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Tentative

# Code for the Prevention of Dust Explosions in the Plastics Industry

*Price Twenty-Five Cents*

**National Fire Protection Association**
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## National Fire Protection Association

INTERNATIONAL

Executive Office: 60 Batterymarch St., Boston 10, Mass.

The National Fire Protection Association was organized in 1896 to promote the science and improve the methods of fire protection and prevention, to obtain and circulate information on these subjects and to secure the co-operation of its members in establishing proper safeguards against loss of life and property by fire. Its membership includes over a hundred national and regional societies and associations and nine thousand individuals, corporations, and organizations.

This pamphlet is one of a large number of publications issued by the Association and sent to the members as published. These include the monthly *News Letter,* standards on fire prevention and fire protection, special reports and bulletins, the Year Book, and the Proceedings of the annual meetings.

Membership in the National Fire Protection Association is open to any Society, Corporation, Firm or Individual interested in the protection of life or property against loss by fire. All the valuable engineering and popular literature issued by the Association is sent, as issued, to every member. The Association is the clearing house for all the authoritative information on Fire Protection and Prevention, and members are privileged to submit to it their individual problems for solution. The Association is always glad to send samples of its publications to prospective members upon request.

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*This Code for the Prevention of Dust Explosions in the Plastics Industry was prepared by the following sub-committee of the Committee on Dust Explosion Hazards in 1943 and 1944 and was tentatively adopted by the Association in 1944.*

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## Other Dust Codes.

The present tentative code is one of a series of codes for the prevention of dust explosions in various industries, prepared by the N.F.P.A. Committee on Dust Explosion Hazards, as follows:

Aluminum Bronze Powder, Code for the Prevention of Dust Explosions in the Manufacture of

Magnesium Powder or Dust, Code for Explosion and Fire Protection in Plants Producing or Handling

Coal Pneumatic Cleaning Plants, Code for the Prevention of Dust Explosions in

Flour and Feed Mills, Code for the Prevention of Dust Explosions in

Pulverized Fuel Systems, Code for the Installation of

Spice Grinding Plants, Code for the Prevention of Dust Ignitions in

Starch Factories, Code for the Prevention of Dust Explosions in

Sugar and Cocoa, Code for Pulverizing Systems for

Sulphur Dust Explosions and Fires, Codes for the Prevention of

Terminal Grain Elevators, Code for the Prevention of Dust Explosions in

Grain Elevators and Storage Units, Suggested Good Practices for the Application of Suction and Venting for the Control of Dust in

Country Grain Elevators, Code for the Prevention of Dust Ignitions in

Wood Flour Manufacturing Establishments, Code for the Prevention of Dust Explosions in

Woodworking Plants, Code for the Prevention of Dust Explosions in

These fifteen American Standards have been brought together for convenient reference in the National Fire Codes for the Prevention of Dust Explosions, 1944, and may be obtained from the N.F.P.A. Executive Office in a cloth-bound edition at $2.00 per copy postpaid, or a paper-bound edition at $1.00 per copy.

# CODE FOR THE PREVENTION OF DUST EXPLOSIONS IN THE PLASTICS INDUSTRY

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**This Code was tentatively adopted by the National Fire Protection Association at the annual meeting in May 1944. It is subject to revision before final adoption in 1945 and any readers having suggestions for consideration of the Committee may file communications with the Chairman, Mr. Hylton R. Brown, U. S. Bureau of Mines, Eastern Experiment Station, College Park, Maryland.**

TENTATIVE

# CODE FOR THE PREVENTION OF DUST EXPLOSIONS IN THE PLASTICS INDUSTRY.

## Contents.



## Definitions.

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

PLASTICS is a generic name for synthetic condensation or polymerization substances, also for certain natural substances, which under heat and pressure become plastic, and can then be shaped into a mold, extruded, or used in the formation of laminated products or molding materials. They may be thermoplastic or thermosetting.

SYNTHETIC RESINS refers to compounds obtained by the condensation and polymerization of certain substances, e.g. phenol and formaldehyde, phenol and furfural, urea and formaldehyde, glycerine and phthalic anhydride, etc.

DUST GENERATING EQUIPMENT refers to grinders, ball mills, tube mills, hammer mills, roller mills, screens, compounding rolls, bucket elevators, etc., in conjunction with which may be used dust collectors, air separators, cyclones, duct work, spouts and conveying apparatus.

PULVERIZING refers to the process of reducing or being reduced to a powder, as by grinding, crushing, or rolling in suitable equipment.

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 the approval of the Inspection Department having jurisdiction.

## Section I. Introduction.

101. This Code is issued as a guide to eliminate or reduce the dust explosion hazards inherent in the manufacture and handling of plastics including the handling of raw materials. This Code is intended to apply to new construction and rebuilt or remodeled plants. It is advisable to remodel wherever possible any present installations to conform with these standards. This Code also applies to certain areas of plants using large quantities of these materials.

102. While this Code is to apply to the entire plastics industry it is based largely upon experience in the phenolic resin class. Since there is a wide variation in raw materials and processing of materials in other classes, some modification of these rules in actual application would appear to be in order, depending upon the relative degree of hazard. As a guide for such modification, the materials listed in Table I are arranged in order of decreasing explosion hazard, taking into consideration the ease of ignition, lower explosive limit, as well as explosive violence.

103. The data in Table I are based on tests with dusts of minus 200-mesh fineness. Laboratory tests indicate that with increase in particle size, the ignition temperature, the minimum energy required for ignition, and the minimum explosive concentration (lower explosive limit) of the dust clouds becomes higher, and the maximum pressure and rates of pressure rise developed during a dust explosion are reduced. In other words, the coarser the dust is, the smaller is the hazard of a dust explosion. As an example, the effect of particle size on the maximum pressure and rates of pressure rise developed in dust explosions of cellulose acetate molding powder is illustrated in Fig. 1. For this reason it is advisable to reduce the production of fines as far as practicable.

104. In some classes of materials the use of inert components in the mix such as asbestos, mica, or litharge, may reduce the dust explosion hazard.

105. It is essential that there shall be as little escape of dust as possible into the atmosphere of the plant, this condition being favorable to a dust explosion and to the rapid propagation of fire. It is important that the apparatus be provided with effective appliances to reduce the chance of ignition, relieve explosion pressure, and confine fire.

106. The equipment employed in the industry usually consists of grinders, crushers, ball mills, air pulverizers, impact and screen hammer mills, roller mills, bucket elevators, screw conveyors, pneumatic conveyors, sifters, blenders, air separators, etc. In some cases driers are used which may introduce a flammable liquid hazard in addition to the dust explosion hazard. Figure 2 shows the relation of various operations and pieces of equipment to one another in a typical molding powder process.

## Section II. Plant Arrangement.

(See also Section V, "Explosion Preventive Measures," for required or recommended location and arrangement of processing equipment.)

201. Buildings in which dry material processing and handling are carried on should be detached or cut off by standard fire walls from the resin manufacturing department, storage areas, and other departments.

202. If, owing to the layout of the plant, the processes cannot be carried on in a location as recommended in Article 201, the portion of the plant devoted to them shall be segregated in such a manner as to minimize the possibility of an explosion or fire reaching other portions of the plant.

203. Departments in which finely pulverized materials are prepared and packaged for sale should, if possible, be segregated from those handling ordinary grinds.

## Section III. Building Construction.

301. Buildings housing dry material handling and processing should be of fire resistive construction, except as modified in Article 303, or of noncombustible construction.

## TABLE 1. Relative Explosion Hazards of Powders Used in the Plastics Industry [1].

| Type of powder [2] | Ignition temperature of dust cloud, °C. | Ignition temperature of dust cloud, °F. | Minimum energy required for ignition joules [3] | Minimum explosive concentration, oz./cu. ft. | Maximum pressure, lb. per sq. in. [4] | Rate of pressure rise, lb./sq. in./sec. [4] Average | Rate of pressure rise, lb./sq. in./sec. [4] Maximum |
|---|---|---|---|---|---|---|---|
| Hexamethylenetetramine* | 410 | 770 | 0.01 | 0.015 | 64 | 940 | 2570 |
| Shellac, rosin, gum | 390 | 735 | .01 | .015 | 58 | 1240 | 2990 |
| Phenolic resins [5] | 500 | 930 | .01 | .025 | 61 | 1370 | 3160 |
| Counarone-indene resins | 520 | 970 | .01 | .015 | 63 | 1370 | 2990 |
| Cellulose acetate molding compounds [6] | 320 | 610 | .01 | .025 | 62 | 1180 | 2260 |
| Pentaerythritol* | 450 | 840 | .01 | .030 | 65 | 980 | 2170 |
| Cellulose acetates [6] | 410 | 770 | .015 | .035 | 68 | 800 | 1740 |
| Lignin resins | 450 | 840 | .02 | .040 | 69 | 760 | 2700 |
| Ground cotton flock† | 470 | 880 | .025 | .050 | 67 | 870 | 2990 |
| Ground wood flour† | 430 | 805 | .02 | .040 | 62 | 830 | 2080 |
| Phenolic molding compounds | 490 | 915 | .01 | .030 | 63 | 900 | 2080 |
| Synthetic rubber | 320 | 610 | .03 | .030 | 59 | 740 | 1870 |
| Phthalic anhydride* | 650 | 1200 | .015 | .015 | 49 | 1270 | 1690 |
| Vinyl butyral resin | 390 | 735 | .01 | .020 | 60 | 470 | 1020 |
| Methyl methacrylate molding compound | 440 | 825 | .015 | .020 | 57 | 570 | 1200 |
| Urea molding compounds | 450 | 840 | .08 | .075 | 63 | 710 | 1800 |
| Polystyrene molding compound | 560 | 1040 | .04 | .015 | 50 | 740 | 1640 |
| Ground alpha pulp† | 480 | 895 | .08 | .060 | 60 | 520 | 1450 |
| Urea resins | 470 | 880 | .08 | .070 | 65 | 340 | 850 |
| Polystyrene resin | 490 | 915 | .12 | .020 | 44 | 350 | 650 |
| Vinyl resins [7] | 550 | 1020 | .16 | .040 | 49 | 250 | 490 |
| Rennet casein* | 520 | 970 | .06 | .045 | 49 | 190 | 500 |
| Vinyl molding compounds | 690 | 1275 | — | — | — | — | — |
| Chlorinated paraffin | 840 | 1545 | — | — | — | — | — |
| Asbestos, asbestine, mica† | No ignitions obtained in any test; these powders present no dust explosion hazard. | | | | | | |

[1] Table is based on tests made in dust explosion laboratory of Bureau of Mines, U. S. Department of the Interior, Pittsburgh, Pa. See Bureau of Mines Report of Investigations No. 3751 for a complete description of the investigation, including test procedure.
[2] The powders are arranged approximately in the order of decreasing dust explosion hazard. All tests were made on minus 200-mesh dusts.
[3] 1 joule = 1 watt-second = 0.00095 British thermal unit. In this test the dust clouds were ignited by static sparks from condenser discharge.
[4] Data on pressures and rates of pressure rise are for a dust concentration of 0.500 ounce per cubic foot.
[5] Samples included phenol formaldehyde, phenol anhydro formaldehyde anilin, and phenol furfural.
[6] Samples included cellulose acetate, cellulose acetate butyrate, and ethyl cellulose.
[7] Samples included polyvinyl acetate and vinyl chloride-vinyl acetate copolymers.

*Ingredients of synthetic resins.
†Fillers for molding compounds.

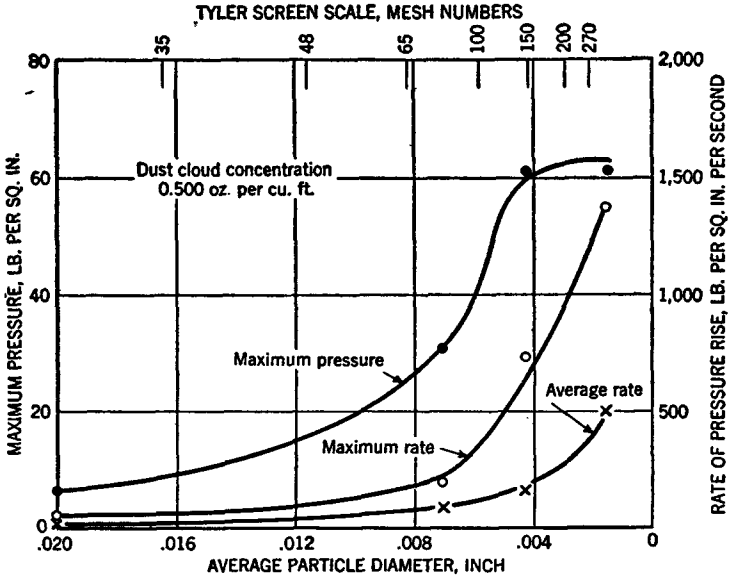


**Fig. 1.**—Variation of maximum explosion pressure and rate of pressure rise with fineness of cellulose acetate molding powder.

302. 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 shall 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.

303. Explosion venting shall be provided in a given room or space in order to approach as nearly as possible a ratio of 1 sq. ft. of relief area to 35 cu. ft. of room volume. This may be accomplished by making all or sections of exterior walls of light noncombustible material, or by the use of approved automatic pressure relieving devices in the form of top-hinged windows or panels so balanced as to open outward under a predetermined pressure. Hinged windows or panels shall be fastened in such a way as to permit opening under pressure originating inside of the room. Venting areas shall be located in such a manner that no part of the room shall be further away from the venting area than a distance equal to 1.1 times the least horizontal dimension of the room.

NOTE.—The lighter the construction the less damage will result from an explosion, but the type employed will be influenced by considerations of cost, permanence, ease of obtaining smooth interior finish, condensation of atmospheric moisture, etc. It is necessary however to provide sufficient strength and anchorage to withstand possible snow and wind loads and resist the lifting force created by winds of hurricane velocity.

304. Existing buildings of combustible construction, but of a type equal in quality or better than standard mill, or plank and timber construction, if

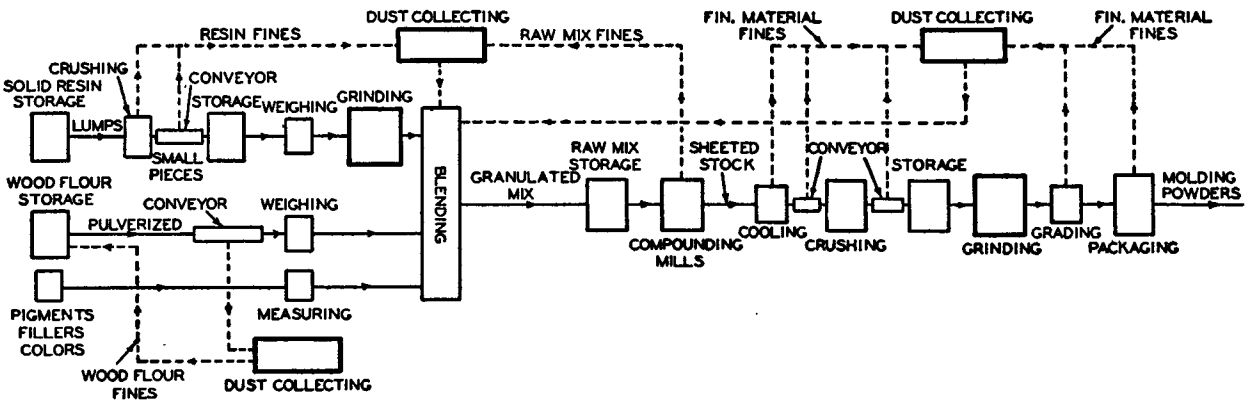


Fig. 2.—Typical flow chart illustrating a continuous process for the manufacture of phenolic molding powders.

used for dry material handling and processing, shall be protected in the following manner:

(a) By application to all combustible surfaces of at least one inch of gypsum plaster on expanded metal or equivalent.

(b) There shall be no concealed spaces at ceilings or partitions.

**Section IV. Communications.**

401. Access to special fine grinding departments or buildings and dry powder departments or buildings in which there are located stock bins, blenders, weight bins, bucket elevators, or dust arrestors should 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 Class A self-closing fire doors, opening out, shall be provided. Where direct communications from dry powder handling to non-hazardous areas are necessary, these shall be protected by standard Class A hinged self-closing fire doors, swinging outward from the room in which the hazardous processes are conducted; when safe egress is provided to the outer air, standard automatic sliding Class A doors, normally kept shut, may be used in the communicating openings. (See Standards on Protection of Openings in Walls and Partitions.)

402. Where power is transmitted to apparatus within the processing room from any driving mechanism or unit outside of the dry powder processing department, the transmission medium (belt or chain) shall be encased inside of the dry powder processing department in practically dust-tight enclosures, constructed of substantial noncombustible material. Where power is transmitted by means of shafts, these shall pass through close-fitting shaft holes in walls or partitions. Shaft transmission of power is preferable to belt or chain drives.

403. All pipe openings through walls or partitions shall be tight.

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

405. 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 of the walls or floors separating the pulverizing department from other portions of the building. Conveyors of the screw type shall be permitted to pass through the walls, provided a portion of the blade, equivalent to at least one diameter of the screw, shall be omitted at a point immediately inside of the wall of the pulverizing department and pins substituted therefor. Finished products may be delivered through the walls of the pulverizing department to adjacent departments through spouts, provided; the material enters the spout from bins, hoppers or other apparatus through a close fitting pocket feeder, or a screw conveyor from which a portion of the blades equivalent to at least one diameter of the screw has been omitted and pins substituted therefor, or an equally effective means of producing a choke. Material may be conveyed into or out of the pulverizing department through walls in one of the vibrating type of conveyors provided the section through the wall is enclosed in a substantial metal stationary sleeve which shall be fastened to a substantial metal hopper. The outlet of this hopper shall be provided with a choke-discharge similar to one of the types mentioned above. (See Fig. 3.)

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

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

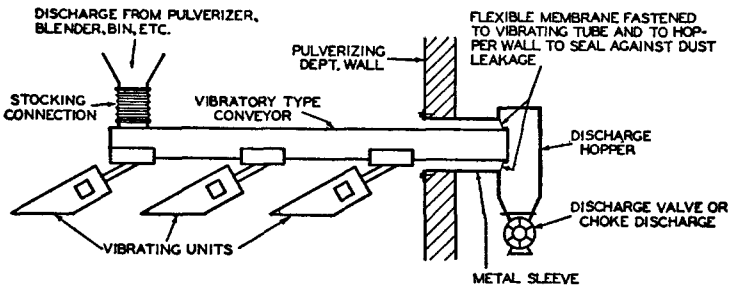


**Fig. 3.**—Method of conveying material through a wall by means of a vibrating conveyor, reducing to a minimum the danger of fire and explosion being transmitted from one fire area to another.

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

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

(d) The conveyor shall discharge into a dust-tight metal discharge chute or hopper, which shall be secured to the conveyor housing in a dust-tight and approved manner and the discharge of which shall consist of an approved choke-discharge.

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.

406. Air may be used to convey raw material to supply bins in the pulverizing department, and to convey finished product from the pulverizing department to another area. When used, these pneumatic conveying systems shall be fed through a rotary or pocket type feeder or an equally effective arrangement for producing a "choke" between the charging hopper and the conveying pipe. The conveying pipe shall be constructed to withstand three times the pressure shown in Table I under "Maximum pressure, Pounds per Sq. Inch" for the material to be conveyed. The receiving bin and the dust filter housing shall be substantially constructed and be dust-tight, and shall be provided with approved explosion relief vents to outside atmosphere of such size and construction as to prevent the rupture of the receiving bin and dust filter casing in the event of an internal explosion of dust. These materials should not be conveyed *through* fans or blowers. (See Article 509.)

All sections of piping and all parts of the apparatus shall be grounded in an effective and approved manner in accordance with the Standards for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal; N.B.F.U. Pamphlet No. 91, page 9, Section 262.

**Section V. Explosion Preventive Measures.**

501. All apparatus shall be properly and securely installed to insure constant true alignment and to avoid hot bearings or friction, and no moving parts such as belts, pulleys, drive chains, etc., shall be fitted close to or come in contact with any part of the enclosures or the structure. On all grinders other than those direct driven, metal driven pulleys should be used. Bearings should be of the ball or roller type, if possible, and all bearings shall be so designed as to be dust-tight. Adequate clearances should be provided around grinder shaft openings to permit flow of air from the room to the grinder

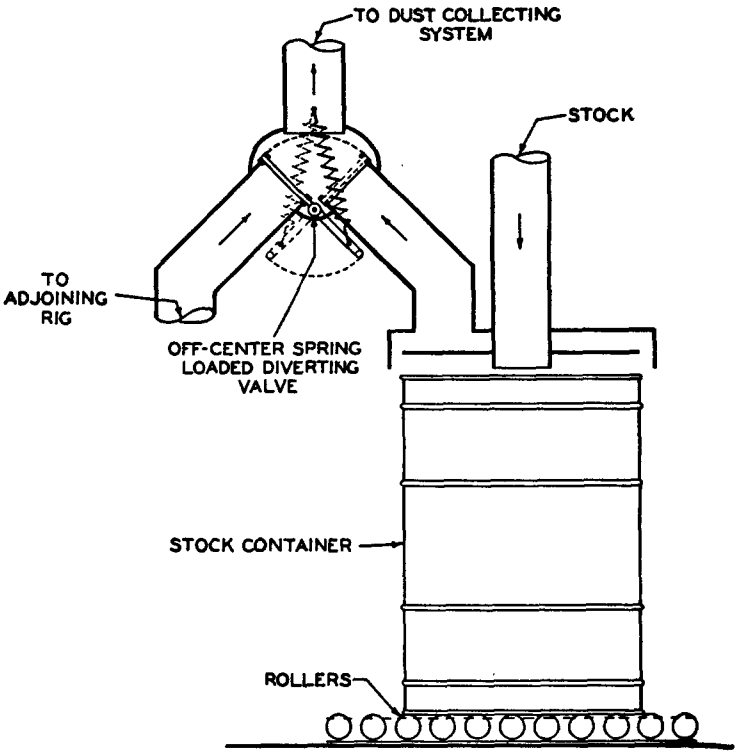


**Fig. 4.—Arrangement of molding powder packaging rig, showing an efficient dust collecting hood and a special diverting or two-way valve in the dust collecting duct system.**

interior in order to prevent the accumulation of stock and consequent heating and possible ignition. The apparatus should preferably be installed and arranged in unit systems so that each grinder will deliver to but (only to) one set of scalpers, bolters and other processing equipment of the same unit. Interconnections between (different) sets of apparatus should not be permitted.

502. All apparatus should be equipped with such devices as will:—

(a) Minimize the amount of dust escaping to the room atmosphere (see Articles 503 and 510, also Fig. 4).

(b) Reduce the chances of ignition of dust (see Articles 501, 504, 505 and 509, also Fig. 5).

(c) Localize the results of ignition (see Article 508, also Fig. 3, 5 and 6).

503. All conveyors handling dusty materials shall be fully enclosed in tight, substantial metal housings; if the tops of these housings are removable, they shall be well secured. (This should not be construed to prohibit the use of explosion relief vents.) Such conveyor housings should be so designed and constructed as to withstand possible explosion pressures, due consideration

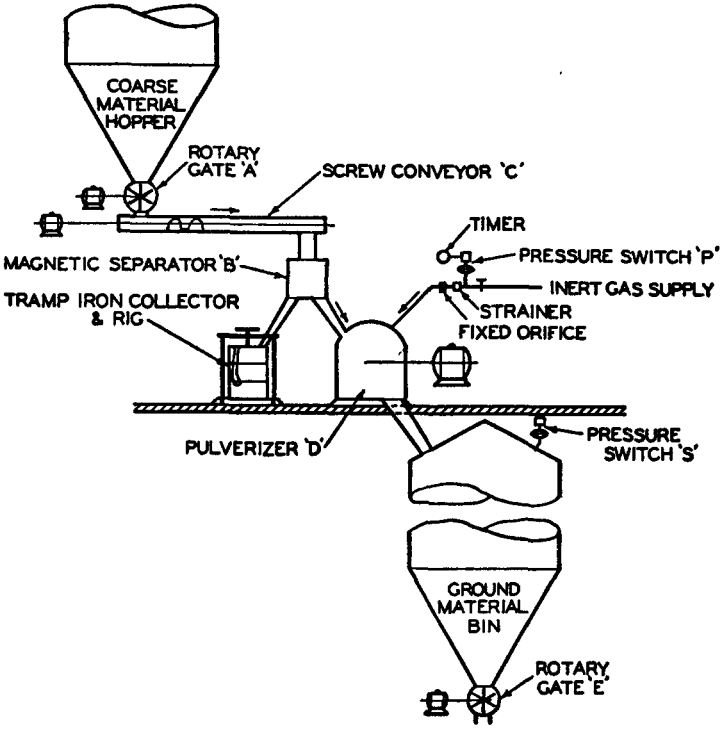


**Fig. 5.**—Typical grinding set-up showing principles of safeguarding. All equipment between positive locks A (or C) and E should be constructed to withstand maximum possible explosion pressure, or reduced pressure resulting from the use of explosion relief vents to atmosphere. System should be so interlocked that operation of locks or gates A (or C) and E and mill D depends upon separator B (both A.C. and D.C. circuits), and operation of pressure switch S will shut down all equipment. With inert gas protection, the starting sequence should be so arranged that gas pressure against orifice will start timer by operation of pressure switch P, unlocking separator B which in turn unlocks all other drives when predetermined safe oxygen atmosphere in grinder and bin has been reached.

being given the effect of explosion relief vents. (See example in Appendix, also Article 702 for location.)

504. Static electricity shall be removed from all machines and equipment, including ductwork and permanently installed or portable vacuum cleaning systems and equipment, by permanent grounding and bonding wires, and from belts by grounded metal combs or other effective methods. The use of 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 the National Electrical Code, Article 250. See also N.F.P.A. Committee Report on Static Electricity.

505. All of the stock delivered to the mills shall pass over magnetic separators of the self-cleaning type, interlocked with the grinder drive, and

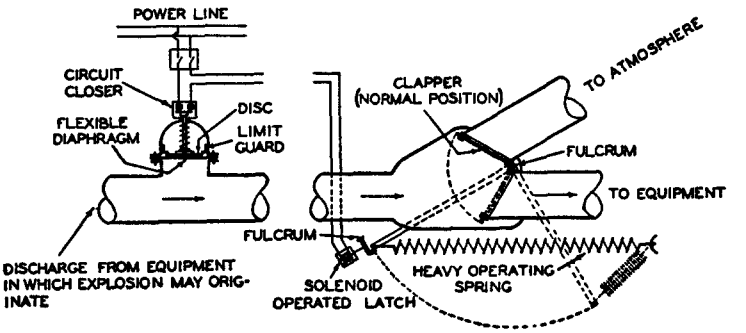


**Fig. 6.—Showing arrangement of an explosion pressure pick-up device, installed close to a major piece of apparatus in which an explosion may originate, connected electrically to an automatic diverting gate, located ahead of apparatus subject to extreme damage. Such a system is known to be effective when the distance between devices is not less than 40 ft.**

the stock shall be protected against the entry 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.

506. If the material is dumped into the delivery hopper from a floor above the mill, such hopper should have a curbing at least 4 inches above the floor.

507. Inspection openings in the grinding apparatus shall be provided with wire mesh screens of not less than ¼ in. mesh.

508. Mills delivering directly through spouts should be provided with devices in or underneath the discharges which retard the flow of product in such a manner as to keep a small space immediately underneath or near the discharge filled up with the pulverized product, thus smothering any spark that may originate in the mill. This can be effected either by means of a revolving choke valve, or if material is delivered directly into a screw conveyor by omitting a small portion of the blade and substituting pins therefor.

509. Blowers or exhaust fans shall be installed on proper foundations and secured in a substantial manner. Where practicable the exhaust fan shall be located beyond the collector. When located between the collector and the grinding apparatus or any portion thereof from which the dust is to be removed, the blades and spider should be of bronze or other non-sparking metal, or (and) the casing consist of or be lined with similar material. Ample clearance shall be provided between the blades and the casing. The fan bearings shall not extend into the casings. (See Standards for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal.)

510. Screens, scalpers, bolters and similar devices shall have their reels or sieves in dust-tight enclosures. When connected to dust collectors, the ducts shall be of metal, and the collectors shall be properly vented to the outside of the building. Care should be taken to securely ground all parts of these devices.

511. 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

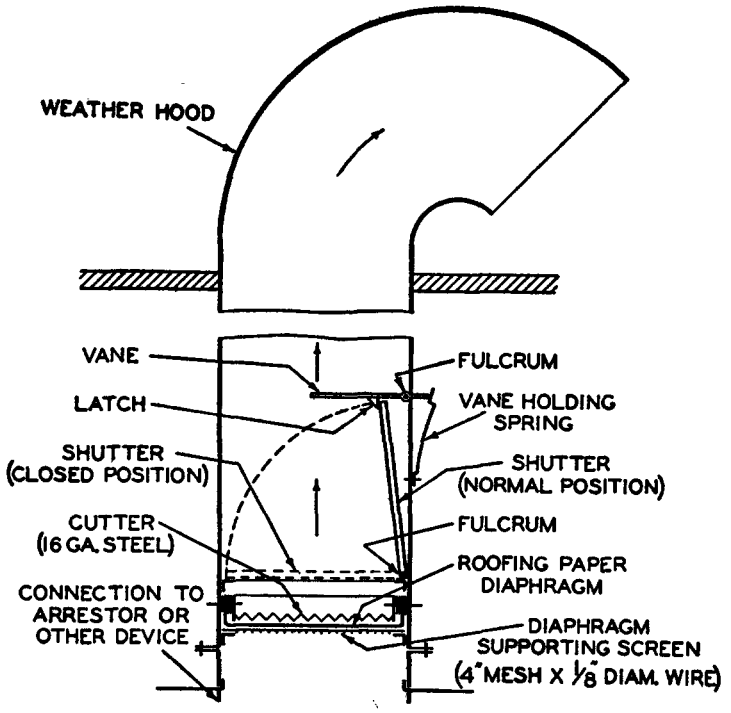


**Fig. 7.—Suggested method of providing satisfactory explosion pressure relief for large sheet steel enclosures such as arrestors. The automatic shutter is provided to close the opening after the pressure has been safely relieved to atmosphere in order that efficient extinguishment of the resulting fire with $CO_2$ may be assured. The area of the explosion vent required is determined by the nature of the stock handled, the strength of the device to be protected, the rupturing strength of the diaphragm, the length and characteristics of the relief duct to atmosphere, etc. The diaphragm sawtooth cutter shown is readily constructed and greatly reduces the bursting pressure required.**

housings should be designed and constructed as to withstand anticipated explosion pressures; due consideration being given the reduction in pressure afforded by adequate explosion relief vents. (See example in Appendix, also Article 701 for location.) The fabric of cloth type collectors should be electrically grounded in an effective manner. Flameproofing of fabric is desirable, wherever practical.

512. No open flames of any kind, nor any operations or repairs resulting in sparks or utilizing direct fire or heat shall be permitted in the dry powder processing department until all equipment has ceased operating and the room and equipment have been carefully cleaned (of dust), including the wiping down of equipment near the point where it is necessary to use the open flame or direct fire heat. Care shall be taken to see that the air in the room is free from dust and that first aid fire protection in the form of small hose or extinguishers is close at hand during such periods.

## Section VI. Electrical Equipment.

601. Electrical equipment in all rooms and spaces where dry powder is stored, handled and processed should conform to the regulations of Article 500 of the National Electrical Code for Class II, Group G Locations (Sections 5052 to 5064 inclusive).

## Section VII. Minimizing the Effect and Extent of Explosions In Dry Powder Processing and Handling Equipment.

701. All cyclone separators and dust collectors should be located on the roof or outside and well removed from buildings, in segregated sections of the plant, or in separate buildings. If this is not possible, they shall be located within the dry powder department and shall be provided with explosion relief vents to a safe point outside of the building, of such size and design as to prevent rupture of the collector. (See Fig. 7, also Standards for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal.)

702. Bucket elevators shall be located outside buildings wherever possible and provided with adequate explosion relief vents. 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 Article 503.)

703. All dry powder stock bins of such dimensions or shape which do not permit construction of sufficient strength to resist maximum calculated explosion pressure (see Table I as a guide) should be located close to exterior walls to facilitate explosion relief venting, except that if bins are provided with ample means of maintaining an inert atmosphere, explosion venting may not be required. (See Article 704 and Code on Inert Gas Protection, also Appendix.)*

704. The use of inert gas is urged to create safe atmospheres within mills and other apparatus, where practical, especially those handling exceedingly fine stock. (See Code on Inert Gas Protection, also Fig. 5.) The approximate safe oxygen percentage in atmospheres for various stocks involved in the industry are shown in Table II.

705. In addition to dust arrestors, separators or collectors, elevators and stock bins (as noted in Articles 701, 702 and 703), ducts, blenders, certain types of mills and spray dryers may require explosion venting. 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 terminals of such equipment as bucket elevators and screw conveyors and especially at turns in ducts (see Fig. 8).

706. Unused plugged outlets, dead-ends, or other pockets which may permit the collection of quantities of dust in ducts, pipe lines, or other conveying apparatus shall not be permitted.

707. Explosion relief vents shall be of such size and design as to prevent rupture of the device or apparatus protected (see Appendix). The explosion vent ducts shall be properly designed, substantially constructed of metal and be carried out-of-doors as directly as possible, avoiding sharp turns—never through an adjoining building or room.

708. Explosion relief vents should be fitted with cowls or hoods, and where the non-escape of dust is essential, with rupture diaphragms, preferably fitted with cutters to accelerate rupture. See Figs. 7 and 8 for details of suggested diaphragm and cutter construction.

*Included in National Fire Codes for Extinguishing and Alarm Equipment.

## TABLE II.

### Permissible Percentage of Oxygen in Atmosphere to Prevent Explosions of Powders Used in the Plastics Industry.[1]

| Type of Powder | Maximum permissible oxygen percentage |
|---|---|
| Alpha pulp, ground | 7 |
| Casein, Rennet | 7 |
| Cellulose acetates | 7 |
| Cellulose acetate molding compounds | 7 |
| Cotton flock, ground | 7 |
| Coumarone-indene resins | 11 |
| Hexamethylenetetramine | 11 |
| Lignin resins | 7 |
| Methyl methacrylate molding compound | 7 |
| Pentaerythritol | 7 |
| Phenolic resins | 9 |
| Phenolic molding compounds | 7 |
| Phthalic anhydride | 11 |
| Polystyrene resin | 7 |
| Polystyrene molding compound | 9 |
| Rubber, synthetic | 11 |
| Shellac, rosin, gum | 9 |
| Urea resins | 11 |
| Urea molding compounds | 9 |
| Vinyl butyral resin | 5 |
| Vinyl resins | 11 |
| Vinyl molding compounds | 15 |
| Wood flour, ground | 7 |

[1]See Bureau of Mines Report of Investigations No. 3751 for description of test method and other details.

### Section VIII. Housekeeping.

801. (a) 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. Accumulations of dust shall not be tolerated in the building. It is recommended that the interior of the dry powder processing department be painted a color which is in contrast with that of the dust.

(b) 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 an adequate pneumatic or vacuum-sweeping system.

(c) Cleaning that is liable to result in production of dust clouds shall not be done while machinery is in operation because of the possibility of the dust being ignited.

802. (a) Portable vacuum cleaners, if of a type approved for hazardous locations, or fixed pipe suction systems with remotely located exhauster and collector, may be used for cleaning. Suction-cleaning appliances should be connected by hose to taps of permanent piping extending to a suction fan or equivalent. Care should be exercised in the grounding of all hose outlets.

(b) The exhauster and the collector shall be located outside the dry powder processing department.

(c) Permanently piped dust collecting systems for cleaning purposes should be independent of all other dust collecting systems.