NFPA No.

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DUST EXPLOSION PREVENTION

PLASTICS INDUSTRY 1963

An American Standard

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International

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SHALL is intended to indicate requirements.

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Standard for the
Prevention of Dust Explosions
in the
Plastics Industry

NFPA No. 654—1963

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1963 Edition of No. 654

The 1963 edition of the Standard for the Prevention of Dust Explosions in the Plastics Industry was prepared by the Sectional Committee on Miscellaneous Dusts and adopted by the National Fire Protection Association at the 1963 Annual Meeting, on recommendation of the Committee on Dust Explosion Hazards. The 1963 edition is a complete revision of the 1959 edition which it supersedes. The 1963 revision makes the Standard applicable to present-day practices in the plastics industry. This edition was approved as an American Standard by the American Standards Association on June 27, 1963.

Origin and Development of No. 654

This standard was initiated by the Committee on Dust Explosion Hazards in 1943, was tentatively adopted in 1944, and was finally adopted in 1945. Amendments were adopted in 1946, 1959, and 1963.

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Standard for the
Prevention of Dust Explosions
in the
Plastics Industry

NFPA No. 654—1963

CHAPTER 1. INTRODUCTION

11. Purpose and Scope

111. This Standard is issued as a guide to eliminate or reduce the dust explosion hazards inherent in the manufacture, fabrication, molding, and handling of plastics including the handling of raw materials. This Standard is intended to apply to new construction and rebuilt or remodeled plants. It is advisable, wherever possible, to remodel present installations to conform with this Standard.

112. This Standard applies to the entire plastics industry.

12. Fundamental Principles of Dust Explosion Prevention

121. It is essential that the escape and dispersion of dust into the atmosphere of the plant be kept to a minimum. It is important that provisions be made to reduce the possibility of ignition, relieve explosion pressure, and to confine and control fire.

122. The presence of flammable vapors in equipment containing air may introduce an additional hazard.

13. Classification of Plastics

131. Plastics are thermoplastic or thermosetting, depending upon basic physical characteristics and properties, particularly the behavior toward heat. Thermoplastic resins are those which soften by heating and reharden by cooling. Thermosetting resins are those which become substantially infusible or insoluble products when cured by heat, pressure, or chemical means; these materials soften when initially heated and become permanently hard on continued heating as the final curing completes a chemical change. Table 1 is a classification of materials as generally used in the industry.

14. Hazard Rating of Plastics

141. The degree of explosion hazard varies primarily with the type of dust and the methods used in processing. The relative hazard of different materials are listed in Table 2 in order of decreasing explosibility; the hazard is characterized by an index number. The position of each type of material in the list is determined by the sample within the subclass having the highest index of explosibility. The arrangement is not exact because of the wide range of indexes within the group; variation in index is attributed to differences in chemical composition, particle size distribu-

TABLE 1. Classification of Materials as Generally Used in the Plastics Industry

Reprinted by permission from Bureau of Mines Report of Investigations 5971.

Class A. — Thermoplastic resins and molding compounds:

I .... Acetal.
II .... Acrylic.
III .... Cellulosic.
IV .... Chlorinated polyether.
V .... Fluorocarbon.
VI .... Nylon (polyamide).
VII .... Polycarbonate.
VIII ...... Polyethylene.
IX .... Polymethylene.
X .... Polypropylene.
XI .... Rayon.
XII .... Styrene polymers and copolymers.
XIII ...... Vinyl polymers and copolymers.

Class B. — Thermosetting resins and molding compounds:

I .... Alkyd.
II .... Allyl.
III .... Amino (melamine and urea).
IV .... Epoxy.
V .... Furane.
VI .... Phenolic (phenol formaldehyde).
VII .... Polyester.
VIII ...... Polyurethane (isocyanate).

Class C. — Special resins and molding compounds:

I .... Cold molded (asphalt and gilsonite).
II .... Coumarone — indene.
III .... Natural (gums, lignin, rosin, shellac, and cashew oil resin).
IV .... Rubber (natural and synthetic).
V .... Miscellaneous.

Class D. — Ingredients.

Class E. — Fillers:

I .... Cellulosic.
II .... Mineral.

TABLE 2. Summary of Explosibility of Materials

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Material		Range of explosibility index	Material presenting maximum explosion hazard
Type	Class		
Natural resins	C III	0.3->10	Rosin, DK.
Ingredients	D	<.1->10	Hexamethylene tetramine.
Coumarone-indene resins	C II	>10	Coumarone-indene resin, hard.
Miscellaneous resins	C V	<.1->10	Petrin acrylate monomer, crude.
Cellulosic resins	A III	<.1->10	Ethyl cellulose molding compound.
Phenolic resins	B VI	<.1->10	Phenol formaldehyde molding compound, cotton-flock filled.
Furane resins	B V	>10	Phenol furfural resin.
Polyethylene resins	A VIII	3.5->10	Polyethylene, low-pressure process.
Styrene polymer resins	A XII	.9->10	Polystyrene latex, spray-dried, with surfactants.
Acrylic polymer resins	A II	<.1->10	Methyl methacrylate-ethyl acrylate copolymer.
Polyester resins	B VII	4.9->10	Dimethyl terephthalate.
Epoxy resins	B IV	1.9->10	Epoxy resin.
Vinyl polymer resins	A XIII	<.1->10	Vinyl multipolymer, with vinylidene cyanide.
Allyl resins	B II	<.1->10	Allyl alcohol derivative, CR-39 resin, from dust collector.
Cellulosic fillers	E I	<.1->10	Wood flour.
Polyurethane resins	B VIII	>10	Polyurethane foam, fire-retardant.
Polypropylene resins	A X	<.1->10	Polypropylene, no anti-oxidant.
Cold-molded res.	C I	6.4->10	Petroleum resin, regular.
Acetal resin	A I	>10	Acetal resin (poly-formaldehyde).
Nylon polymer r.	A VI	4.0->10	Nylon polymer resin.
Rubber	C IV	<.1->10	Rubber, synthetic.
Amino resins	B III	<.1->10	Urea formaldehyde molding compound, grade II, fine.
Polycarbonate r.	A VII	8.6	Polycarbonate resin.
Rayon	A XI	.1- 0.2	Rayon (viscose) flock, 1.5-denier, 0.02-inch, maroon.
Chlorinated polyether resin	A IV	.2	Chlorinated polyether alcohol resin.
Polymethylene r.	A IX	<.1	Carboxypolymethylene resin.
Alkyd resins	B I	<.1	Alkyd molding compound, mineral filler, not self-extinguishing.
Fluorocarbon resins	A V	≪.1	Fluoroethylene polymer resins.
Mineral fillers	E II	0	Asbestine, asbestos, mica.

tion, particle shape and treatment, and to the inherent variability in the test results used to evaluate the explosibility parameters.

142. To facilitate evaluating the explosibility of dusts and to provide a numerical rating for the relative hazard, an empirical index has been developed by the Bureau of Mines. The index is not derived from theoretical considerations, but provides a rating of explosibility which is consistent with research observations and experience. The potential hazard of a dust is related to its ignition sensitivity and to the severity of the subsequent explosion. Ignition sensitivity is considered a function of ignition temperature, minimum igniting energy, and minimum explosion concentration; explosion severity is related to maximum explosion pressure and rate of pressure rise. Ignition sensitivity and explosion severity relative to Pittsburgh (Pgh.) coal are defined as follows:

$$\text{Ignition sensitivity} = \frac{(\text{Ign. temp.} \times \text{min. energy} \times \text{min. conc.})\ \text{Pgh. coal dust}}{(\text{Ign. temp.} \times \text{min. energy} \times \text{min. conc.})\ \text{sample dust}}$$

$$\text{Explosion severity} = \frac{(\text{Max. explosive press.} \times \text{max. rate of press. rise})\ \text{sample dust}}{(\text{Max. explosive press.} \times \text{max. rate of press. rise})\ \text{Pgh. coal dust}}$$

a. The index of explosibility is the product of the ignition sensitivity and the explosion severity. This index is a dimensionless quantity having a numerical value of 1.0 for a dust equivalent in explosibility to the standard Pittsburgh coal. An index greater than 1.0 indicates a hazard greater than that for the coal dust. The notation <<0.1 designates materials presenting primarily a fire hazard as ignition of the dust cloud is not obtained by spark or flame, but by a surface heated to a relatively high temperature.

b. The relative explosion hazard of a dust may be further classified by ratings of weak, moderate, strong, or severe. These ratings are correlated with the empirical index as follows:

Relative explosion hazard rating	**Ignition sensitivity**	**Explosion severity**	**Index of explosibility**
Weak	<0.2	<0.5	<0.1
Moderate	0.2-1.0	0.5-1.0	0.1-1.0
Strong	1.0-5.0	1.0-2.0	1.0-10
Severe	>5.0	>2.0	>10

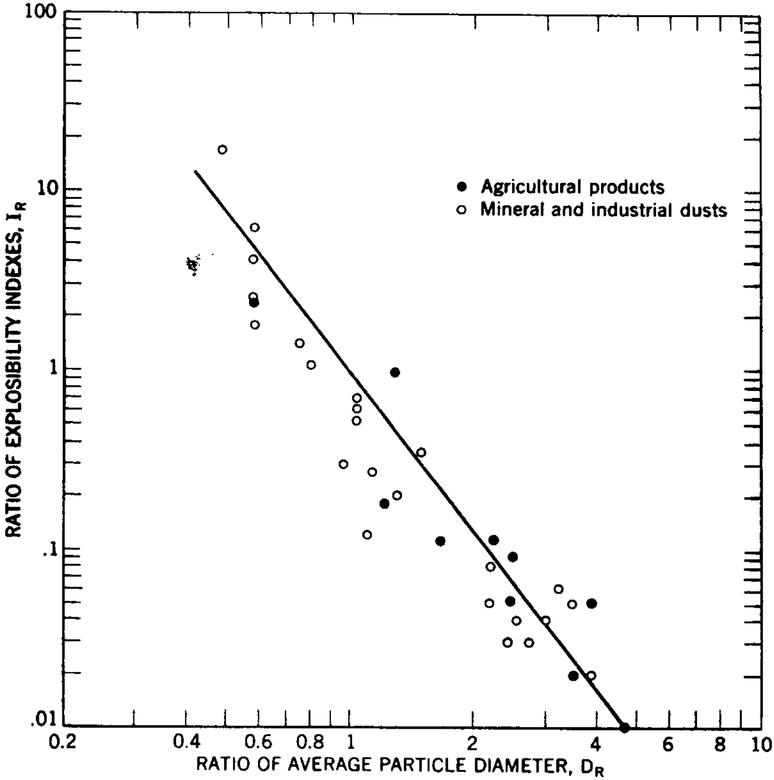

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Figure 1. Effect of particle diameter on relative explosibility index. Relative average particle diameter is the ratio of the mean particle size of the dust to the mean size of the through No. 200 sieve sample. Relative explosibility index is the ratio of the index computed for the dust to that computed for a through No. 200 sieve sample.

c. In calculating explosion severity, values of explosion pressure and maximum rate of pressure rise at a dust concentration of 0.50 oz./cu. ft. are considered. (See Appendixes A and B for characteristics of various materials.)

143. Explosibility of dusts increases with decrease in particle size. Figure 1 shows the effect of relative mean particle diameter on the relative explosibility index. The relative particle diameter is the ratio of the mean particle size of the dust to the mean size of the through No. 200

sieve sample; and the relative explosibility index is the ratio of the index computed for the dust to that computed for a through No. 200 sieve sample. These data indicate the explosibility index is approximately inversely proportional to the cube of the relative mean particle diameter. (See Bureau of Mines Report of Investigations 5753, Explosibility of Agricultural Dusts,* for complete details.) For this reason it is advisable to reduce the production of fines as much as practicable.

144. The following observations of factors affecting explosibility of dusts were published in Bureau of Mines Report of Investigations 5971, Explosibility of Dusts Used in the Plastics Industry.*

PARTICLE SHAPE — In general, dusts composed of irregular shaped particles present a greater hazard than those composed of spherical particles.

ADDITIVES — Explosion hazards of molding compounds tend to increase with addition of combustibles, which in themselves present a strong to severe hazard. Admixing of noncombustible fillers such as asbestos, glass, and mica tends to decrease the hazard. Incorporation of low percentages of a fire retardant has little effect on explosibility.

RESIN STRUCTURE — Generally, the basic chemical structure of the resin governs its explosibility. Incorporation of halogens and substitution of a relatively nonflammable salt of a compound for the more flammable compound tends to reduce the potential explosion hazard. In some cases, modification of the resin structure affects its explosion hazard. Explosibility of the formaldehyde resins, melamine, urea and phenol appears to increase as the nitrogen content of the primary ingredients (exclusive of formaldehyde) decreases. Little difference in explosibility was noted between the polyethylene, polypropylene and polystyrene resins.

COPOLYMERIZATION — The explosion hazard of copolymerized materials is essentially related to the explosibility of the separate compounds.

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*Published by Bureau of Mines, 4800 Forbes Avenue, Pittsburgh 13, Pennsylvania.

15. Definitions

151. In this Code, the following words are used as defined below:

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. They may be thermoplastic or thermosetting.

MOLDING COMPOUND — A mixture of resins, ingredients, and fillers before processing into the finished product.

RESIN — A synthetic addition or condensation polymerization substance or a natural substance of high molecular weight, which under heat, pressure, or chemical treatment becomes moldable.

INGREDIENT — The primary and higher order reactant of the resins and the chemical constituents of the molding compound, such as plasticizer, lubricant, solvent, catalyst, stabilizer, fire retardant, hardener, and coloring compound.

COMBUSTIBLE DUST — A dust which presents an explosion hazard when dispersed in air.

PULVERIZING — Pulverizing refers to the process of reducing material to dust form, as by grinding, crushing, or rolling.

SHALL is intended to indicate requirements.

SHOULD is intended to indicate recommendations or that which is advised but not required.

APPROVED refers to approval by the authority having jurisdiction in the enforcement of the regulations.

The terms ADEQUATELY, EFFECTIVE and SECURELY shall be interpreted as conditions subject to determination of the authority having jurisdiction.

CHAPTER 2. PLANT ARRANGEMENT AND BUILDING CONSTRUCTION

(See also Chapter 3 for required or recommended location and arrangement of processing equipment.)

21. Segregation of Dust Handling and Processing Areas

211. Buildings in which combustible dusts are processed and handled should be detached or separated by standard fire walls from the resin manufacturing department, storage areas, and other departments.

212. The processes that cannot be located as recommended in Section 211, shall be segregated in such a manner as to minimize the possibility of an explosion or fire damaging other portions of the plant.

22. Building Construction

221. New buildings for handling and processing of combustible dusts shall be of fire-resistive or noncombustible construction except as modified in Section 231. Existing buildings of combustible construction, in which combustible dusts are handled and processed, shall be modified to prevent dust accumulations and to facilitate cleanup.

222. To facilitate cleaning, interior surfaces should 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 should have the tops sharply inclined, or other provision shall be made to minimize the deposit of dust thereon. Overhead steel I-beams or similar structural shapes shall be "boxed" with concrete or other fire-resistive material to eliminate surfaces for dust accumulation.

223. Concealed spaces are to be sealed so that dust accumulation is not possible.

224. Access to areas handling and processing combustible dusts shall be from the outside wherever possible. Doors at such openings shall open out and shall be of light construction, unless openings are seriously exposed by other buildings, in which event standard hinged self-closing fire doors suitable for Class A openings, opening out, shall be

provided. Where direct communications from combustible dust handling areas to nonhazardous areas are necessary, these openings should be protected by standard hinged self-closing fire doors suitable for Class A openings, swinging outward from the room in which the hazardous processes are conducted; when safe egress to the outside is provided, standard automatic sliding doors suitable for Class A openings, normally kept shut, may be used in the communicating openings. (See Standard for the Installation of Fire Doors and Windows, NFPA No. 80.)

225. All pipe openings through floors, walls or partitions shall be dust-tight.

226. Conveyors, spouts, chutes and elevator enclosures shall be of substantial metal construction and practically dust-tight.

227. With the exception of spouts and conveyors for raw material or for finished product in bulk, no conveyors, spouts, chutes, etc., shall pass through any wall or floor separating the pulverizing department from other portions of the building. Finished products may be delivered through a wall or floor of the pulverizing department to adjacent departments provided the material passes through an effective seal.

228. Many different types of seals, such as rotary valves, have been developed for use with conveyors, feeding devices and other equipment. This Code does not imply that such devices are always effective in preventing fire or explosion propagation. The selection and installation of seals should be made in each case with technical knowledge or advice on the characteristics of the product being handled and other factors which may have a bearing on the effectiveness of certain types of seals.

229. Material may be conveyed from the pulverizing department to other departments by means of "en masse" or drag type conveyors, provided:

(1) The conveyor housing is of substantial, dust-tight metal construction.

(2) The adjustable bearings are on the end of the conveyor located within the pulverizing department.

(3) The bearings at the discharge end of the conveyors are fastened to the conveyor housing in such a manner as to be dust-tight.

(4) The conveyor shall discharge through an effective seal.

(5) The number and size of the openings through which any of the above conveyors pass through the walls of the pulverizing area to adjacent areas shall be held to the minimum necessary for installation and maintenance of the conveyor.

23. Explosion Venting

231. Explosion venting shall be provided in a room or space in which dusts presenting an explosion hazard are processed. The effective venting area should approach as nearly as possible a ratio of 1 square foot to 35 cubic feet of room volume. This may be accomplished by making all, or sections of, exterior walls and/or roof of light noncombustible material, or by the use of approved automatic pressure relief devices such as windows or panels designed to open outward under a predetermined pressure and remain open. Windows may be glazed with plastic blowout panes and wall or roof sections replaced with plastic blowout panels. The use of combustible plastics should be referred to the authority having jurisdiction.

232. The lighter the exterior wall construction, the less damage will result from an explosion. It is necessary, however, to provide sufficient strength and anchorage to withstand possible snow and wind loads.

233. The Guide for Explosion Venting, NFPA No. 68, should be used to guide design of explosion venting.

CHAPTER 3. EXPLOSION PREVENTIVE MEASURES

31. Pneumatic Conveying

311. Pneumatic conveying (including fluidized systems) of combustible dusts requires careful design to minimize and/or eliminate the hazards of dust explosion and fire. For this type of conveying inert atmospheres are preferred and should be used to prevent a dust explosion. When air is used for conveying, the design and location of the conveying system must be given careful consideration. An effective seal shall be used between the charging hopper and conveying pipe.

312. All sections of piping and all parts of the apparatus shall be electrically bonded and grounded effectively in accordance with the Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying, NFPA No. 91. (See also Static Electricity, NFPA No. 77M.)

32. Installation of Equipment

321. All apparatus should be properly and securely installed to:

(1) Insure true alignment.
(2) Avoid friction and hot surfaces.
(3) Provide dust-tight bearings.
(4) Provide arrangement of unit systems so that each grinder will deliver to one set of scalpers, bolters and other processing equipment of the same unit. Interconnections between different sets of apparatus should not be permitted.
(5) Prevent leaks of combustible dust to the room.
(6) Reduce the chance of ignition of dust.
(7) Localize the results of ignition of the dust.

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

323. All combustible dust 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 should not be construed to prohibit the use of explosion relief vents.) All conveyors should be designed and constructed to withstand the anticipated explosion pressure, considering the pressure release afforded by explosion relief vents. (See Section 421 for location of bucket elevators.)

324. Mills delivering directly through spouts should be provided with devices in the discharges to retard the flow of product, thereby keeping a small space immediately underneath or near the discharge filled up with the pulverized product. This can be effected by a seal (see Section 228). Chutes or ducts from bins or hoppers delivering stock to apparatus in which a fire might occur should be similarly protected.

325. Blowers or exhaust fans shall be installed on proper foundations and secured in a substantial manner. The exhaust fan should be located after the collector. When a fan is located between the primary and secondary collectors, ample clearance shall be provided between the blades and the casing. The fan bearings shall not extend into the casings. Belt drives should not be located in a conveyor gas stream. (See Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying, NFPA No. 91.)

326. Screens, scalpers, bolters and similar devices shall have their reels or sieves in dust-tight enclosures. Connecting ducts shall be of metal. Care should be taken to bond and ground all parts of these devices securely.

327. All dust collectors (except those of cloth type) shall be constructed throughout of noncombustible materials. Cloth-type collectors should be provided with dust-tight metal enclosures or their equivalent. Such collector housings should be designed and constructed to withstand anticipated explosion pressures considering the pressure release afforded by explosion relief vents. (See Section 411 for location of collectors.) Flameproofing of fabric is desirable.

33. Removal of Static Electricity

331. To prevent static electricity accumulation, all machines and equipment, including duct work and permanently installed or portable vacuum cleaning systems and equipment, shall be bonded and grounded. Grounded metal combs or other effective methods shall be provided for belts. The use of conductive belting and low belt speeds and short center drives is highly recommended as a means of reducing the accumulation of static. Grounding connections shall be secured to equipment and to the earth in accordance with Static Electricity, NFPA No. 77M.

34. Removal of Foreign Materials

341. All of the stock delivered to the mills shall pass over magnetic separators of the self-cleaning type, interlocked with the grinder drive, and the stock shall be protected against contamination of foreign materials in its passage to the mills. The separators shall be of sufficient size to expose and insure the removal of all ferrous materials passing over them.

342. Open charging hoppers on a floor above a mill should be provided with a protective grating to prevent entry of foreign objects. Such charge hoppers should be provided with hoods with suction connections to a dust removal system, or other suitable means provided to prevent the escape of dust into the operating area.

343. Inspection openings in the grinding apparatus shall be provided with protective screens having openings not larger than ½ inch in any dimension in order to prevent entry of foreign objects.

35. Inert Gas Atmospheres

351. The use of inert gas is urged to create safe atmospheres within mills and other apparatus, especially those handling exceedingly fine stock. In using controlled oxygen atmospheres, it is desirable to maintain as low an oxygen content as practical as a safeguard against abnormal conditions. With potential igniting sources such as static or friction sparks, the presence of glowing particles, or possi-

bly the flame from a match, the limiting or terminal values reported in Appendix A for the electric spark igniting source should provide adequate protection. For protection where strong igniting sources are present, the oxygen content of the atmosphere should be maintained at least 6 per cent lower than the values reported for the spark igniting source. As the reported data contain no factor of safety and because of possible leaks in the system, failure of inert gas supply, non-uniformity of flow patterns, etc., consideration should be given to reducing oxygen concentrations below the listed values. (See Standard for Inerting for Fire and Explosion Prevention, NFPA No. 69.) If positive means is provided for maintaining an inert atmosphere in bins and equipment, the explosion venting requirements of this Section may be modified by the authority having jurisdiction.

36. Control of Open Flames, Sparks, Heat

361. No open flames of any kind including cartridge powered gun-type tools nor any operations or repairs resulting in sparks or utilizing direct fire or heat shall be permitted in the combustible dust processing department until all equipment has ceased operating. The room and equipment must be carefully cleaned of dust. Combustible material shall be moved to a safe location. Care shall be taken to see that the air in the room is free from dust and the sprinkler system is in service. Hose equipped with a water spray nozzle, and an extinguisher suitable for Class A fires shall be available. It is desirable that the area be wetted down and a fire watch maintained. A careful check shall be made to be sure that no cartridges or charges are left on the premises where they could enter equipment or be accidentally discharged after operation of the dust-producing or dust-handling machine is resumed.

362. The importance of close control of "open flame or hot work" in a combustible dust-processing department cannot be minimized. To effectively control "open flame or hot work," the "open flame or hot work permit" system shall be used. The authority having jurisdiction should be consulted for aid in establishment of this system.

37. Electrical Equipment

371. Electrical equipment in all rooms and spaces where combustible dusts are stored, handled and processed should conform to the regulations of Article 502 of the National Electrical Code, NFPA No. 70.

38. Housekeeping

381. Good housekeeping is an extremely important factor; apparatus which will not leak and permit the escape of dust or sifting out of the material is essential. Hazardous accumulations of dust in the atmosphere and building shall not be tolerated. Particular attention should be paid to horizontal surfaces such as ducts, pipes, hoods, ledges, and beams, on which quantities of dust may accumulate. It is recommended that the interior of the dry powder processing department be painted a color which is in contrast to that of the dust.

382. Interior surfaces shall be cleaned in such a manner as to minimize the scattering of dust to other places. To this end it is recommended that dust removal be accomplished by a vacuum-sweeping system.

383. Cleaning that will produce dust clouds (i.e., vigorous sweeping, blowing down with steam, compressed air, etc.) shall not be done.

384. Portable vacuum cleaners, of an approved type for hazardous locations, or fixed pipe suction systems with remotely located exhauster and collector, shall be used for cleaning. Suction-cleaning appliances should be connected by hose to taps of permanent piping extending to a suction fan or equivalent. All hose terminals shall be bonded and grounded.

385. The exhauster and the collector for the vacuum cleaning system shall be located outside the combustible dust-processing department. (See Section 411.)

386. Permanently piped dust collecting systems for cleaning purposes should be independent of all other dust collecting systems.

CHAPTER 4. MINIMIZING THE EFFECT OF DUST EXPLOSIONS IN EQUIPMENT

41. Dust Separators and Collectors

411. All cyclone separators and dust collectors shall be located as follows:

(1) On the roof.
(2) Outside and adequately detached from buildings.
(3) In segregated sections of the building with room explosion venting.
(4) In separate buildings with room explosion venting.
(5) In penthouses with room explosion venting.

(See Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying, NFPA No. 91.)

42. Bucket Elevators

421. Bucket elevators, wherever possible, should be located outside buildings. Where it is necessary to locate them inside, they should be located as close as possible to exterior walls to facilitate explosion relief venting to atmosphere. (See the Guide for Explosion Venting, NFPA No. 68.)

43. Stock Bins

431. All combustible dust stock bins which do not have sufficient strength to resist anticipated explosion pressure should be located to facilitate explosion relief venting.

44. Equipment Strength and Explosion Venting

441. Dust arrestors, separators, collectors, elevators, stock bins, ducts, blenders, mills and spray dryers shall be constructed to withstand anticipated explosion pressures, consideration being given the reduction in pressure afforded by explosion relief vents. Depending upon strength and dimensions of the apparatus involved, as well as the nature and state of the stock handled, explosion relief vents may be required at intermediate points as well as at terminals of equipment such as bucket elevators and screw conveyors and especially at turns in ducts. (See Guide for Explosion Venting, NFPA No. 68.)

45. Elimination of Pockets in Conveying Apparatus

451. Unused plugged outlets, dead-ends, or other pockets in ducts, pipe lines, or other conveying apparatus where dust might accumulate shall not be permitted.

46. Design of Explosion Relief Vents

461. Explosion relief vents shall be of adequate size and design to prevent rupture of the device or apparatus protected. The explosion vent ducts shall be properly designed, substantially constructed of metal and extend out-of-doors as directly as possible, avoiding sharp turns. Explosion vent ducts shall not pass through an adjoining building or room. (See Guide for Explosion Venting, NFPA No. 68.)

462. For weather protection explosion relief vents should be terminated with cowls or hoods. Rupture diaphragms should be preferably fitted with cutters to accelerate rupture. (See Guide for Explosion Venting, NFPA No. 68.)

CHAPTER 5. FIRE PROTECTION

51. Fire Protection for Buildings

511. The buildings or rooms in which the storage, processing, and handling of combustible dust are conducted shall be protected by a system of hydraulically designed, approved automatic sprinklers and shall be equipped with approved portable fire extinguishers, together with approved small hose. Straight stream nozzles shall not be used because of their ability to produce dust clouds. (See the Standard for the Installation of Sprinkler Systems, NFPA No. 13, the Standard for the Installation of Standpipe and Hose Systems, NFPA No. 14, the Standard for the Installation, Maintenance and Use of Portable Fire Extinguishers, NFPA No. 10.)

52. Fire Protection for Apparatus

521. Apparatus of large volume in which pulverized stock is stored or may accumulate, such as bins, silos, and dust collectors, shall be protected by:

(1) Automatic sprinklers or fixed-pipe inert gas extinguishing systems, or both; means shall be provided to close automatically all openings to the enclosure involved; also, to shut down all blowers in connection therewith in order to confine the extinguishing agent and prevent the spread of fire.

(2) Explosion detection and suppression techniques may be used to advantage in controlling or minimizing explosions in equipment. (See Standard for Inerting for Fire and Explosion Prevention, NFPA No. 69.)

APPENDIX A — INDEX OF EXPLOSIBILITY, IGNITION CHARACTERISTICS, MINIMUM EXPLOSIVE CONCENTRATION AND LIMITING OXYGEN CONCENTRATION OF ATMOSPHERE FOR DUSTS

Compiled from data published in Bureau of Mines Report of Investigations 5971

Material	**Index of Explosibility**	**Ignition temperature °C.**		**Minimum igniting energy for dust cloud, joule**	**Minimum explosive concentration, oz./cu. ft.**	**Relative flammability, percent inert**		**Limiting oxygen concentration, percent**	
		Cloud	**Layer**			**In furnace**	**In spark apparatus**	**Spark**	**Furnace 850°C.**
Class A. Thermoplastic Resins and Molding Compounds									
Group I. Acetal Resins									
Acetal, linear (Polyformaldehyde)	>10	440	—	0.020	0.035	90+	90+	11	—
Group II. Acrylic Resins									
Methyl methacrylate polymer	6.3	480	—	.020	.030	90+	80	11	8
Methyl methacrylate molding compound, cyclone fines	>10	440	—	.015	.020	90+	80	14	7
Methyl methacrylate-ethyl acrylate copolymer	>10	480	—	.010	.030	90+	90	11	—
Methyl methacrylate-ethyl acrylate-styrene copolymer	>10	440	—	.020	.025	90+	90	—	—
Methyl methacrylate-styrene-butadiene-acrylonitrile copolymer	>10	480	—	.020	.025	90+	90	11	—
Methyl methacrylate-styrene-butadiene-ethyl acrylate copolymer	>10	480	—	.025	.025	—	—	13	—
Methacrylic acid polymer, modified	0.6	450	290	.100	.045	90+	85	—	—
Isobutyl methacrylate, from ledges in pulverizing room	5.0	500	280	.040	.020	90+	90	—	—
Acrylamide polymer	2.5	410	240	.030	.040	90+	80	—	—
Acrylamide-vinyl benzyl trimethyl ammonium chloride copolymer	< 0.1	810	500	8.000	1.000	—	10	—	—
Acrylonitrile polymer	>10	500	460	.020	.025	90+	90+	13	—
Acrylonitrile-vinyl pyridine copolymer	>10	510	240	.025	.020	90+	90+	—	—
Acrylonitrile-vinyl chloride-vinylidene chloride copolymer (70-20-10)	>10	650	210	.015	.035	90+	85	—	—

Group III. Cellulosic Resins									
Cellulose acetate	>10	440	340	.020	.055	90+	85	—	—
Cellulose acetate molding compound	3.2	410	—	.040	.035	90+	80	14	7
Cellulose triacetate	5.4	430	—	.030	.035	90+	80	14	11
Cellulose acetate butyrate	5.6	410	—	.030	.035	90+	85	14	7
Cellulose acetate butyrate molding compound	8.0	370	—	.030	.025	90+	90	14	7
Cellulose propionate, 0.3 percent free hydroxyl	7.5	460	—	.060	.025	90+	90	—	—
Cellulose tripropionate, 0 percent free hydroxyl	7.0	460	—	.045	.025	90+	85	—	—
Ethyl cellulose, no fillers or plasticizers	>10	340	330[1]	.015	.025	90+	90	—	—
Ethyl cellulose molding compound	>10	320	—	.010	.025	90+	90	11	7
Methyl cellulose, no fillers or plasticizers	>10	360	340	.020	.030	90+	90	13	—
Carboxy methyl cellulose, low viscosity, 0.3 to 0.4 percent substitution, acid product	1.4	460	310	.140	.060	90+	80	—	—
Hydroxyethyl cellulose-mono sodium phosphate sizing compound	1.7	390	340	.035	.070	90+	85	—	—
Group IV. Chlorinated Polyether Resins									
Chlorinated polyether alcohol	.2	460	—	.160	.045	90+	65	—	—
Group V. Fluorocarbon Resins									
Tetrafluoroethylene polymer, micronized	<< .1	670	570[1]	(2)	(3)	60	—	—	8
Monochlorotrifluoroethylene polymer	<< .1	600	720[1]	(2)	(3)	75	—	—	—
Do.	<< .1	600	—	(2)	(3)	55	—	—	—
Monochlorotrifluoroethylene polymer, contaminated with monomer	<< .1	620	—	(2)	(3)	55	—	—	—
Monochlorotrifluoroethylene polymer, vacuum-dried	<< .1	670	—	(2)	(3)	10	—	—	—
Group VI. Nylon Resins (Polyamide)									
Nylon (polyhexamethylene adipamide) polymer, from filter	>10	500	430	.020	.030	90+	90	13	6
Group VII. Polycarbonate Resins									
Polycarbonate	8.6	710	—	.025	.025	—	85	15	—

APPENDIX A (Continued)

Material	**Index of Explosibility**	**Ignition temperature °C.**		**Minimum igniting energy for dust cloud, joule**	**Minimum explosive concentration, oz./cu. ft.**	**Relative flammability, percent inert**		**Limiting oxygen concentration, percent**	
		Cloud	**Layer**			**In furnace**	**In spark apparatus**	**Spark**	**Furnace 850°C.**
Group VIII. Polyethylene Resins									
Polyethylene, high-pressure process	>10	450	380	.030	.020	90+	90+	13	—
Polyethylene, low-pressure process	>10	450	—	.010	.020	90+	90+	12	7
Polyethylene wax, low molecular weight	5.8	400	—	.035	.020	—	—	13	—
Group IX. Polymethylene Resins									
Carboxy polymethylene, regular	< .1	520	—	(2)	.325	90+	70	—	—
Group X. Polypropylene Resins									
Polypropylene, linear	8.0	420	—	.030	.020	90+	90+	—	—
Polypropylene, contains no antioxidant	>10	420	—	.030	.020	90+	90+	—	—
Group XI. Rayon									
Rayon (viscose) flock, 1.5 denier, 0.020 inch, maroon	.2	520	250	.240	.055	—	—	—	—
Group XII. Styrene Polymer and Copolymer Resins									
Polystyrene molding compound	>10	560	—	.040	.015	90+	90+	14	9
Polystyrene, beads	4.1	500	470[1]	.060	.025	90+	90	—	—
Polystyrene latex, spray-dried, contains surfactants	>10	500	500[1]	.015	.020	90+	90+	—	—
Styrene-acrylonitrile copolymer (70-30)	1.9	500	—	.030	.035	90+	85	—	—
Polystyrene-Buna N rubber coprecipitate	5.8	510	500[1]	.080	.020	90+	90	—	—
Styrene-butadiene latex copolymer, over 75 percent styrene, alum coagulated	>10	440	—	.025	.025	90+	90+	13	—
Group XIII. Vinyl Polymer and Copolymer Resins									
Polyvinyl acetate	.2	550	—	.160	.040	90+	75	17	11
Polyvinyl acetate alcohol	1.1	520	440	.120	.035	90+	85	—	—
Polyvinyl butyral	>10	390	—	.010	.020	90+	80	14	5

Polyvinyl chloride, fine	<< .1	660	400	(2)	(3)	80	—	—	—
Vinyl chloride-vinyl acetate copolymer	<< .1	690	—	(2)	(3)	5	—	—	15
Vinyl chloride-acrylonitrile copolymer (60-40), water emulsion product	>10	570	470	0.025	0.045	90+	70	—	—
Vinyl chloride-acrylonitrile copolymer (33-67), water emulsion product	>10	530	470	.015	.035	90+	90	15	—
Vinyl chloride-polyoctyl acrylate copolymer (79-21)	< .1	500	430	.960	.100	90+	30	—	—
Vinyl chloride-diisopropyl fumerate copolymer (70-30)	.9	580	—	.060	.060	90+	70	—	—
Polyvinyl chloride-dioctyl phthalate mixture (67-33)	2.9	320	—	.050	.035	90+	70	—	—
Polyvinyl chloride-Hycar rubber copolymer	9.4	490	—	.030	.025	90+	90	—	—
Vinyl and vinylidene chloride copolymer, mainly vinyl	<< .1	780	450	(2)	(3)	—	—	—	—
Vinyl and vinylidene chloride copolymer, mainly vinylidene	<< .1	(4)	420	(2)	(3)	—	—	—	—
Vinyl multipolymer, contains monomeric vinylidene cyanide	>10	500	510	.015	.030	90+	90	11	—
Vinyl toluene-acrylonitrile-butadiene copolymer (58-19-23)	>10	530	—	.020	.020	90+	90+	—	—
Polyvinyl toluene, sulfonated	< .1	540	330	2.880	1.000	90+	5	—	—
Polyvinyl benzyl trimethyl ammonium chloride, yellow, contains some divinyl benzene	1.0	410	220	.100	.035	90+	80	—	—

Class B. Thermosetting Resins and Molding Compounds

Group I. Alkyd Resins

Alkyd molding compound, mineral filler, not self-extinguishing	< .1	500	270	.120	.155	90+	25	15	—
Alkyd molding compound, mineral filler, self-extinguishing	<< .1	510	270	(2)	(3)	90+	—	—	—

Group II. Allyl Resins

Allyl alcohol derivative, CR-39, from dust collector	>10	510	—	.020	.035	90	85	13	4
Allyl alcohol derivative, CR-149 — glass fiber mixture (65-35)	< .1	540	—	1.600	.345	90+	35	—	—

APPENDIX A (Continued)

Material	Index of Explos-ibility	Ignition temperature °C.		Minimum igniting energy for dust cloud, joule	Minimum explosive concentration, oz./cu. ft.	Relative flammability, percent inert		Limiting oxygen concentration, percent	
		Cloud	Layer			In furnace	In spark apparatus	Spark	Furnace 850°C.
Group III. Amino Resins (Melamine and Urea)									
Melamine formaldehyde, unfilled laminating type, no plasticizer	< .1	810	—	.320	.085	—	55	17	—
Melamine formaldehyde, unfilled laminating type, contains plasticizer	.7	790	—	.050	.065	—	70	15	—
Urea formaldehyde, spray-dried	< .1	530	—	1.280	.135	70	25	17	15
Urea formaldehyde, glue, no hardener or conditioning agents	< .1	510	—	.640	.070	85	50	17	13
Urea formaldehyde, glue, contains hardener and conditioning agents	.1	510	—	.960	.075	85	50	17	15
Urea formaldehyde, laminating and impregnating glue	.5	470	—	.080	.070	85	60	17	11
Urea formaldehyde molding compound, from dust collector	.6	530	—	.080	.090	85	65	17	11
Urea formaldehyde molding compound, Grade II, fine	1.0	460	—	.080	.085	90+	70	17	9
Group IV. Epoxy Resins									
Epoxy, one part anhydride type, 1 percent catalyst	7.2	530	—	.035	.030	90+	85	—	—
Epoxy, no catalyst, modifier or additives	>10	540	—	.015	.020	90+	90	12	—
Epoxy-bisphenol A mixture	1.9	510	—	.035	.030	90+	85	—	—
Group V. Furane Resins									
Phenol furfural	>10	530	—	.010	.025	90+	90	14	11
Group VI. Phenolic Resins									
Phenol formaldehyde	>10	580	—	.015	.025	90+	85	17	11
Phenol formaldehyde, 1-step	>10	640	—	.010	.040	90+	90	14	9
Phenol formaldehyde, 2-step	>10	580	—	.010	.025	90+	90	14	9
Phenol formaldehyde, semiresinous	< .1	460	—	(2)	.235	90+	—	—	—

Phenol formaldehyde, amine modified	—	510	—	—	.070	90+	90	—	12
Phenol formaldehyde, polyalkylene polyamine modified	>10	420	290	.015	.020	90+	90	—	—
Phenol formaldehyde molding compound, cotton flock filler	>10	490	—	.010	.030	90+	80	14	7
Phenol formaldehyde molding compound, wood flour filler	>10	500	—	.015	.030	90+	80	14	9
Phenol anhydro formaldehyde aniline, 2-step	>10	570	—	.010	.035	90+	90	14	9

Group VII. Polyester Resins

Polyethylene terephthalate	7.5	500	—	.035	.040	90+	85	13	—
1,4-Cyclohexylene dimethylene isophthalate — 1,4-cyclohexylene dimethylene terephthalate copolymer	4.9	500	—	.025	.030	—	70	13	—
Styrene modified polyesterglass fiber mixture (65-35)	5.2	440	360	.050	.045	90+	85	—	—

Group VIII. Polyurethane Resins (Isocyanate)

Polyurethane foam (toluene diisocyanate-polyhydroxy with fluorocarbon blowing agent), not fire retardant	>10	510	440	.020	.030	—	—	—	—
Polyurethane foam (toluene diisocyanate-polyhydroxy with fluorocarbon blowing agent), fire retardant	>10	550	390	.015	.025	—	—	—	—

Class C. Special Resins and Molding Compounds

Group I. Cold-Molded Resins

Gilsonite, from Michigan	>10	560	—	.025	.020	90+	85	—	—
Petroleum resin (blown asphalt), regular	>10	510	500[1]	.025	.025	90+	90	—	—
Petroleum resin (blown asphalt), collector fines	6.2	510	550[1]	.040	.035	90+	90+	—	—

Group II. Coumarone-Indene Resins

Coumarone-indene, hard	>10	550	—	.010	.015	90+	90+	14	11

APPENDIX A (Continued)

Material	Index of Explosibility	Ignition temperature °C.		Minimum igniting energy for dust cloud, joule	Minimum explosive concentration, oz./cu. ft.	Relative flammability, percent inert		Limiting oxygen concentration, percent	
		Cloud	Layer			In furnace	In spark apparatus	Spark	Furnace 850°C.
Group III. Natural Resins									
Cashew oil phenolic, hard	>10	490	200	.025	.025	90+	90	14	—
Gum arabic, from Sudan	1.0	500	260	.100	.060	90+	85	—	—
Gum, DK	>10	390	—	.010	.015	90+	90	14	9
Gum, karaya, from India	.3	520	240	.180	.100	90+	75	—	—
Gum, manila (copal), from Philippines	>10	360	390[1]	.030	.030	90+	90	—	—
Gum, tragacanth, from Iran	7.5	490	260	.045	.040	90+	85	—	—
Lignin, pure	.8	510	—	.160	.065	90+	55	17	13
Lignin, hydrolized-wood-type, fines	>10	450	—	.020	.040	90+	75	17	7
Rosin, DK	>10	390	—	.010	.015	90+	90+	14	9
Rosin, pine	—	440	—	—	.055	90+	90+	17	10
Shellac	>10	400	—	.010	.020	90+	90+	14	9
Sodium resinate, dry size, grade XXX	2.6	350	220	.060	.040	90+	90	17	—
Group IV. Rubber									
Rubber, crude, hard	7.4	350	—	.050	.025	90+	90	15	13
Rubber, synthetic, hard, contains 33 percent sulfur	>10	320	—	.030	.030	90+	90+	15	11
Rubber, chlorinated	<< .1	940	290	(2)	(3)	—	—	—	—
Group V. Miscellaneous Resins									
Alkyl ketene dimer sizing compound, dimer dispersed on silica (50-50)	>10	420	160	0.030	0.030	90+	85	15	—
Chlorinated paraffin, plant milled, 70 percent chlorine	<< .1	840	—	(2)	(3)	—	—	—	—
Chlorinated phenol (bis 2-hydroxy-5-chlorophenyl methane)	1.1	570	—	.060	.040	90+	65	16	13
Chlorinated phenol (bis 2-hydroxy-3,5,6-trichlorophenyl methane)	<< .1	(4)	450	(2)	(3)	—	—	—	—

Cracking polymer, hydrocarbon, formed in separation of ethylene and propylene	7.5	450	290	.030	.030	90+	85	—	—
Formaldehyde-naphthalene sulfonic acid copolymer, drum-dried	< .1	620	290	(2)	.570	80	—	—	—
Ethylene oxide polymer	5.8	350	—	.030	.030	90+	90	12	5
Ethylene-maleic anhydride copolymer, dry	.2	540	—	.040	.095	90+	70	11[5]	—
Styrene-maleic anhydride copolymer	4.6	470	420	.050	.030	90+	90+	—	—
Styrene-maleic anhydride copolymer, nonsolvent process	>10	470	490	.020	.030	90+	90+	—	—
Styrene-(sodium salt)-maleic anhydride copolymer, 75 percent salt of styrene	.1	400	420	.240	.105	90+	50	—	—
Styrene sulfonate, sodium	<< .1	610	290	(2)	(3)	60	—	—	—
Petrin acrylate monomer, crude	>10	220	—	.020	.045	90+	85	—	—
Lacquer, stripped from gas cylinders	< .1	490	200	.180	.250	90+	40	—	—
Class D. Ingredients									
Aceto acetanilide	>10	560	—	.020	.030	90+	90	—	—
Adipic acid	1.9	550	—	.060	.035	90+	85	—	—
a Amino, a methyl mercaptan butyric acid (dl-methionine)	>10	370	360[1]	.035	.025	90+	85	15	7
Alkyl nitroso methyl amide	>10	150	—	.015	.025	90+	90+	—	—
Aryl nitroso methyl amide	>10	490	—	.015	.050	90+	85	—	—
Azelaic acid	6.4	610	—	.025	.025	—	—	14	—
a, a' Azoisobutyronitrile	>10	430	350[1]	.025	.015	90+	90+	—	—
Bisphenol A	>10	570	—	.015	.020	90+	90+	12	—
Casein, rennet	.4	520	—	.060	.045	90	35	17	7
Dicumyl peroxide suspended on $CaCO_3$ (40-60)	6.8	560	180	.030	.045	90+	80	13	—
Dicyclopentadiene dioxide	>10	420	—	.030	.015	90+	90+	—	—
Dimethyl isophthalate	>10	580	—	.015	.025	—	85	13	—
Dimethyl terephthalate	>10	570	—	.020	.030	90+	90+	12	6
Ditertiary butyl para cresol	>10	420	—	.015	.015	90+	90+	13	9
Ethylene diamine tetra acetic acid, technical grade, spray-dried	.8	450	—	.050	.075	90+	75	—	—
Fumaric acid, finely divided	1.6	520	—	.035	.085	90+	80	—	—

Material	Index of Explosibility	Ignition temperature °C.		Minimum igniting energy for dust cloud, joule	Minimum explosive concentration, oz./cu. ft.	Relative flammability, percent inert		Limiting oxygen concentration, percent	
		Cloud	Layer			In furnace	In spark apparatus	Spark	Furnace 850°C.
			Class D. Ingredients (continued)						
Glyoxyl hydrate, polymeric	>10	360	250	.020	.065	90+	85	12	9
Hexamethylene tetramine	>10	410	—	.010	.015	90+	90+	14	11
Isophthalic acid	4.0	700	—	.025	.035	—	—	14	—
Lactalbumin	3.2	570	240	.050	.040	90+	85	15	11
N-Cyclohexyl-2-benzothiazole sulfonamide, from dry hopper	8.9	390	—	.045	.035	90+	90	—	—
Nitrosamine, 100 percent	>10	270	—	.060	.025	90+	90+	—	—
Para formaldehyde	>10	410	—	.020	.040	90+	90	12	—
Para nitro chlor benzol ferric sulfonate	< .1	460	330[1]	(2)	.420	85	—	—	—
Para nitro chlor benzol sodium sulfonate	< .1	450	320[1]	(2)	.180	85	—	—	—
Para oxy benzaldehyde	>10	380	430	0.015	0.020	90+	90+	—	—
Para phenylene diamine, milled	9.0	620	—	.030	.025	90+	90	—	—
Para tertiary butyl benzoic acid	>10	560	—	.025	.020	90+	90+	—	—
Pentaerythritol	>10	450	—	.010	.030	90+	90	14	7
Phenyl beta naphthylamine, contains some beta naphthol	7.1	680	—	.025	.025	90+	90	—	—
Phthalic anhydride	>10	650	—	.015	.015	90+	90	14	11
Terephthalic acid	6.9	680	—	.020	.050	—	80	15	—
Urea, crystal, ground	<< .1	900	—	(2)	(3)	—	—	—	—
			Class E. Fillers						
			Group I. Cellulosic						
Cellulose	2.8	480	270	.080	.055	90+	80	13	—
Cellulose, alpha, from tunnel walls	>10	410	300	.040	.045	90+	85	—	—
Cellulose flock, fine cut	8.7	460	260	.035	.055	90+	85	13	—
Cellulose flock, chemical cotton, collector dust	4.6	460	280	.040	.065	90+	80	13	—

Cellucotton	1.9	460	310	.080	.050	90+	80	—	—
Cotton flock, ground, filler for phenolic molding compound	>10	470	—	.025	.050	90+	75	17	7
Cotton linters, raw	< .1	520	—	1.920	.500	90+	—	18	5
Cork	9.7	470	—	.045	.035	90+	85	—	—
Wood, birch bark, ground	6.7	450	250	.060	.020	90+	90+	—	—
Wood, Douglas fir bark, ground, before screening	5.0	540	270	.040	.030	90+	90+	—	—
Wood flour, Grasselli ground, filler for urea molding compound	>10	430	—	.020	.050	90+	80	17	7
Group II. Mineral									
Asbestine	0	(4)	—	(2)	(3)	—	—	—	—
Asbestos	0	(4)	—	(2)	(3)	—	—	—	—
Mica	0	(4)	—	(2)	(3)	—	—	—	—
Pittsburgh coal, high volatile A, bituminous	1.0	610	—	.060	.055	—	—	—	—

[1] Ignition denoted by flame, all others glow.

[2] No ignition to 8.32 joules, the highest tried.

[3] No ignition to 2.00 oz./cu. ft., the highest tried.

[4] No ignition to 1,000°C., the highest tried.

[5] Air-N_2 atmosphere, all others air-CO_2.

The notation <<0.1 designates materials presenting primarily a fire hazard as ignition of the dust cloud is not obtained by the spark or flame source but only by the intense heated surface source.

APPENDIX B. INDEX OF EXPLOSIBILITY, PRESSURES, AND

Compiled from data published in Bureau of Mines Report of Investigations 5971

			Concentration					
			0.10 oz./cu. ft.			**0.20 oz./cu. ft.**		
No.	**Material**	**Index of Explosibility**	**Max. Press. psig**	**Rate of Pressure Rise, psi/sec. Av.**	**Max.**	**Max. Press. psig**	**Rate of Pressure Rise, psi/sec. Av.**	**Max.**
	Class A. Thermoplastic Resins and Molding Compounds							
	Group I. Acetal Resins							
1	Acetal, linear (Polyformaldehyde)	>10	30	250	450	66	1,100	2,800
	Group II. Acrylic Resins							
2	Methyl methacrylate polymer	6.3	34	150	250	54	400	1,200
3	Methyl methacrylate molding compound, cyclone fines	>10	44	600	1,200	—	—	—
4	Methyl methacrylate-ethyl acrylate copolymer	>10	67	1,400	5,000	70	2,000	6,000
5	Methyl methacrylate ethyl acrylate-styrene copolymer	>10	61	1,100	2,800	64	1,400	3,400
6	Methyl methacrylate-styrene-butadiene-acrylonitrile copolymer	>10	62	1,500	3,900	68	1,700	4,700
7	Methyl methacrylate-styrene-butadiene-ethyl acrylate copolymer	>10	61	1,100	2,900	73	1,500	4,300
8	Methacrylic acid polymer, modified	0.6	7	100	100	33	200	400
9	Isobutyl methacrylate from ledges in pulverizing room	(1)5.0	46	1,200	1,600	74	1,800	2,800
10	Acrylamide polymer	2.5	49	600	1,200	65	900	2,500
11	Acrylamide-vinyl benzyl trimethyl ammonium chloride copolymer	<0.1	--	—	—	—	—	—
12	Acrylonitrile polymer	>10	65	2,600	7,000	75	3,200	11,000
13	Acrylonitrile-vinyl pyridine copolymer	>10	61	1,600	3,900	71	1,700	4,800
14	Acrylonitrile-vinyl chloride-vinylidene chloride copolymer (70-20-10)	>10	72	2,500	15,000	87	3,200	13,000
	Group III. Cellulosic Resins							
15	Cellulose acetate	>10	47	700	1,500	72	1,000	3,100
16	Cellulose acetate molding compound	3.2	40	400	800	—	—	—
17	Cellulose triacetate	5.4	36	400	800	—	—	—
18	Cellulose acetate butyrate	5.6	42	600	1,100	—	—	—
19	Cellulose acetate butyrate molding compound	8.0	49	500	1,400	—	—	—

RATES OF PRESSURE RISE OF DUST EXPLOSIONS

	Concentration								
	0.50 oz./cu. ft.			1.00 oz./cu. ft.			2.00 oz./cu ft.		
		Rate of Pressure Rise, psi/sec.			Rate of Pressure Rise, psi/sec.			Rate of Pressure Rise, psi/sec.	
No.	Max. Press. psig	Av.	Max.	Max. Press. psig	Av.	Max.	Max. Press. psig	Av.	Max.
1	89	1,600	4,100	103	1,500	3,600	113	1,100	2,900
2	84	900	2,000	75	500	1,100	67	350	900
3	101	450	1,800	—	—	—	—	—	—
4	85	1,500	6,000	85	1,300	3,900	79	800	2,200
5	75	1,400	4,400	90	1,200	3,200	76	600	1,500
6	76	1,300	3,400	87	1,100	3,100	74	700	1,900
7	83	1,300	3,500	84	1,200	3,100	80	800	1,500
8	82	700	1,500	97	900	1,800	—	—	—
9	73	1,600	2,500	55	1,600	2,400	—	—	—
10	74	900	1,600	85	700	1,200	70	400	700
11	—	—	—	9	100	100	13	100	100
12	89	2,000	5,000	77	800	3,000	—	—	—
13	77	1,900	6,000	85	1,300	2,600	76	800	1,600
14	83	1,900	7,000	76	1,000	3,100	67	500	1,500
15	99	1,500	6,000	120	1,600	6,000	113	1,000	2,200
16	90	1,000	1,900	—	—	—	—	—	—
17	89	1,200	2,600	—	—	—	—	—	—
18	85	1,100	2,700	—	—	—	—	—	—
19	81	1,000	2,700	—	—	—	—	—	—

APPENDIX B (Continued)

No.	Material	Index of Explosibility	Concentration 0.10 oz./cu. ft. Max. Press. psig	0.10 oz./cu. ft. Rate of Pressure Rise, psi/sec. Av.	0.10 oz./cu. ft. Rate of Pressure Rise, psi/sec. Max.	Concentration 0.20 oz./cu. ft. Max. Press. psig	0.20 oz./cu. ft. Rate of Pressure Rise, psi/sec. Av.	0.20 oz./cu. ft. Rate of Pressure Rise, psi/sec. Max.
20	Cellulose propionate, 0.3 percent free hydroxyl	7.5	37	600	1,000	—	—	—
21	Cellulose tripropionate, 0 percent free hydroxyl	(1)7.0	42	700	1,200	—	—	—
22	Ethyl cellulose, no fillers or plasticizers	>10	62	1,700	3,500	74	2,200	4,700
23	Ethyl cellulose molding compound	>10	47	800	1,700	—	—	—
24	Methyl cellulose, no fillers or plasticizers	>10	40	800	1,600	64	1,400	3,100
25	Carboxy methyl cellulose, low viscosity, 0.3 to 0.4 percent substitution, acid product	(1)1.4	46	900	1,800	84	1,800	4,000
26	Hydroxyethyl cellulose-mono sodium phosphate sizing compound	1.7	20	200	300	41	600	1,100
	Class IV. Chlorinated Polyether Resins							
27	Chlorinated polyether alcohol	.2	23	200	350	40	400	700
	Group V. Fluorocarbon Resins							
28	Tetrafluoroethylene polymer, micronized	<<.1	(2)	—	—	—	—	—
29	Monochlorotrifluoroethylene polymer	<<.1	(2)	—	—	—	—	—
30	Same as No. 29	<<.1	(2)	—	—	—	—	—
31	Monochlorotrifluoroethylene polymer, contaminated with monomer	<<.1	(2)	—	—	—	—	—
32	Monochlorotrifluoroethylene polymer; vacuum-dried	<<.1	(2)	—	—	—	—	—
	Group VI. Nylon Resins (Polyamide)							
33	Nylon (polyhexamethylene adipamide) polymer, from filter	>10	57	1,000	2,100	67	1,000	2,200
	Group VII. Polycarbonate Resins							
34	Polycarbonate	8.6	56	900	2,400	64	1,400	3,700
	Group VIII. Polyethylene Resins							
35	Polyethylene, high-pressure process	>10	64	1,000	2,600	78	1,700	4,000

APPENDIX B (Continued)

	Concentration								
	0.50 oz./cu. ft.			1.00 oz./cu. ft.			2.00 oz./cu ft.		
No.	Max. Press. psig	Rate of Pressure Rise, psi/sec.		Max. Press. psig	Rate of Pressure Rise, psi/sec.		Max. Press. psig	Rate of Pressure Rise, psi/sec.	
		Av.	Max.		Av.	Max.		Av.	Max.
20	105	1,600	4,700	—	—	—	—	—	—
21	88	2,200	4,000	—	—	—	—	—	—
22	98	2,600	7,000	112	2,200	4,500	—	—	—
23	102	2,100	6,000	—	—	—	—	—	—
24	99	1,900	6,000	133	2,400	5,500	—	—	—
25	114	1,600	4,500	130	1,600	5,000	—	—	—
26	76	800	1,900	110	1,400	4,000	107	1,100	3,000
27	66	500	1,000	79	900	1,900	88	500	1,200
28	—	—	—	—	—	—	—	—	—
29	—	—	—	—	—	—	—	—	—
30	—	—	—	—	—	—	—	—	—
31	—	—	—	—	—	—	—	—	—
32	—	—	—	—	—	—	—	—	—
33	85	1,200	4,000	95	1,500	3,600	67	450	1,000
34	78	1,600	4,700	96	1,400	3,300	91	900	2,000
35	81	1,500	3,400	72	800	2,000	—	—	—

APPENDIX B (Continued)

No.	Material	Index of Explosibility	Concentration 0.10 oz./cu. ft. Max. Press. psig	0.10 oz./cu. ft. Rate of Pressure Rise, psi/sec. Av.	0.10 oz./cu. ft. Rate of Pressure Rise, psi/sec. Max.	Concentration 0.20 oz./cu. ft. Max. Press. psig	0.20 oz./cu. ft. Rate of Pressure Rise, psi/sec. Av.	0.20 oz./cu. ft. Rate of Pressure Rise, psi/sec. Max.
36	Polyethylene, low-pressure process	>10	67	2,100	7,500	73	1,900	6,500
37	Polyethylene wax, low molecular weight	5.8	60	900	2,000	72	1,100	3,000
	Group IX. Polymethylene Resins							
38	Carboxy polymethylene, regular	<.1	—	—	—	—	—	—
	Group X. Polypropylene Resins							
39	Polypropylene, linear	8.0	63	1,500	3,900	63	1,500	3,600
40	Polypropylene, contains no antioxidant	>10	64	1,600	4,800	66	1,800	5,500
	Group XI. Rayon							
41	Rayon (viscose) flock, 1.5 denier, 0.020 inch, maroon	.2	—	—	—	29	150	250
	Group XII. Styrene Polymer and Copolymer Resins							
42	Polystyrene molding compound	>10	37	500	1,000	—	—	—
43	Polystyrene, beads	(1)4.1	45	800	1,800	71	1,800	3,600
44	Polystyrene latex, spray-dried, contains surfactants	>10	67	2,300	5,000	79	2,800	7,000
45	Styrene-acrylonitrile copolymer (70-30)	1.9	27	150	300	49	350	600
46	Polystyrene-Buna N rubber coprecipitate	5.8	62	1,200	3,000	87	1,400	3,500
47	Styrene-butadiene latex copolymer, over 75 percent styrene, alum coagulated	>10	46	1,100	2,200	68	1,300	3,300
	Group XIII. Vinyl Polymer and Copolymer Resins							
48	Polyvinyl acetate	(1) .2	27	200	400	—	—	—
49	Polyvinyl acetate alcohol	1.1	20	300	500	59	900	1,700
50	Polyvinyl butyral	(1)>10	42	300	700	—	—	—
51	Polyvinyl chloride, fine	(1)<<.1	—	—	—	—	—	(3)
52	Vinyl chloride-vinyl acetate copolymer	(1)<<.1	(2)	—	—	—	—	—
53	Vinyl chloride-acrylonitrile copolymer (60-40), water emulsion product	>10	49	600	1,200	70	1,200	3,200
54	Vinyl chloride-acrylonitrile copolymer (33-67), water emulsion product	>10	62	1,700	5,000	77	2,700	7,500

APPENDIX B (Continued)

No.	Concentration: 0.50 oz./cu. ft. — Max. Press. psig	0.50 oz./cu. ft. — Rate of Pressure Rise, psi/sec. Av.	0.50 oz./cu. ft. — Rate of Pressure Rise, psi/sec. Max.	1.00 oz./cu. ft. — Max. Press. psig	1.00 oz./cu. ft. — Rate of Pressure Rise, psi/sec. Av.	1.00 oz./cu. ft. — Rate of Pressure Rise, psi/sec. Max.	2.00 oz./cu ft. — Max. Press. psig	2.00 oz./cu ft. — Rate of Pressure Rise, psi/sec. Av.	2.00 oz./cu ft. — Rate of Pressure Rise, psi/sec. Max.
36	80	1,600	5,500	68	900	5,500	53	400	1,100
37	74	900	2,100	71	800	2,000	71	600	1,300
38	70	1,600	5,500	66	1,000	2,000	57	500	1,000
39	69	900	2,800	67	600	1,300	64	400	700
40	76	1,500	5,000	74	1,200	3,600	62	500	900
41	88	800	1,700	107	700	1,500	—	—	—
42	77	1,500	5,000	—	—	—	—	—	—
43	73	1,500	4,000	74	900	2,200	—	—	—
44	91	2,400	7,000	100	1,700	5,000	80	600	1,100
45	71	600	1,400	—	—	—	—	—	—
46	97	1,500	4,500	85	1,200	3,800	—	—	—
47	82	1,400	3,900	92	1,300	3,300	88	1,200	3,100
48	69	500	1,000	—	—	—	—	—	—
49	75	1,300	3,100	89	1,200	3,000	—	—	—
50	84	1,000	2,000	—	—	—	—	—	—
51	20	100	200	28	100	200	—	—	—
52	—	—	—	—	—	—	—	—	—
53	71	800	1,600	81	700	1,200	74	300	450
54	87	1,700	4,400	95	1,100	3,300	81	500	900

APPENDIX B (Continued)

			Concentration					
			0.10 oz./cu. ft.			0.20 oz./cu. ft.		
No.	Material	Index of Explosibility	Max. Press. psig	Rate of Pressure Rise, psi/sec.		Max. Press. psig	Rate of Pressure Rise, psi/sec.	
				Av.	Max.		Av.	Max.
55	Vinyl chloride-polyoctyl acrylate copolymer (79-21)	< .1	—	—	—	16	100	200
56	Vinyl chloride-diisopropyl fumarate copolymer (70-30)	.9	39	400	1,100	60	800	2,700
57	Polyvinyl chloride-dioctyl phthalate mixture (67-33)	2.9	48	1,000	2,600	49	1,100	2,700
58	Polyvinyl chloride-Hycar rubber copolymer	9.4	45	1,000	1,700	71	2,200	4,000
59	Vinyl and vinylidene chloride copolymer, mainly vinyl	<<.1	(2)	—	—	—	—	—
60	Vinyl and vinylidene chloride copolymer, mainly vinylidene	<<.1	(2)	—	—	—	—	—
61	Vinyl multipolymer, contains monomeric vinylidene cyanide	>10	59	1,500	4,400	80	2,400	7,000
62	Vinyl toluene-acrylonitrile-butadiene copolymer (58-19-23)	>10	66	1,500	3,400	69	1,700	4,700
63	Polyvinyl toluene, sulfonated	< .1	—	—	—	—	—	—
64	Polyvinyl benzyl trimethyl ammonium chloride, yellow contains some divinyl benzene	1.0	56	700	1,800	71	1,300	2,900

Class B. Thermosetting Resins and Molding Compounds

Group I. Alkyd Resins

65	Alkyd molding compound, mineral filler, not self-extinguishing	< .1	—	—	—	—	—	—
66	Alkyd molding compound, mineral filler, self-extinguishing	<<.1	(2)	—	—	—	—	—

Group II. Allyl Resins

67	Allyl alcohol derivative, CR-39, from dust collector	(1)>10	42	700	1,300	—	—	—
68	Allyl alcohol derivative, CR-149 — glass fiber mixture (65-35)	(1)<.1	—	—	—	—	—	—

APPENDIX B (Continued)

	Concentration								
	0.50 oz./cu. ft.			1.00 oz./cu. ft.			2.00 oz./cu ft.		
No.	Max. Press. psig	Rate of Pressure Rise, psi/sec.		Max. Press. psig	Rate of Pressure Rise, psi/sec.		Max. Press. psig	Rate of Pressure Rise, psi/sec.	
		Av.	Max.		Av.	Max.		Av.	Max.
55	37	200	500	62	400	1,000	79	500	1,000
56	71	700	2,400	85	600	1,600	71	300	600
57	65	900	2,300	72	900	2,300	—	—	—
58	90	1,800	3,500	83	1,000	2,200	—	—	—
59	—	—	—	—	—	—	—	—	—
60	—	—	—	—	—	—	—	—	—
61	95	2,100	6,000	109	1,700	5,500	93	500	1,000
62	79	1,500	3,900	85	1,200	3,000	72	1,100	2,200
63	—	—	—	12	100	100	40	150	300
64	72	800	1,800	78	600	1,200	71	300	900
65	15	100	150	27	100	150	40	150	300
66	—	—	—	—	—	—	—	—	—
67	91	3,000	7,500	—	—	—	—	—	—
68	34	500	1,000	60	400	800	—	—	—

APPENDIX B (Continued)

No.	Material	Index of Explosibility	Concentration 0.10 oz./cu. ft. Max. Press. psig	0.10 oz./cu. ft. Rate of Pressure Rise, psi/sec. Av.	0.10 oz./cu. ft. Rate of Pressure Rise, psi/sec. Max.	0.20 oz./cu. ft. Max. Press. psig	0.20 oz./cu. ft. Rate of Pressure Rise, psi/sec. Av.	0.20 oz./cu. ft. Rate of Pressure Rise, psi/sec. Max.
	Group III. Amino Resins (Melamine and Urea)							
69	Melamine formaldehyde, unfilled laminating type, no plasticizer	<.1	9	100	100	14	100	100
70	Melamine formaldehyde, unfilled laminating type, contains plasticizer	.7	25	200	350	44	350	700
71	Urea formaldehyde, spray-dried	(1)<.1	6	100	100	—	—	—
72	Urea formaldehyde, glue, no hardener or conditioning agents	(1)<.1	16	100	150	—	—	—
73	Urea formaldehyde, glue, contains hardener and conditioning agents	(1) .1	6	100	100	—	—	—
74	Urea formaldehyde, laminating and impregnating glue	(1) .5	11	100	100	—	—	—
75	Urea formaldehyde molding compound, from dust collector	.6	3	100	100	—	—	—
76	Urea formaldehyde molding compound, Grade II, fine	1.0	20	100	200	—	—	—
	Group IV. Epoxy Resins							
77	Epoxy, one part anhydride type, 1 percent catalyst	7.2	57	700	1,500	59	900	2,100
78	Epoxy, no catalyst, modifier or additives	>10	56	1,900	4,700	74	2,600	8,500
79	Epoxy-bisphenol A mixture	1.9	43	500	900	52	600	1,100
	Group V. Furane Resins							
80	Phenol furfural	>10	45	1,000	1,900	—	—	—
	Group VI. Phenolic Resins							
81	Phenol formaldehyde	(1)>10	43	800	1,400	—	—	—
82	Phenol formaldehyde, 1-step	>10	33	600	1,300	—	—	—
83	Phenol formaldehyde, 2-step	>10	41	800	1,500	—	—	—
84	Phenol formaldehyde, semiresinous	(1)<.1	—	—	—	—	—	—
85	Phenol formaldehyde molding compound, cotton flock filler	>10	46	800	1,500	—	—	—

APPENDIX B (Continued)

No.	Concentration								
	0.50 oz./cu. ft.			1.00 oz./cu. ft.			2.00 oz./cu ft.		
	Max. Press. psig	Rate of Pressure Rise, psi/sec.		Max. Press. psig	Rate of Pressure Rise, psi/sec.		Max. Press. psig	Rate of Pressure Rise, psi/sec.	
		Av.	Max.		Av.	Max.		Av.	Max.
69	61	300	700	81	350	800	59	300	700
70	91	800	1,800	93	700	1,500	82	450	1,000
71	52	200	500	—	—	—	—	—	—
72	60	500	1,200	—	—	—	—	—	—
73	91	600	1,600	—	—	—	—	—	—
74	59	700	1,800	—	—	—	—	—	—
75	91	900	2,300	—	—	—	—	—	—
76	89	1,300	3,600	—	—	—	—	—	—
77	81	1,500	4,700	92	800	2,300	83	450	800
78	86	2,000	6,000	94	1,800	5,000	64	500	1,400
79	68	800	1,500	85	1,000	2,200	76	500	1,200
80	88	2,000	8,500	—	—	—	—	—	—
81	77	1,600	3,500	—	—	—	—	—	—
82	92	3,000	11,000	—	—	—	—	—	—
83	89	2,200	8,500	—	—	—	—	—	—
84	18	100	200	79	400	800	—	—	—
85	92	2,300	11,000	—	—	—	—	—	—