, *Recommendations for Organization, Training, and Equipment of Private Fire Brigades.*

6-5 Alarm Service. Alarm service, if provided, shall comply with one of the following standards, as applicable:

(a) NFPA 71, *Standard for Signaling Systems for Central Station Service*

(b) NFPA 72A, *Standard for Local Protective Signaling Systems*

(c) NFPA 72B, *Standard for Auxiliary Protective Signaling Systems*

(d) NFPA 72C, *Standard for Remote Station Protective Signaling Systems*

(e) NFPA 72D, *Standard for Proprietary Protective Signaling Systems*

(f) NFPA 72E, *Standard on Automatic Fire Detectors.*

Chapter 7 Training and Inspection

7-1 Employee Training.

7-1.1 There shall be policies and requirements that provide for initial and continuing training for all employees. These shall include the development of operating procedures which are reviewed at least once per year, and after every process change.

7-1.2 All employees shall be carefully and thoroughly instructed at scheduled intervals regarding the hazards of their working environment, and their behavior and procedures in case of equipment or process failures that may result in fire and/or explosion.

7-2 Periodic Inspection.

7-2.1 A thorough systematic inspection for safe operation of items listed in 7-2.2 shall be made at regular intervals and shall be submitted to plant management for review.

7-2.2 The inspection shall include the following:

(a) fire and explosion protection and prevention equipment;

(b) dust control equipment;

(c) housekeeping;

(d)* electrical and mechanical equipment, including interlocks;

(e) procedures.

7-2.3 Competent persons shall conduct such inspections and the record of their findings and recommendations shall be permanently recorded in the principal plant office.

7-2.4* An emergency plan shall be maintained up-to-date and coordinated with existing local community emergency planning.

Chapter 8 Referenced Publications

8-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

8-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 10-1988, *Standard for Portable Fire Extinguishers*

NFPA 11-1988, *Standard for Low Expansion Foam and Combined Agent Systems*

NFPA 11A-1988, *Standard for Medium and High Expansion Foam Systems*

NFPA 12-1985, *Standard on Carbon Dioxide Extinguishing Systems*

NFPA 12A-1987, *Standard on Halon 1301 Fire Extinguishing Systems*

NFPA 12B-1985, *Standard on Halon 1211 Fire Extinguishing Systems*

NFPA 13-1987, *Standard for the Installation of Sprinkler Systems*

NFPA 14-1986, *Standard for the Installation of Standpipe and Hose Systems*

NFPA 15-1985, *Standard for Water Spray Fixed Systems for Fire Protection*

NFPA 16-1986, *Standard on Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*

NFPA 17-1985, *Standard for Dry Chemical Extinguishing Systems*

NFPA 24-1987, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*

NFPA 31-1987, *Standard for the Installation of Oil Burning Equipment*

NFPA 51B-1984, *Standard for Fire Prevention in Use of Cutting and Welding Processes*

NFPA 68-1988, *Guide for Venting of Deflagrations*

NFPA 69-1986, *Standard on Explosion Prevention Systems*

NFPA 70-1987, *National Electrical Code*

NFPA 71-1987, *Standard for the Installation, Maintenance, and Use of Signaling Systems for Central Station Service*

NFPA 72A-1987, *Standard for the Installation, Maintenance, and Use of Local Protective Signaling Systems for Guard's Tour, Fire Alarm, and Supervisory Service*

NFPA 72B-1986, *Standard for the Installation, Maintenance, and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service*

NFPA 72C-1986, *Standard for the Installation, Maintenance, and Use of Remote Station Protective Signaling Systems*

NFPA 72D-1986, *Standard for the Installation, Maintenance, and Use of Proprietary Protective Signaling Systems*

NFPA 72E-1987, *Standard on Automatic Fire Detectors*

NFPA 77-1988, *Recommended Practice on Static Electricity*

NFPA 80-1986, *Standard for Fire Doors and Windows*

NFPA 85A-1987, *Standard for Prevention of Furnace Explosions in Fuel Oil- and Natural Gas-Fired Single Burner Boiler-Furnaces*

NFPA 85B-1984, *Standard for Prevention of Furnace Explosions in Natural Gas-Fired Multiple Burner Boiler-Furnaces*

NFPA 85D-1984, *Standard for Prevention of Furnace Explosions in Fuel Oil-Fired Multiple Burner Boiler-Furnaces*

NFPA 85E-1985, *Standard for Prevention of Furnace Explosions in Pulverized Coal-Fired Multiple Burner Boiler-Furnaces*

NFPA 86-1985, *Standard for Ovens and Furnaces*

NFPA 91-1983, *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying*

NFPA *101*-1988, *Life Safety Code*

NFPA 220-1985, *Standard on Types of Building Construction*

NFPA 493-1978, *Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous Locations*

NFPA 496-1986, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*

NFPA 505-1987, *Firesafety Standard for Powered Industrial Trucks, Including Type Designations, Areas of Use, Maintenance, and Operation*

NFPA 600-1986, *Recommendations for Organization, Training, and Equipment of Private Fire Brigades*

NFPA 650-1984, *Standard for Pneumatic Conveying Systems for Handling Combustible Materials*

Appendix A

This Appendix is not a part of the requirements of this NFPA document, but is included for information purposes only

A-1-3 Combustible 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 three requirements, all of which must be met:

(a) The dust must be combustible.

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

(c) A source of ignition must be present.

Evaluation of a combustible dust explosion hazard and the prevention techniques employed shall be determined by means of actual test data. All combustible dusts that may 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.

Optional Testing.

(a) Dust cloud ignition temperature.

(b) Maximum permissible oxygen content to prevent ignition.

(c) Electrical resistivity measurement.

A-2-1.2 Where sections of walls are designed to remain after explosion venting, they should have a designed pressure retaining factor of at least five times that of the vent operating pressure.

A-2-2.2 Window ledges, girders, beams, and other horizontal projections or surfaces can have the tops sharply inclined, or other provisions can be made to minimize the deposit of dust thereon. Overhead steel I-beams or similar structural shapes can be boxed with concrete or other noncombustible material to eliminate surfaces for dust accumulation.

A-2-2.9 The use of load bearing walls should be avoided to prevent structural collapse should an explosion occur.

A-3-1 The following items are areas of concern during the design and installation of process equipment.

(a) The elimination of friction by use of detectors for slipping belts, temperature supervision of moving or impacted surfaces, etc.

(b) Pressure resistance or maximum pressure containment capability and pressure relieving capabilities of:

1. The machinery or process equipment.
2. The building or room.

(c) The proper classification of electrical equipment for the area and condition.

(d) Proper alignment and mounting to minimize or eliminate vibration and overheated bearings.

(e) The use of electrically conductive belting, low speed belts, and short center drives as a means of reducing static electricity accumulation. See Section 5-3.

(f) When power is transmitted to apparatus within the processing room by belt or chain, it should be encased in a practically dust-tight enclosure, constructed of substantial noncombustible material which should be maintained under positive air pressure. Where power is transmitted by means of shafts, these should pass through close-fitting shaft holes in walls or partitions.

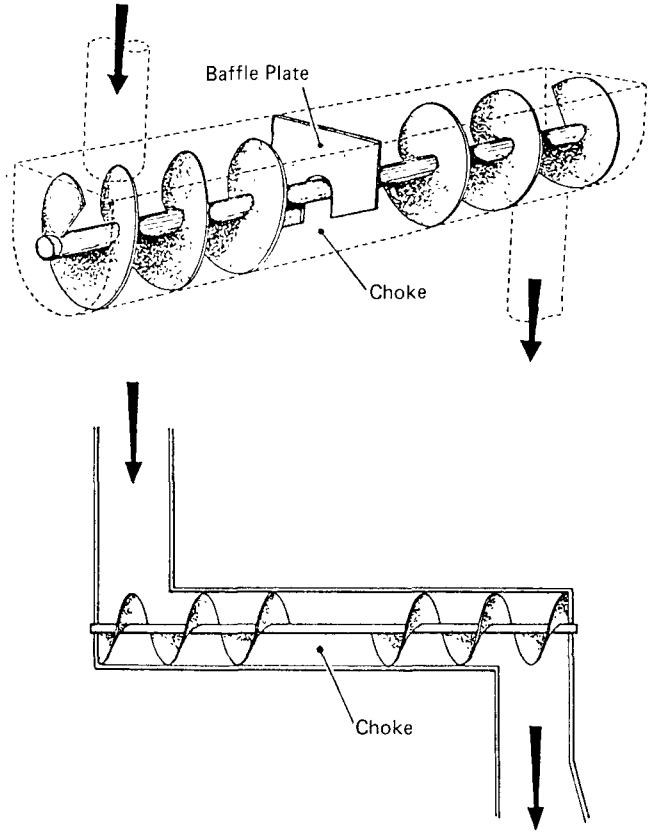
A-3-1.1.1(a) When equipment is designed to contain the explosion, the strength of the material used in the design calculations should be at least 90 percent of the ultimate strength of that material.

A-3-1.1.1(b) For explosion relief venting through ducts, consideration should be given to the thrust forces generated and the length of the ducts. The relief duct should be restricted to no more than three meters.

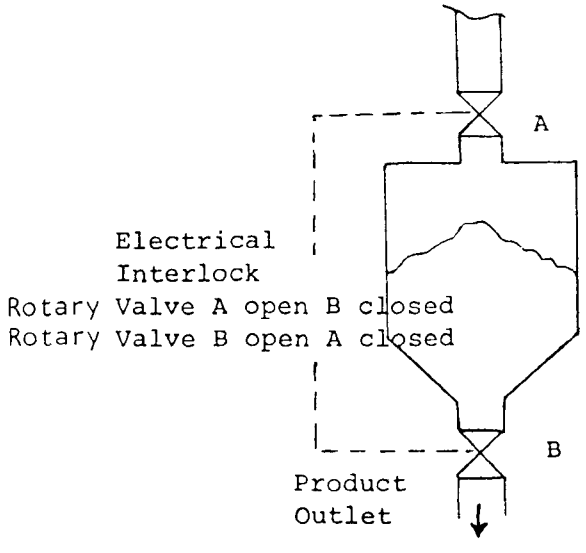
A-3-1.1.1(d) Inerting may be done by product dilution using a noncombustible dust, such as talc or lime, to reduce

the concentration of the combustible dust to below the minimum explosive concentration. This technique is used in coal mines.

A-3-1.2 The following diagrams illustrate the use of chokes.



A-3-1.2.1 When rotary valves are installed in both the inlet and outlet of equipment, care must be taken to ensure that the rotary valve on the inlet is stopped before the unit becomes overfilled. See the following diagram.



A-3-1.3 If the hydrocarbon concentration in a dust/air mixture is less than ⅓ of the lower explosive limit (LEL), the enhanced explosibility should be noted but a dust nomogram may still be used. For hydrocarbon concentrations above ⅓ of the LEL, consideration should be given to the presence of the hydrocarbon in the sizing of explosion venting.

Hybrid mixtures can be of concern even if the dust is normally considered to be "nonexplosive." For example, polyvinyl chloride is considered to be a "nonexplosive" dust. However, tests have shown that PVC can form explosive hybrid mixtures with methane at concentrations below the lower explosive limit.

Inerting should be used to prevent the hydrocarbon concentration from exceeding ⅓ LEL in a dust/air atmosphere.

A-3-3.2.1 Conveying dust systems should be as straight as possible, right angle bends being avoided.

A-3-3.4.2 Some plastics release flammable vapors such as residual monomer, resin thinners, or resin additives. These vapors may be released from the material in the conveying system or in its final storage unit. Design of the system should be based on a minimum air flow sufficient to keep the concentration of the particular flammable vapor in the air stream below 25 percent of the lower explosive limit of the vapor.

Startup and shutdown periods are the times when pneumatic conveying systems pass through the explosive range. Correct sequencing can reduce this:

Startup: Full air first; then full load dust flow

Shutdown: Dust stop quickly first; then run full air flow to clean.

A-3-5.1 Explosion protection should be provided when the hazard is significant. (*See 3-1.1.*)

A-3-7.1 Dryers commonly found in industry include tray, drum, rotary, fluidized bed, pneumatic, spray, and vacuum.

A-3-7.2 Heating by indirect means is less hazardous than by direct means and is therefore preferred. Improved protection can be provided for direct-fired dryers by providing an approved automatic spark detection and extinguishing system.

A-4-2.1 Historically, a relatively small initial dust explosion will disturb and suspend in air dust which has been allowed to accumulate on the flat surfaces of a building or equipment. This dust cloud provides fuel for the secondary explosion which usually causes the major portion of the damage. Housekeeping is, therefore, a major factor in reducing the damage in areas where a dust hazard may exist.

Using a bulk density of 75 lbs/ft^3 (1200 kg/m^3) and an assumed concentration of 0.35 oz/ft^3 (350 g/m^3), it has been calculated that a dust layer which averages $\frac{1}{32}$ in. (0.8 mm) thick covering the floor of a building is sufficient to produce a dust cloud, of optimum concentration, 10 ft (3 m) high, throughout the building. This is an idealized situation and several factors must be considered.

First, the layer will rarely be uniform or cover all surfaces and, secondly, the layer of dust will probably not be completely dispersed by the turbulence of the pressure wave from the initial explosion. However, if only 50 percent of the 1/32 in. (0.8 mm) thick layer is suspended, this is still sufficient material to create an atmosphere within the explosive range of most dusts.

Consideration must be given to the proportion of building volume which could be filled with an explosive dust concentration. Since floor area is a measure of volume, the percentage of floor area covered can be used as a measure of the hazard. For example, a 10 ft × 10 ft (3m × 3m) room with a 1/32 in. (0.8 mm) layer of dust on the floor is obviously hazardous and should be cleaned. Now consider this same 100 sq ft (9.3 m^2) area in a 2,025 sq ft (188 m^2) building; this also is a moderate hazard. This area represents about 5 percent of the floor area and is about as much coverage as should be allowed in any plant. To gain proper perspective, the overhead beams and ledges must also be considered. Rough calculations show that the available surface area of the bar joist is about 5 percent of the floor area. For steel beams, the equivalent surface area can be as high as 10 percent.

From the above information, the following guidelines are established:

(a) Dust layers 1/32 in. (0.8 mm) thick are sufficient to warrant immediate cleaning of the area (1/32 in. is about the diameter of a paper clip wire or the thickness of the lead in a mechanical pencil).

(b) The dust layer is capable of creating a hazardous condition if it exceeds 5 percent of the building floor area.

(c) Overhead beams and joists contribute significantly to the secondary dust cloud and are approximately equivalent to 5 percent of the floor area.

(d) The 5 percent factor should not be used if the floor area exceeds 20,000 sq ft (1858 m^2). In such cases, a 1,000 sq ft (93 m^2) layer of dust is the upper limit.

(e) Due consideration should be given to dust which adheres to walls since this is easily dislodged.

(f) Attention and consideration should also be given to other projections such as light fixtures which can provide surfaces for dust accumulation.

(g) Dust collection equipment should be monitored to be certain it is operating effectively. For example, dust collectors using bags operate most effectively between limited pressure drops of 3-5 in. of water (0.74-1.24 kPa). An excessive decrease or low drop in pressure indicates insufficient coating to trap dust.

The energy required to ignite dust in air is about 10.0 millijoules or 20 to 50 times greater than that required to ignite flammable vapors. Surface voltage of less than 5,000 volts might be considered safe except that such voltages may be indicative of higher voltages elsewhere in the system. Ungrounded metal parts having such high voltages would be hazardous because the energy stored and deliverable would be much greater. The minimum bond and ground wire size recommended is No. 8 or No. 10 AWG.

The above guides will serve to establish a cleaning schedule frequency.

A-4-2.2 Vacuum cleaning systems are preferred for this purpose.

A-5-1.1 See the following diagrams for examples of tramp metal removal.

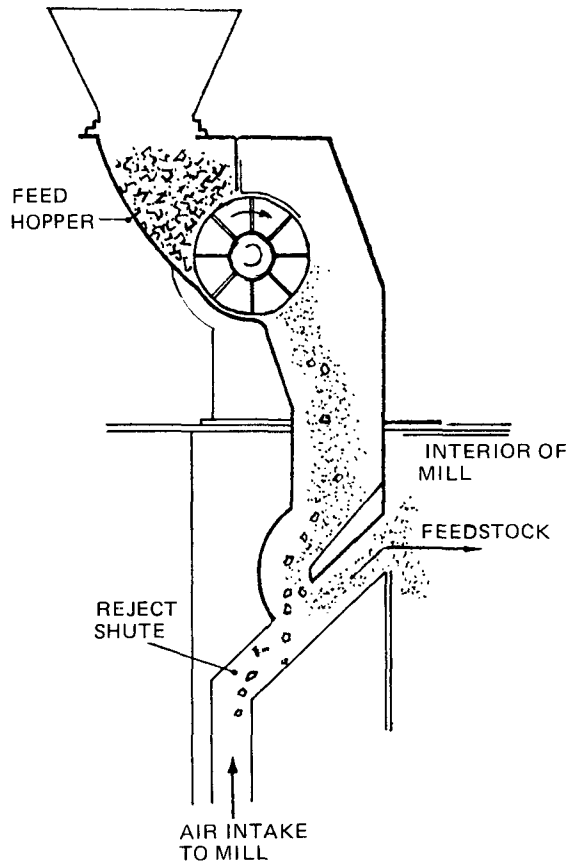


Figure A-5-1.1(a) Pneumatic Separator.

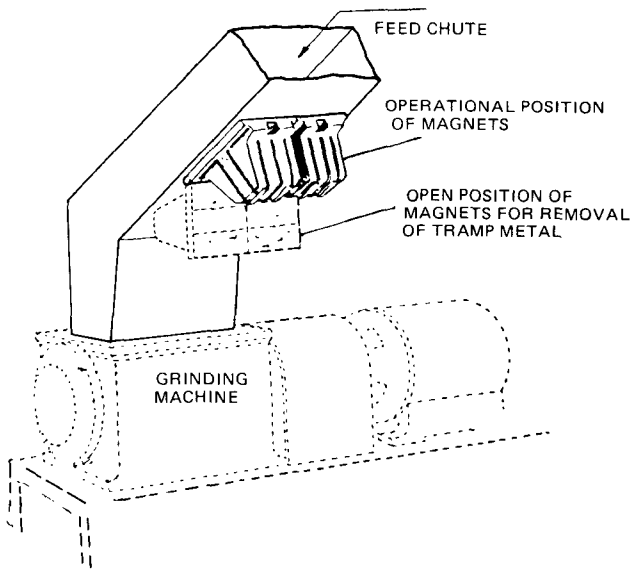


Figure A-5-1.1(b) Magnetic Separator.

A-7-2.2(d) Safety interlocks should be calibrated and tested every six months in the manner in which they are intended to operate with written test records maintained for review by management.

A-7-2.4 Emergency Plan. All plant personnel including management, supervisors, maintenance and operating personnel should be trained to participate in plans for controlling plant emergencies. Trained plant fire squads or fire brigades should be maintained.

The objectives of an emergency plan are to:

(a) Minimize the effect on operating personnel and the community.

(b) Keep property and equipment losses to a minimum.

(c) Assure inter-departmental and inter-plant cooperation.

(d) Assure the cooperation of outside agencies.

(e) Promote the release of accurate information to the public.

Simulated emergency drills should be performed by process operators. Malfunctions of the process should be simulated and emergency actions undertaken. "Disaster" drills which simulate a major catastrophe situation should be undertaken periodically with the cooperation and participation of public fire, police, and other local community emergency units and nearby cooperating plants. The emergency plans should be tested annually.

Appendix B Referenced Publications

B-1 The following documents or portions thereof are referenced within this standard for informational purposes only and thus are not considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

B-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 61A-1984, *Standard for the Prevention of Fire and Dust Explosions in Facilities Manufacturing and Handling Starch*

NFPA 61B-1980, *Standard for the Prevention of Fires and Explosions in Grain Elevators and Facilities Handling Bulk Raw Agricultural Commodities*

NFPA 61C-1984, *Standard for the Prevention of Fire and Dust Explosions in Feed Mills*

NFPA 61D-1984, *Standard for the Prevention of Fire and Dust Explosions in the Milling of Agricultural Commodities for Human Consumption*

NFPA 65-1987, *Standard for the Processing and Finishing of Aluminum*

NFPA 85F-1988, *Standard for the Installation and Operation of Pulverized Fuel Systems*

NFPA 490-1986, *Code for the Storage of Ammonium Nitrate*

NFPA 651-1987, *Standard for the Manufacture of Aluminum and Magnesium Powder*

NFPA 655-1988, *Standard for Prevention of Sulfur Fires and Explosions*

NFPA 664-1987, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*

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SUBMITTING PROPOSALS ON NFPA TECHNICAL COMMITTEE DOCUMENTS

Contact NFPA Standards Administration for final date for receipt of proposals on a specific document.

INSTRUCTIONS

Please use the forms which follow for submitting proposed amendments. Use a separate form for each proposal.

1. For each document on which you are proposing amendment indicate:
   (a) The number and title of the document
   (b) The specific section or paragraph.

2. Check the box indicating whether or not this proposal recommends new text, revised text, or to delete text.

3. In the space identified as "Proposal" include the wording you propose as new or revised text, or indicate if you wish to delete text.

4. In the space titled "Statement of Problem and Substantiation for Proposal" state the problem which will be resolved by your recommendation and give the specific reason for your proposal including copies of tests, research papers, fire experience, etc. If a statement is more than 200 words in length, the technical committee is authorized to abstract it for the Technical Committee Report.

5. Check the box indicating whether or not this proposal is original material, and if it is not, indicate source.

6. If supplementary material (photographs, diagrams, reports, etc.) is included, you may be required to submit sufficient copies for all members and alternates of the technical committee.

NOTE: The NFPA Regulations Governing Committee Projects in Paragraph 10-10 state: Each proposal shall be submitted to the Council Secretary and shall include:

(a) identification of the submitter and his affiliation (Committee, organization, company) where appropriate, and

(b) identification of the document, paragraph of the document to which the proposal is directed, and

(c) a statement of the problem and substantiation for the proposal, and

(d) proposed text of proposal, including the wording to be added, revised (and how revised), or deleted.

FORM FOR PROPOSALS ON NFPA TECHNICAL COMMITTEE DOCUMENTS

Mail to: Secretary, Standards Council
National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269

Date 5/18/85 Name John B. Smith Tel. No. 617-555-1212

Address 9 Seattle St., Seattle, WA 02255

Representing (Please indicate organization, company or self) Fire Marshals Assn. of North America

1. a) Document Title: Protective Signaling Systems NFPA No. & Year NFPA 72D

   b) Section/Paragraph: 2-7.1 (Exception)

2. Proposal recommends: (Check one) ☐ new text
   ☐ revised text
   ☒ deleted text.

3. Proposal (include proposed new or revised wording, or identification of wording to be deleted):

   Delete exception.

4. Statement of Problem and Substantiation for Proposal:

   A properly installed and maintained system should be free of ground faults. The occurrence of one or more ground faults should be required to cause a "trouble" signal because it indicates a condition that could contribute to future malfunction of the system. Ground fault protection has been widely available on these systems for years and its cost is negligible. Requiring it on all systems will promote better installations, maintenance and reliability.

5. ☒ This Proposal is original material.
   ☐ This Proposal is not original material; its source (if known) is as follows: _____

(Note: Original material is considered to be the submitter's own idea based on or as a result of his own experience, thought, or research and, to the best of his knowledge, is not copied from another source.)

I agree to give NFPA all and full rights, including rights of copyright, in this Proposal and I understand that I acquire no rights in any publication of NFPA in which this Proposal in this or another similar or analogous form is used.

John B. Smith
Signature

PLEASE USE SEPARATE FORM FOR EACH PROPOSAL