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Explosion and Fire Protection

in Plants Producing or Handling

MAGNESIUM POWDER OR DUST

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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 cooperation of its members in establishing proper safeguards against loss of life and property by fire. Its membership includes two hundred national and regional societies and associations (list on outside back cover) and seventeen thousand individuals, corporations, and organizations. Anyone interested may become a member; membership information is available on request.

This pamphlet is one of a large number of publications on fire safety issued by the Association including periodicals, books, posters and other publications; a complete list is available without charge on request. All NFPA standards adopted by the Association are published in six volumes of the **National Fire Codes** which are re-issued annually and which are available on an annual subscription basis. The standards, prepared by the technical committees of the National Fire Protection Association and adopted in the annual meetings of the Association, are intended to prescribe reasonable measures for minimizing losses of life and property by fire. All interests concerned have opportunity through the Association to participate in the development of the standards and to secure impartial consideration of matters affecting them.

NFPA standards are purely advisory as far as the Association is concerned, but are widely used by law enforcing authorities in addition to their general use as guides to fire safety.

Definitions

The official NFPA definitions of shall, should and approved are:

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.

Units of measurements used here are U. S. standard. 1 U. S. gallon = 0.83 Imperial gallons = 3.785 liters.

Approved Equipment

The National Fire Protection Association does not "approve" individual items of fire protection equipment, materials or services. The standards are prepared, as far as practicable, in terms of required performance, avoiding specifications of materials, devices or methods so phrased as to preclude obtaining the desired results by other means. The suitability of devices and materials for installation under these standards is indicated by the listings of nationally recognized testing laboratories, whose findings are customarily used as a guide to approval by agencies applying these standards. Underwriters' Laboratories, Inc., Underwriters' Laboratories of Canada and the Factory Mutual Laboratories test devices and materials for use in accordance with the appropriate standards, and publish lists which are available on request.

Magnesium Powder or Dust.

NFPA No. 652—1959

This Code, prepared by the NFPA Committee on Dust Explosion Hazards, was adopted in its present form by the Association in June 1959. It was first presented by the Committee in 1942, and officially adopted in 1944. Amendments recommended by the Committee were adopted in 1945, 1946, 1952 and 1959.

This Code has been approved as American Standard by the American Standards Association, ASA No. Z12.15.

Revision Adopted in 1959

1-707. Addition of paragraph giving precautions required where powder-operated tools are used.

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. For additional data on explosive properties of magnesium powder see U. S. Bureau of Mines Report of Investigation 3722 "Inflammability and Explosibility of Metal Powders."

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 that should be followed in guarding against magnesium fire and explosion hazards in connection with the production and handling of magnesium powder. For information and recommendations dealing with the collection, removal and disposal of dust produced in grinding, buffing and other processing operations see the Standards for the Storage, Handling and Processing of Magnesium.*

*No. 48, published in separate pamphlet and in National Fire Codes, Vol. II.

Definitions:

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

"Magnesium powder," fine magnesium, all or part of which is 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.

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 have buildings in which magnesium powder is produced or handled in unsealed containers at least 300 feet distant from railways, highways and occupied structures such as public buildings, dwellings, stores or manufacturing establishments other than those which are a part of the powder manufacturing plant.

1-102. Buildings in which magnesium powder is produced or handled in unsealed containers shall be at least 50 feet apart, at least 100 feet from electric or steam power plants and at least 75 feet from other buildings on the plant property not connected with magnesium powder operations.

1-103. Buildings in which more than 1,000 pounds of magnesium powder may be exposed during screening, blending or processing operations shall be at least 75 feet apart and at least 115 feet from other buildings on the plant property not connected with magnesium powder operations. In no case shall more than 5,000 pounds be exposed in processing equipment or in unsealed containers in one building.

1-104. The entire property should be surrounded with a high, strong fence, preferably of noncombustible material, designed to prevent entrance of unauthorized persons.

1-105. Gates or entrances to the property should be guarded.

Section 2. Construction 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

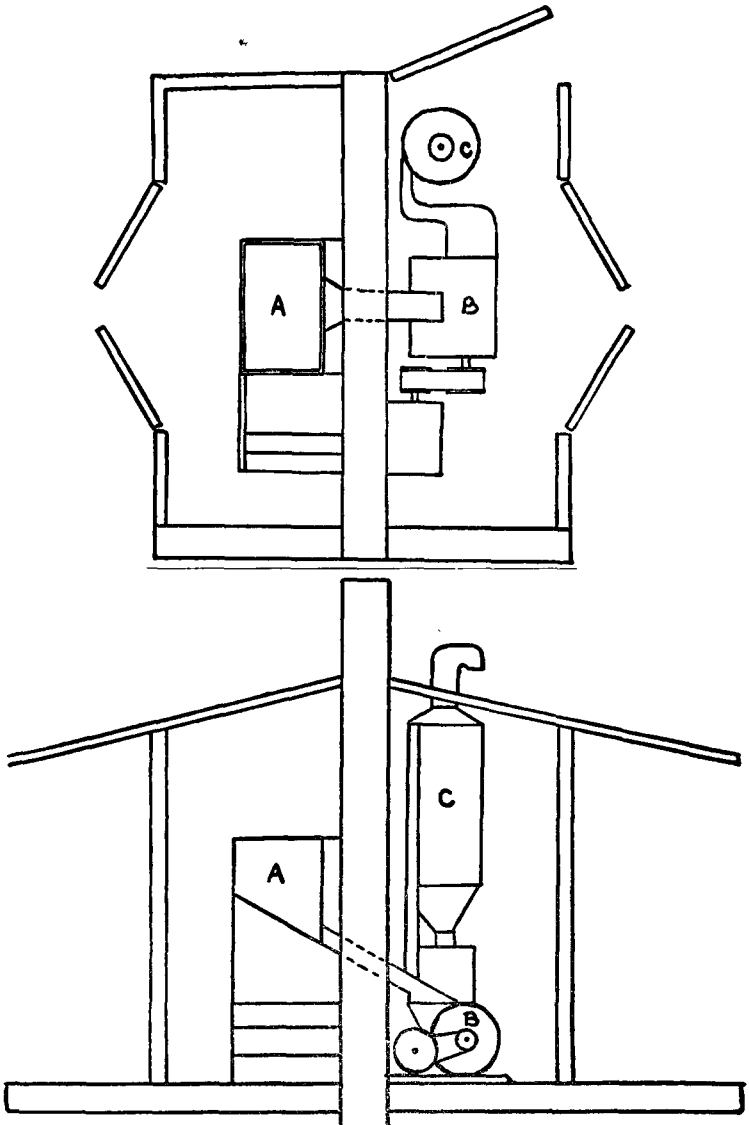

Fig. 1.

A. Hopper. (Automatic feed.)
B. Pulverizer or Hammer Mill.
C. Collector.

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 one exterior wall comprising not less than 25 percent of the total wall area of the room. This wall shall consist of doors, hinged sash or light explosion release panels insofar as construction will permit but not less than 80 percent of the wall shall be of such light construction. 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 and panic bar.* There shall be no direct communication between rooms or buildings in which the grinding or screening equipment is installed.

1-205. Each hammer mill or pulverizing unit shall be installed in a segregated building. Provision shall be made to keep all persons at least 50 feet from the building while the mill is in operation unless they are protected by a 12 in. reinforced concrete barrier wall. Where the charging hopper and the pulverizer unit are in separate compartments a choke or damper shall be provided in the separating barrier wall or in the feeding mechanism through which the material passes from the hopper to the pulverizer. The barrier wall shall be extended as a parapet, 3 feet above the roof. One end wall of the building shall be of reinforced concrete and shall be constructed as a wing or buttress to brace the barrier wall. Other walls shall consist of doors which can be kept open during operation or light panels which will readily vent explosive pressure. See Figure 1. Where dual installation of pulverizing units is permitted the wing or buttress wall shall be of 12-inch reinforced concrete and constructed to serve as a barrier wall with a parapet 3 feet above the roof and horizontal extensions 3 feet beyond the building line.

1-206. Covered passageways or corridors may be provided between buildings or alongside the rooms or compartments housing individual machines other than pulverizing units. 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.

1-207. 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.

1-208. 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.

1-209. 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.

*See N.F.P.A. Building Exits Code, published in National Fire Codes, Volume III. Building Construction and Equipment.

1-210. 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 reduce to a minimum the adherence of dust is recommended.

1-211. Roofs of buildings should 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.

1-212. Roofs shall be constructed and maintained in a tight condition to prevent leakage.

1-213. 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 sufficient number of free swinging doors, hinged windows and light panels to provide 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.

1-214. Ventilators or openings equipped with louvers and spark arrester screens should be placed near the ceiling in the walls of all operating rooms to clear the rooms of smoke in case of fire.

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° 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 shall be produced or handled by the batch or semi-batch system in which only a limited amount is processed at one time. Batches handled through pulverizing units shall be limited to 50 pounds.

1-302. Production units designed to use air in connection with their operation shall be installed with the pulverizer and cyclone directly connected with metal ducts of minimum length that installation conditions will permit.

1-303. Air shall not be used for conveying magnesium powder to or between production or processing units.

1-304. Magnesium powder should be handled in bulk containers and not allowed to fall through chutes or spouts into open bins or hoppers where dust clouds may be produced.

1-305. Hand trucks and carts 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.

1-306. Carts and trucks used for transporting magnesium powder should have non-sparking tires on wheels or casters. Wheels and rubber tires should be electrically conductive where carts or trucks are used on conductive floors.

1-307. Shovels or scoops used in handling magnesium powder should be made of magnesium, aluminum, copper or other nonsparking material.

1-308. Grinding equipment used for the production of magnesium powder should not be used for any other grinding until it has been thoroughly cleaned and all traces of magnesium powder removed.

1-309. Magnetic separators should be used to remove all foreign material from magnesium entering grinders and screens should be installed ahead of hammer mills or pulverizers to prevent the entrance of oversize pieces of magnesium.

1-310. Automatic operation of mills and screens should be arranged with remote controls for starting and stopping the machinery.

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 sufficient time interval should elapse to permit all moving parts to come to rest before the room is entered. A reset system should be provided to prevent restarting of machinery when the door is closed until the normal starting procedure is followed. This rule is not intended to prohibit the presence of maintenance or repair men in the room while machinery is being operated for tests or observations.

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. 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.

1-314. 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. To make explosion vents most effective mills or other machines should be installed close to outside walls or windows to permit using short vent ducts but sufficient space should be provided betwen machines and walls for cleaning and maintenance operations. Ducts should be as strong as the housing of the equipment they are designed to vent.

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 National Electrical Code.

1-402. Provisions 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. Transformers and capacitors shall be outside and at a safe distance from magnesium powder producing buildings and shall be installed in accordance with the National Electrical Code requirements for plants producing metal 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. The system should be installed in accordance with the N.F.P.A. Code for Protection Against 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 room or section of the building where the repairs are to be made shall be shut down and the entire room or section with its machinery shall be thoroughly cleaned to remove all accumulations of magnesium powder.

NOTE.—Operators of cutting or welding torches should be required to obtain a permit from the safety or fire protection officer of the plant before using such equipment under any condition around magnesium powder plants. Attention is called to the hazardous conditions that may exist either inside or outside of the plant if cutting torches are used in dismantling dust collectors or powder producing machinery before all dust accumulations have been removed.

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 or when dismantling such equipment. These tools shall be regularly inspected and all embedded particles of iron or steel removed 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.

1-707. Gun-type tools using powder or cartridges for driving pegs or pins into concrete, brick, steel, etc., shall not be used where flammable dust or dust clouds are present. When the use of this type of equipment becomes necessary, all dust producing machinery in the area shall be shut down, all equipment, floors and walls shall be carefully cleaned, and all dust accumulations removed. 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 handling machinery is resumed.

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.

NOTE.—There are no restricitions on the storage of magnesium powder in sealed containers as regards quantity or distance insofar as the explosion hazard is concerned. Precautions should be observed with regard to the fire hazard involved.

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 or powder stored for short periods shall be kept in closed containers to protect it against possible ignition.

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

1-902. Burning magnesium powder 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, 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. On tight noncombustible surfaces magnesium fires of moderate size may be extinguished by carefully and completely covering the burning pile with a layer of coal tar pitch of the type known as "very hard" with a softening point of approximately 300° F. The pitch softens and seals the burning magnesium with an airtight covering which smothers the flames. The fire should not be disturbed until the pitch cools and hardens. 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.

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 manual application of the extinguishing agent, but portable apparatus has been developed that is capable of throwing certain types of powder a distance of 30 feet or more.

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 powder 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 and distributed in manual or pamphlet form to employees for their constant reference.

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.