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

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CODE FOR EXPLOSION AND FIRE PROTECTION IN PLANTS PRODUCING OR HANDLING MAGNESIUM POWDER OR DUST

Interim Edition, September 15, 1943.

This Code was adopted by the National Fire Protection Association at the annual meeting in May, 1943, with authority to the Committee on Dust Explosion Hazards to make certain changes subject to subsequent approval by the N.F.P.A. Board of Directors. The present tentative edition incorporates the changes agreed upon by the Committee to date but is subject to further revision by the Committee at its next meeting, prior to final N.F.P.A. adoption. Those having suggestions on this Code should communicate with Mr. Hylton R. Brown, Chairman, N.F.P.A. Committee on Dust Explosion Hazards, Eastern Experiment Station, College Park, Maryland, prior to December 1, 1943.

CODE FOR EXPLOSION AND FIRE PROTECTION IN PLANTS PRODUCING OR HANDLING MAGNESIUM POWDER OR DUST.

Introduction:

Unusual explosion and fire hazards are present in plants producing or handling magnesium powder and in plants producing dust, shavings, or chips in connection with the sawing, grinding, machining, or buffing of castings or stampings made from magnesium or its alloys. Magnesium in the form of powder, shavings, chips, or dust can be ignited readily by a spark, flame, or friction sufficient to raise the temperature to about 900° F.

Magnesium powder or dust will ignite readily and when ignited while in suspension in air, it will explode violently. The high pressure recorded and the very rapid rate of pressure rise observed in laboratory tests emphasize the importance of adopting all possible protective measures wherever magnesium powder is produced, processed or handled.

NOTE: *At dust concentrations of 500 milligrams per liter (500 ounces per 1000 cubic feet) maximum pressures in excess of 70 pounds per square inch (5 tons per square foot) were recorded in laboratory tests. The maximum rate of pressure rise determined with the Clement Frazer apparatus is nearly 800 pounds per square inch per second; in the Hartmann apparatus at the Bureau of Mines laboratories, a rate of nearly 5,000 pounds per square inch per second was recorded. The maximum pressure of 70 pounds per square inch at the concentration cited is developed in from one-tenth to one-fiftieth of a second.*

Burning magnesium powder normally produces a temperature of about 2,500° F. but under certain conditions this figure may be greatly exceeded. Such fires cannot be extinguished by the application of water, carbon dioxide, foam, carbon tetrachloride, or other common fire extinguishing agents. Application of these agents may intensify the burning or cause violent explosions.

The purpose of this code is to direct attention to the precautions which can be taken and safe practices which should be followed in guarding against magnesium fire and explosion hazards. This code consists of two parts: Part I deals with the production and handling of magnesium powder. Part II deals with the collection, removal and disposal of magnesium dust.

Definitions:

The following terms are used in this code as defined below:

"Magnesium powder," fine magnesium, 30 mesh or finer, a product specially prepared in equipment designed or installed for the purpose.

"Magnesium dust," fine magnesium considered as a waste product in grinding or otherwise preparing magnesium parts.

"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 regulations.

PART I

MAGNESIUM POWDER PLANTS

Section 1. Location of Plants.

1-101. At the present time no practical method of providing complete protection against ignitions and explosions of magnesium powder is known.

Accordingly, it is recommended that plants engaged in the production, processing, handling and storage of magnesium powder be located in sparsely settled sections where sufficient space is available to permit location of the buildings in accordance with the quantity distance table given below:

TABLE A. — Quantity and distance table for magnesium powder or dust not in sealed containers

Quantity		Distance in feet from nearest (with or without barricade)			
Pounds Over	Pounds Not Over	Building Not on Plant Property	Railway	Highway	Building on Plant Property
10	25	60	40	20	40
25	50	145	90	45	60
50	100	240	140	70	80
100	200	360	220	110	100
200	300	520	310	150	120
300	400	640	380	190	130
400	500	720	430	220	140
500	750	890	535	270	160
750	1,000	1,020	610	310	180
1,000	1,500	1,060	640	320	210
1,500	2,000	1,200	720	360	230
2,000	3,000	1,300	780	390	260

NOTE: *These distances may be reduced 50 per cent if operations are in buildings with 12-inch solid reinforced concrete or masonry walls and a light roof which will provide a venting area of 1 square foot for each 25 cubic feet of room volume. Buildings housing magnesium powder producing or handling equipment shall be at least 100 feet from electric or steam power plants.*

1-102. The entire property should be surrounded with a high, strong fence, preferably of noncombustible material, designed to prevent unauthorized access to the plant or traversing of the grounds.

1-103. Gates or entrances to the property should be guarded.

Section 2. Construction and Location of Buildings

1-201. All buildings comprising a magnesium powder plant shall be of non-combustible construction.

NOTE: *During the present emergency shortage of critical materials, the requirements for noncombustible material may be waived by the authority having jurisdiction when it is shown that such materials are not obtainable.*

1-202. Separate rooms or separate buildings shall be provided for each manufacturing operation, such as cutting, grinding, screening and packaging. If separate rooms in one building are used, the rooms shall have 12 inch reinforced masonry division walls extended as parapets, 3 feet above the roof and extended 3 feet beyond the line of the exterior wall of the room.

1-203. Buildings in which the cutting or grinding, screening, collecting, or packaging machines are located shall be constructed without basements and be not more than one story in height.

1-204. Each grinding mill or screen shall be installed in a separate room or compartment with at least two exterior walls and where hammer mills or pulverizers are used for grinding, not more than two rooms con-

taining such grinding equipment shall be permitted in one building. One exterior wall shall be of light construction to provide adequate explosion venting. An emergency exit from each screening or grinding room shall be provided in the light venting wall. This exit may be a panel or light door, operable from the inside only and designed to open outward. The normal means of entrance and exit shall be through an approved Class A self-closing fire door in one of the reinforced masonry walls, hinged to open outward, and this door shall be equipped with a positive latch. There shall be no direct communication between rooms or buildings in which the grinding or screening equipment is installed.

1-205. Covered passageways with sloping roof enclosed on the low side only may be provided between buildings or alongside the rooms or compartments housing individual machines. Entrance to rooms shall be at right angles to the direction of travel through the passageway and all connections to the passageway shall be protected by approved Class A self-closing swinging fire doors. An opening from one room to the passageway shall not be directly opposite the opening from another room to the passageway.

1-206. Buildings shall be designed so that all horizontal ledges or surfaces above the floor level are eliminated as far as practical. Ledges which cannot be eliminated shall be filled and beveled to provide a smooth, steeply inclined surface which will not retain dust deposits.

1-207. Floors shall be constructed to prevent the production of metallic or static sparks. If conductive flooring is used, it shall be effectively bonded and grounded.

1-208. Floors shall be smooth with the junction of floor and walls free from cracks or other dust catchers. Fillets with a minimum radius of 2 inches at floors and wall junctures are recommended.

1-209. All interior walls shall be made as smooth as possible to prevent the retention of dust on their surfaces. Coating of the walls with enamel or other material to produce a surface which will prevent the adherence of dust is recommended.

1-210. Roofs of buildings shall be as light as practical and arranged so that they will be easily blown off by an internal explosion. Piping or other equipment should not be supported by the roof deck but secured only to structural members not likely to be damaged by an explosion.

1-211. Roofs shall be constructed and maintained in a tight condition to prevent leakage.

1-212. Windows shall be large in area to provide maximum lighting and to provide a vent for the release of pressure in case of an explosion. A venting ratio of not less than 1 square foot for each 25 cubic feet of volume is recommended. Windows or sections of windows which open should be hinged at the top and be of an explosion venting type with catches designed to release on the application of pressure from within. Fixed glass should be scored on the outside with a glass cutter to reduce the resistance of the glass to pressure from within.

Section 3. Making and Handling Magnesium Powder

NOTE: *Several different methods of producing magnesium powder are now in use and new systems are being tried but comparable data on explosion hazards during operation are not available. Where magnesium powder is manufactured by the so-called wet process, that is, by the use of special files or milling cutters operating under a liquid medium such as mineral spirits having a flash point of approximately* 105 *degrees F., the hazards up to the time of the removal of the oil from the magnesium powder by drainage and evaporation are principally*

those associated with flammable liquids and the recommendations of the committee on flammable liquids are applicable. The provisions of this code will apply to magnesium powder manufactured by the so-called wet process whenever the material is handled or stored in the dry powdered form. The following recommendations covering the making and handling of magnesium powder are based on past experiences and information now available on manufacturing methods.

1-301. All magnesium powder should be produced and handled by the batch system as used in the manufacture of explosives.

1-302. Air shall not be used to convey magnesium powder in manufacturing or processing operations where other means of conveying are feasible unless permitted by the authority having jurisdiction.

1-303. Hand trucks, carts, and drums should be used for transporting both the magnesium in the process of being reduced to powder and the finished product itself. Power driven trucks, other than the type approved for use in Class II, Group E locations, shall not be used.

1-304. Carts, trucks, boxes, or drums used during manufacture as containers for magnesium powder should be constructed of nonsparking material or be lined with nonsparking material, and have nonsparking tires on wheels or casters. Rubber tires should be electrically conductive.

1-305. Shovels or scoops used in handling magnesium powder should be made of magnesium, aluminum, copper or other nonsparking material.

1-306. Grinding equipment used for the production of magnesium powder should not be used for any other grinding.

1-307. Screens and magnetic separators should be used to remove all foreign material and oversize pieces from the magnesium entering the grinder.

1-308. All powder producing and handling machinery should be as dust-tight as possible to prevent the escape of powder into the air of the room in which it is located.

1-309. Automatic operation of mills and screens should be arranged with remote controls for starting and stopping the machinery.

1-310. Devices to detect unusual increases in temperature are recommended for installation in grinding or processing equipment. These devices should be arranged to shut down the equipment when a hazardous condition is indicated.

1-311. Operators shall be instructed to shut down machinery before entering screening or pulverizing rooms. To insure compliance with this rule, entrance doors to such rooms should be interlocked with the power supply so that machinery will be automatically stopped if the door is opened while the machinery is operating. A reset system should be provided to prevent restarting of machinery when the door is closed until the normal starting procedure is followed.

1-312. Not more than two and preferably only one person should enter the rooms or compartments to charge or unload the machines or perform cleaning or maintenance duties.

1-313. Magnesium powder should be handled and transported in bulk containers and not allowed to fall through chutes or spouts into open bins or hoppers where dust clouds may be created.

1-314. If practical, all enclosed equipment for the production and handling of magnesium powder should be provided with explosion relief vents to the outside of the building. These vents should be so constructed that there will be no loss of fine powder and should be designed to prevent the entrance of moisture.

1-315. To make explosion vents most effective, mills or other machines should be installed close to walls or windows to permit using the shortest possible vent duct.

Section 4. Electrical Wiring and Equipment

1-401. All electrical wiring and equipment in buildings where magnesium powder is regularly produced or handled, and in other sections of the plant where magnesium powder or dust may be present, shall be in accordance with the requirements for Class II locations (Group E atmospheres containing metal dust), Article 500 of the 1940 edition of the National Electrical Code and subsequent revisions thereof.

1-402. Provision should be made for remote control of the electrical circuits, so that the current for light and power in any dust making building may be cut off by switches outside of the building at a distance of at least 4 feet from the nearest doorway. It should also be arranged so that the power of the whole plant can be cut off by switches located at one or more central points, such as the office, watchman's booth, etc.

1-403. All electrical equipment shall be inspected and cleaned periodically.

1-404. Where flashlights or storage battery lamps are used, they should be of a type approved for the purpose.

1-405. Installation of transformers and capacitors shall be outside and at a safe distance from magnesium powder production buildings as now required in the National Electrical Code for plants producing aluminum bronze powder.

1-406. Electric lights for use in magnesium powder plants must be of a type which will operate continuously with all exposed parts of the lamp and fixture at a temperature well below the ignition temperature of the powder.

1-407. All electric lines supplying powder buildings should be underground or shall be protected against arcing caused by lightning.

Section 5. Control of Static Electricity

1-501. Preventing the formation or accumulation of static electricity is essential for safety in magnesium powder plants. Grounding of all buildings, machines and equipment is necessary from the standpoint of static control as well as for lightning protection. Grounding shall be in accordance with the recommendations of the N.F.P.A. Committee on Static Electricity.

1-502. Magnesium powder should not be allowed to slide over metal aprons or chutes unless they are grounded to prevent static charges accumulating. Nonmetallic or insulated chutes may be dangerous.

Section 6. Lightning Protection

1-601. An approved lightning conductor system should be provided around or upon the powder producing and handling section of the plant, of sufficient size and capacity to protect fully all buildings in the area from lightning.

Section 7. Preventing Ignitions of Magnesium Powder

1-701. Ignition of magnesium powder can be prevented in laboratory apparatus when argon, neon, or helium is used to create an inert atmosphere, but it has not been found practical to provide such protection under all commercial methods of production and handling. Nitrogen produces partial protection but will react directly with magnesium when the source of ignition is strong. Carbon dioxide reacts readily with magnesium and should not be used. It is necessary, therefore, to give particular attention to the

elimination of all possible sources of ignition in magnesium powder plants and the following general recommendations and requirements covering ignition hazards have been prepared to supplement the rules listed under separate headings.

1-702. No open flames nor electric or gas cutting or welding equipment shall be permitted within the buildings housing the powder producing or handling machinery during operation. If it becomes absolutely necessary to use such equipment inside the building for making repairs, all machinery in the building should be shut down and the section in which the repairs are to be made shall be thoroughly cleaned to remove all accumulations of magnesium powder.

1-703. Hot air heating should not be employed. The stirring action of a forced hot air heating system might easily be dangerous as it would keep fine dust in suspension. Heating by easily cleaned steam or hot water coils is entirely satisfactory and safe.

1-704. Only nonsparking tools shall be used in making repairs or adjustments on magnesium powder producing or handling equipment. These tools shall be regularly inspected and all embedded particles of iron or steel removing by dressing.

1-705. Grinding wheels shall not be used where magnesium powder is being produced or handled or where accumulations of powder may be ignited by sparks from the wheel.

1-706. Grinding wheels used for grinding magnesium, or wheels coated with magnesium powder should not be used for grinding other metals.

Section 8. Storage of Magnesium Powder

1-801. The principal precaution to observe in storing magnesium powder is to avoid storage in open bins or other open containers and limit the storage in any one area to the smallest possible amount.

1-802. Magnesium powder must be kept dry.

NOTE: *This rule refers to contamination of powder with water and is not intended to prohibit the use of approved wet methods of grinding or dust collecting.*

1-803. Magnesium powder shall be protected against any form of heat capable of raising the temperature to the ignition point.

1-804. Magnesium in the process of being manufactured into powder shall be kept in covered containers to protect it against possible ignition by sparks.

1-805. The finished product shall be packed in cans, drums, or moisture-proof containers which can be closed to prevent accidental spilling during handling.

1-806. All containers in which magnesium is stored shall be plainly labeled.

Section 9. Fire Protection for Magnesium Powder Plants

NOTE: *Special attention is being given to the development of fire extinguishing equipment suitable for use in magnesium powder plants. The recommendations in this section are based on information at present available to the committee. Revisions will be made as promptly as possible in accordance with operating experience and data furnished to the committee. Comments by N.F.P.A. members and plant operators are solicited.*

1-901. Fire protection for magnesium powder plants is largely a fire prevention problem. Small magnesium powder fires can be extinguished but no satisfactory method of extinguishing large fires is known. It is es-

sential, therefore, that magnesium powder fires be detected in the incipient stage and the proper extinguishing procedure followed.

1-902. Burning magnesium produces a temperature which may under certain conditions greatly exceed 2500° F. and cannot be extinguished by the application of water, carbon dioxide, foam, carbon tetrachloride, or common fire extinguishing agents. These extinguishing agents when applied to a magnesium fire may stimulate the burning and may cause an explosion. To avoid the possibility of extinguishers of the types mentioned being used by persons unfamiliar with the hazard, it is recommended that all such extinguishers be excluded from sections of the plant in which magnesium fires may occur.

1-903. Sprinkler systems shall not be installed in buildings where magnesium powder constitutes the principal fire hazard.

1-904. Violent disturbance of a magnesium powder fire by the application of extinguishing agents, drafts of air, or movement of the surface on which the fire is burning should be avoided. Magnesium powder thrown into the air under such conditions will explode violently.

1-905. Small fires in dry magnesium powder can be controlled by carefully spreading graphite, dry sand, dry salt, clean, unrusted cast iron borings, talc, slag, or certain other materials on and around the fire, but if air reaches the fire through this covering the magnesium will continue to burn and the mass will remain hot for a long time.

1-906. Coal-tar pitch of the type known as "very hard" with a softening point of approximately 300° F. has been found to be a satisfactory extinguishing agent for magnesium fires in tests made with quantities of burning magnesium ranging from 1 to 10 pounds. When spread over a hot magnesium fire the pitch softens and seals the burning magnesium with an airtight covering which smothers the flames. Because pitch is combustible and fine particles may ignite readily, it is important that only granulated pitch, through 6 mesh and on 40 mesh U. S. sieves, or pitch in flake or other form screened to remove the fines under 40 mesh, be used as an extinguishing agent. On tight noncombustible surfaces, magnesium fires of moderate size, even when quite active may be extinguished by carefully and completely covering the burning pile with a layer of pitch of the type and size specified and allowing the pitch to cool and partially harden without disturbing the fire.

1-907. Other effective extinguishing agents for magnesium fires are generally marketed as proprietary compounds. These are generally in powder or paste form and are applied by means of scoops, shovels, tubes, or specially designed distributing apparatus. Their use is generally limited to fires of moderate size which can be approached closely enough to permit application of the extinguishing agent.

1-908. Special fire brigades of employees should be organized and trained in fire fighting operations by conducting tests and demonstrations with the extinguishing agents on fires built at a safe distance from the plant. Members of nearby fire departments who may be called to the plant should be instructed in magnesium fire control and advised of the possible hazards incident to the use of certain types of extinguishers on magnesium powder fires. Only men trained to fight magnesium fires should be allowed near the scene of the fire.

1-909. Extinguishing a magnesium powder fire may be a very dangerous undertaking because of the possibility of an explosion occurring when the burning power is disturbed. For this reason many operators prefer to seal a magnesium fire in the room or compartment in which it originates and allow it to burn itself out. Sand or other noncombustible material can be used to seal openings around the fire doors at entrances to these rooms.

Section 10. Safety Precautions

1-1001. As in all other plants where fire and explosion hazards exist, good housekeeping is essential and all possible precautions should be taken to insure safe operation of the plant.

1-1002. Employees should be carefully instructed in their duties.

1-1003. All employees should be advised of the fire and explosion hazard and instructed in the procedure to follow in case of emergencies.

1-1004. Rules and regulations for safe operating procedure should be conspicuously posted throughout the plant.

1-1005. Thorough inspections of the plant should be made at frequent and regular intervals by competent persons to see that no powder or dust has been allowed to accumulate around the machines; that no excessive amounts of powder are stored in any one area; that all equipment is in perfect operating condition and that proper protection facilities are available. Records of such inspections should be kept on file.

1-1006. Cleanliness is a factor of utmost importance. Loose or spilled powder must not be allowed to accumulate. Each time any of the powder-making machines are charged or discharged all dust and other material spilled on open surfaces of the machinery or on the floor of the room shall be promptly and thoroughly removed. Soft push brooms and nonsparking scoops shall be used for cleaning.

1-1007. Competent supervision and periodic cleaning should always be maintained and the foreman should be alert to prevent the accumulation of excessive dust on any portions of buildings or machinery which are not regularly cleaned in daily operations. Regular periodic cleaning, with all machinery idle and power off, should be carried out as often as local conditions require it to maintain safety, but in any case at least once a week.

1-1008. Motor driven vehicles shall not be permitted to enter factory buildings. Receiving and delivery doors shall be so arranged that the exhaust from motor vehicles cannot be directed through the door opening into the factory buildings. Such doors shall be kept in the closed position whenever the motor or the vehicle is running.

1-1009. Smoking materials and matches shall be prohibited on the premises except in the official change-house at the entrance. They shall not be carried nor used by employees or visitors about the premises adjacent to or in any building in which explosive dust is made or loaded for shipment. This is not intended to preclude the bringing of tobacco by employees in their street clothes into the change- or wash-house. This building should be of fire-resistive construction, located at or near the entrance to the premises which should be surrounded by a fence. In this building the employees should leave their street clothes and put on special clothing as specified in paragraph 1-1010. Nor does this provision preclude smoking in a recreational room in the change-house which may be provided by the company for the purpose, nor in the office. It is desirable that a fixed tobacco-lighter be furnished in such room to avoid accidental carrying of matches into the plant grounds and buildings.

1-1010. Special clothing for employees in magnesium powder producing plants is recommended. Employees' clothing should be easily removable, kept clean and free from powder. Leather or other smooth clothing from which the dust can be brushed off readily may be worn. Smooth canvas or denim suits can be made fire-retardant. Wearing of woolen, silk, or fuzzy outer clothing should be prohibited. Shoes worn by employees or any one entering the powder buildings should have conductive, non-sparking soles and heels fastened with wooden pegs or copper nails. The wearing of shoes with exposed steel parts by magnesium powder plant employees should be prohibited.

PART II

COLLECTION AND DISPOSAL OF WASTE DUST FROM GRINDING, BUFFING AND SIMILAR DUST PRODUCING OPERATIONS IN THE HANDLING OF MAGNESIUM ALLOY PRODUCTS.

Section 1. Dust Collection

2-101. Dust shall be collected by means of suitable hoods or enclosures at each operation, such enclosures to be connected to a liquid precipitation type of separator, and the suction unit in such a way that the dust shall be converted to sludge without contact, in a dry state, with any high-speed moving parts.

2-102. Connecting ducts or suction tubes shall be as short as possible, and with no unnecessary bends. Ducts shall be carefully fabricated and assembled, with a smooth interior and with internal lap joints pointing in the direction of air flow, and without unused capped side outlets, pockets or other dead-end spaces which might allow an accumulation of dust.

2-103. Each machine shall be equipped with its individual dust separating unit, except that with multi-unit machines not more than two dust-producing units may be served by one separator unit. Not more than four portable dust-producing units in a single enclosure or stand may be served by one separator unit.

2-104. Power supply to machines shall be interlocked with (a) exhaust air flow and (b) liquid pressure level or flow in such a way that improper functioning of the dust removal and separator system will shut down the machine it serves. Figs. 1, 2, 3 and 4 show typical arrangements set up as to make it comparatively safe.

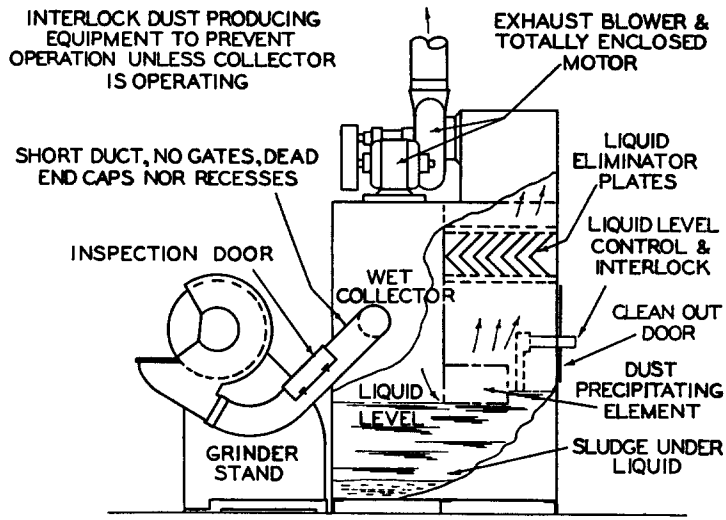
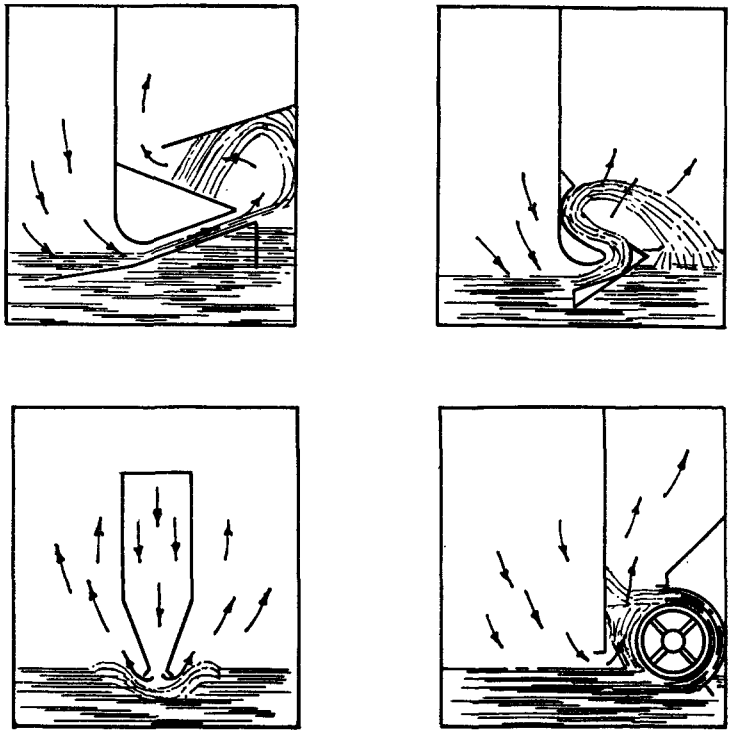


Fig. 1.



TYPICAL DUST PRECIPITATING ELEMENTS

Fig. 2.

Section 2. Cleaning

2-201. Systematic cleaning of entire area involved, including roof members, pipes, conduits, etc., should be conducted daily or as often as conditions warrant, (a) by use of soft brushes and nonsparking scoops and containers, or (b) by means of a fixed suction pipe and outlet vacuum cleaning system, provided the separator unit is of the liquid-precipitation type and provided also that the suction piping system is of standard mild steel pipe and standard recessed drainage fittings, with a check valve installed at each outlet. A rupture diaphragm shall be provided in the piping at its connection to the inlet side of the separator in such a way that a possible explosion in the piping may be safely vented to atmosphere.

Section 3. Dust Disposal

2-301. Sludge from dust separators and vacuum cleaning unit precipitators should be removed at least daily or as often as conditions warrant. Covered containers, preferably of not over fifty pounds capacity each, should be used to transport the collected sludge to a safe point for disposal by mixing with sand and burying or burning by approved methods.