



Safe Handling of Magnesium

Magnesium Is A Combustible Metal

The use of magnesium is a rapidly growing commodity on a worldwide basis and millions of tons of magnesium have been melted and processed without incident by following well-developed safety practices.

With proper safeguards, magnesium fires or explosions can be prevented.

This brochure will describe those practices.

In certain forms, like a thin ribbon, magnesium ignites quite easily. In solid forms, such as magnesium ingots, ignition is difficult.

Magnesium is an excellent conductor of heat and as a practical matter the entire piece must be brought to a temperature near the melting point before ignition will occur. Normally this will not occur unless the solid magnesium piece is surrounded by a fire from other sources.

Care must be exercised with Magnesium when it is:

- in a molten state.
- in a finely divided form such as chips, granules or powder.
- involved in a general conflagration (fire).

February 2020

The information contained in this publication is general in nature and is not intended to replace applicable local, state, and national regulations that deal with the processing, storage, or transportation of magnesium. Specific situations must be dealt with as appropriate and as described in your company's safety program. The International Magnesium Association and its members make no warranty, expressed or implied, for the information presented herein.



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MOLTEN MAGNESIUM

While the handling of molten magnesium requires care and certain precautions, many producers and foundries worldwide routinely melt and process thousands of tons each year without incident by strictly adhering to well-proven safety practices.



SAFETY CLOTHING AND EQUIPMENT

Molten magnesium, with a melting point of approximately 650°C, will cause severe burns upon contact with the skin. Those who work around molten magnesium must wear adequate protective clothing and equipment. This includes:

- Safety glasses
- Hard hat with safety shield
- Fire-retardant clothing
- Safety shoes
- Spats and safety boots recommended to prevent molten metal from entering the boot
- Insulated gauntlet gloves

All safety clothing and equipment should be tested to ensure that the protection is adequate. First aid provisions should include fire blankets and safety showers. All personal protective equipment should meet applicable statutory codes.



PROTECTION OF THE MELT

Molten magnesium will ignite and burn when exposed to air so it must be protected during the melting operations. The most common practice today, although not universal, is to use a protective gas such as sulfur dioxide (SO_2) in very low concentrations mixed with Nitrogen, Argon, or air and carbon dioxide. Sulfur dioxide forms a film on the melt surface which prevents excessive oxidation.

The traditional protective measure was to cover the surface of the Mg melt with molten chloride salts; that prevented air contact at the surface.

Other cover gases such as HFC-134a, 3M™ Novec™ mixed with nitrogen or in air and carbon dioxide can be used.

SF6 is also an acceptable form of protection although many countries are moving towards elimination of this gas due to its effects on the environment.



GAS FEEDING SYSTEM

Molten magnesium can react exothermically with iron oxide in a thermite reaction which generates temperatures in excess of 2,200°C.

Because most magnesium melting pots are made of steel it is extremely important to keep the inside area of the pot clean and free of scale. Likewise, scale (oxides of iron) should be removed regularly from the furnace to prevent a reaction with molten magnesium in the event of a pot failure. The refractories used for the furnace should be high in alumina or magnesia because molten magnesium can react violently with even small amounts of silica (often present in ceramic materials). Run-out pans should be provided in the event of a pot failure and should be kept clean and free of moisture and scale at all times.

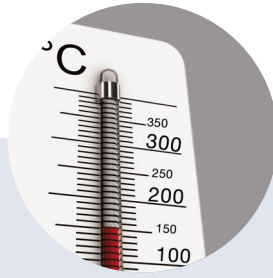
Pot thickness and appearance (cracks) should be periodically checked.



PREVENT CONTACT WITH WATER

Automatic sprinklers should not be installed over melting operations, heat treating furnaces, or in storage/production areas containing magnesium in finely divided forms.

If water comes in contact with any molten magnesium, whether it is in the foundry furnace or a puddle in a burning building, there could be an explosion. The water will expand up to 1,000 times its original volume and in so doing may throw molten metal a considerable distance. In addition, magnesium's great affinity for oxygen will dissociate the water releasing flammable hydrogen which can add fuel to fires and explosions.



PREHEAT INGOTS AND TOOLS

Any materials, such as ingots, alloys or tools, that are introduced into molten magnesium must be preheated well above 100°C to drive off all moisture or other volatile species. Any cold surface could be a source of moisture condensed from the atmosphere. As mentioned previously, any water or condensed moisture presented on a cold surface will expand up to 1,000 times its original volume when in contact with molten metal; trapped moisture exposed to intense heat can propel molten metal considerable distances during the expansion.



KEEP MELTING POT CLEAN

The gas feeding system should be designed to evenly distribute cover gases over the melt because high concentrations of cover gases can severely corrode the steel cover and melting pot. Corrosion products, such as iron oxides, can violently react with molten magnesium and could cause an explosion.

The system should be designed to counteract circulating air from disturbing the cover gas blanket.



FIRE EXTINGUISHING MATERIALS

Dry, Class D fire extinguishing materials, such as G-1 powder and foundry flux, should always be kept nearby.



FOUNDRY STRUCTURE

Magnesium foundry structures should be built with non-combustible materials and the floors around melting operations should be hard burned or vitreous paving block. The heat from molten magnesium can release the water of hydration in concrete which will cause it to spall, sometimes explosively.

Buildings should be grounded to protect against lightning strikes.

AIRBORNE MAGNESIUM IS DANGEROUS

FINELY DIVIDED FORMS— HOUSEKEEPING

Magnesium in finely divided forms such as powders, grinding residues, and swarf from machining or sawing is readily ignitable and can ignite spontaneously in the presence of water or cutting fluids containing fatty acids. Hydrogen will also be produced—introducing an explosion hazard in addition to fire.

Airborne magnesium dust will burn with explosive violence if ignited. Smoking and the use of open flames or electrical welding must be prohibited in areas where magnesium is being machined, sawed or ground. All electrical connections and motors must be explosion-proof. Non-sparking conductive tools must be used where magnesium dust may be present. It is also recommended that all transfer containers and equipment be grounded to prevent sparks from static electricity.

Avoid the accumulation of large amounts of finely divided magnesium in the work area. Place in non-combustible, covered containers and transfer to an isolated storage area.

SAFETY EQUIPMENT

- Safety glasses with side shields or a full-face shield should be worn by the operator at all times.
- Clothing should be easily removable, made of flame-resistant, smooth fabric with non-ferrous fasteners and no external pockets or cuffs that could accumulate fines.
- Safety shoes should have no exposed steel parts.
- Dust masks or respirators should be used where dust levels could exceed limits set by applicable health standards.

DUST COLLECTOR SYSTEMS

Grinding dust should be captured in a wet dust collector system that is engineered for magnesium and dedicated to magnesium use only. The entire system should be grounded, and the power supply to the exhaust fan and the liquid level controller should be interlocked.

The system should be designed to avoid dry dust accumulation at any point before being converted to sludge, as well as to avoid dry dust contacting any high-speed moving parts. The collector must also be designed so that hydrogen generated in the sludge is vented at all times even in the event of a power failure.

Sparks from any source can ignite the grinding dust and the resulting fire can travel through the entire system.

Sludge from the liquid separators should be removed at least daily and transported to the disposal site or staging area in covered and vented steel drums.

PNEUMATIC CONVEYING

Magnesium shall be pneumatically conveyed with air, nitrogen and inert gas such as argon or helium. In all cases the conveying gas shall have a dew point such that no free moisture can condense or accumulate at any point in the system.

Conveyor ducts shall be fabricated of conductive material. Ducts shall be electrically bonded and grounded to minimize accumulation of static charge. Where the conveying duct is exposed to weather or moisture, it shall be moisture tight.

Blades and housings of fans used to move air or inert gas in conveying ducts shall be constructed of conductive material also. Fans shall be located outside of all manufacturing buildings wherever practical. Fans shall be electrically interlocked with dust producing machinery so that the machine shuts down if the fan stops.

A minimum conveying velocity of 3,500 ft/min (1,068 m/min) shall be maintained throughout the conveying system to prevent the accumulation of dust at any point and to pick up any dust or powder that can drop out during an unscheduled system stoppage. Higher conveying velocities are more desirable and increase safety

If the conveying gas is air, the magnesium dust-to-air ratio throughout the conveying system shall be held safely below the lower flammable limit (LFL) of the magnesium dust at normal operating conditions. For safety reasons, the conveying system shall be designed such that the concentration of magnesium in the system is 25% or lower than the LFL of magnesium powder (less than 100 mesh).

Explosion vents, openings protected by anti-flashback swings valves, or rupture diaphragms shall be provided on the duct work. Relief shall be to a safe location.

MACHINING AND GRINDING MAGNESIUM

Machining of magnesium requires less power than any of the other commonly used metals allowing for maximum speeds and feeds producing large chips. Cutting tools should be kept sharp and never allowed to ride on the metal without cutting. Dull tools and idling could produce enough heat to ignite the turnings.

Dry swarf should be placed in covered, dry, non-combustible containers that are clearly labeled and moved to an isolated storage area.

Swarf contaminated with residual machining lubricant should be placed in covered and vented, non-combustible containers that are plainly labeled and transferred to an isolated storage area.

Nonsparking tools should be used where magnesium dust may be present.

Never grind magnesium on a conventional stone grinder or where steel will be ground thereafter as it could cause the grinding wheel to explode.

DISPOSAL OF FINES AND WASTE

Small amounts of magnesium fines may be disposed of by controlled burning where the incinerator meets all regulations for that location.

Where permitted by the responsible authority, grinding sludge may be mixed with five parts or more of sand and discarded in an authorized landfill.

Magnesium fines may be reacted with ferrous chloride to yield an inert sludge that can be land-filled where permitted. The reaction produces hydrogen gas that is highly flammable and potentially explosive. The operation should be conducted in open containers outdoors—open flames and smoking should be prohibited in the area.

Another recommended solution for safe disposal of fines and waste is the use of compaction equipment such as a briquetter. In a compacted or briquetted form, the fines are less susceptible to fire and create a more valuable product for use in recycling. In addition, it improves the ability to increase package quantity and allow for safe transportation.



MAGNESIUM STORAGE AND TRANSPORTATION

PICK WELL-DRAINED AREAS

Magnesium in any product form should be stored at ground level in a well-drained area where water will not puddle. Preferred storage for ingots and parts is a single level, non-combustible building, but this may not be practical in all cases. If stored with other combustible materials the National Fire Protection Association recommends the following storage pile volumes for magnesium parts:

Parts Weighing...	Limit To...
11.3 kg or more	36 cubic meters
Less than 11.3 kg	28 cubic meters

AUTOMATIC SPRINKLERS RECOMMENDED

Unlike areas where molten metal is present, automatic sprinkler systems are strongly recommended in ingot or parts storage areas because their operation may prevent the magnesium from becoming involved in a fire originating in nearby combustible materials.

Aisles should be wide enough to permit effective use of equipment by fire fighters.

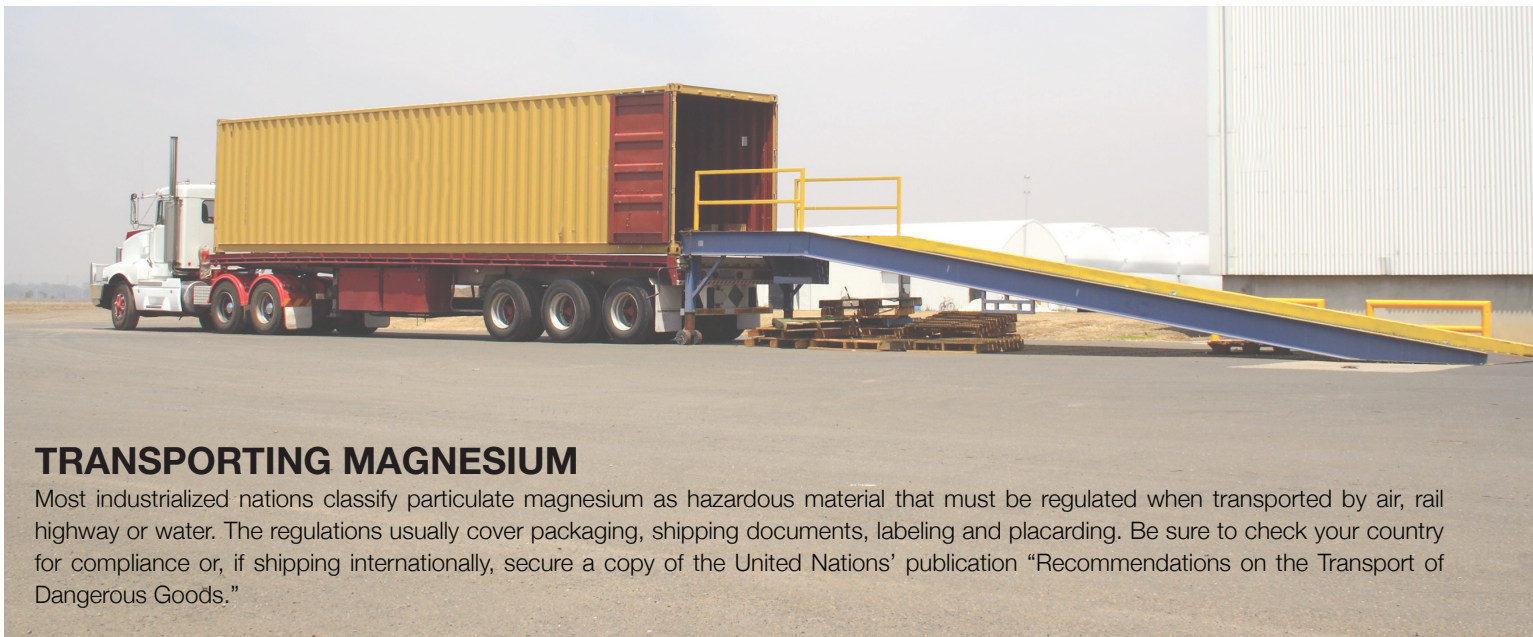
POWDER, CHIPS, GRANULES, AND TURNINGS

Dry magnesium powder chips, granules and turnings should be stored in tightly sealed non-combustible containers, such as steel drums, that are well separated from other combustible materials. ***The use of automatic sprinklers in these areas should be prohibited.***

Wet magnesium turnings, fines, or sludge should be kept under water in covered and vented non-combustible containers and stored outdoors. When damp and exposed to air magnesium will generate heat that accelerates the evaporation and will eventually result in ignition.

Containers should never be stacked and ignition sources should be kept away from the container vents.

It is recommended that all storage areas be well vented. The installation of exhaust fans near the highest points of the ceilings are to be used to exhaust hydrogen should it be present.



TRANSPORTING MAGNESIUM

Most industrialized nations classify particulate magnesium as hazardous material that must be regulated when transported by air, rail highway or water. The regulations usually cover packaging, shipping documents, labeling and placarding. Be sure to check your country for compliance or, if shipping internationally, secure a copy of the United Nations' publication "Recommendations on the Transport of Dangerous Goods."



CATCH IT WHILE IT'S SMALL

Magnesium fires are spectacular because they give off a bright light and billowing clouds of white smoke. Care should be taken to avoid looking at bright burning metal where possible. The white smoke is magnesium oxide that, by itself, is non-toxic. However, Inhalation should be avoided because excessive amounts of fume inhalation can produce metal fume fever symptoms. One must also recognize the possibility that toxic fumes from other sources could be in the smoke.

If There Is A Fire

The best chance to control any fire is to catch it while it is small, and magnesium is no exception. Fires in dry magnesium particulate will burn rather slowly and evenly but can flare up quickly if disturbed, or if moisture or cutting oils are present.

SMOTHERING AGENTS

Magnesium burns by direct oxidation and thus the only way to control a magnesium fire is to smother it with dry air-excluding agents - or let it burn to extinction. Faced with a fire that is out of control firefighters may have to resort to damage control of adjacent structures.

Suitable "smothering agents" for magnesium fires are:

- Dry G-1 Powder
- Met-L-X Powder
- Magnesium Foundry Flux (with low melting point)
- Proprietary Materials that are specific to magnesium
- Dry Sand

In confined areas such as a storage tank, magnesium fires may be suppressed with argon. It is important to keep the magnesium fire under argon blanket for many hours or days until temperature drops to near room temperature before removing material from the tank.

NEVER USE WATER ON A MAGNESIUM FIRE

Water should never be used on a magnesium fire because the water will dissociate into oxygen and hydrogen accelerating the fire and creating an explosion hazard.






Many conventional extinguishing agents will also accelerate a magnesium fire including:

- Foam
- Carbon Dioxide
- Halogenated Agents
- Certain Dry Chemicals containing mono- or di-ammonium phosphate
- Sand, if not dry.

EMPLOYEE TRAINING AND RESPONSE TEAM

If you are manufacturing, processing, or storing magnesium, then you must train all operating personnel on safety procedures, including proper housekeeping, and have a **skilled in-house emergency team**.

There is a legal requirement in a few countries that you must notify your local fire department if you are processing or storing magnesium and have a joint plan developed for emergency response. This should be done regardless of any legal requirements.

FIRE CLASSIFICATIONS		
LETTER SYMBOL:	PICTURE SYMBOL:	FOR USE ON:
A		ORDINARY COMBUSTIBLES SUCH AS TRASH, PAPER, WOOD AND TEXTILES
B		FLAMMABLE LIQUIDS
C		ELECTRICAL EQUIPMENT
D		COMBUSTIBLE METAL
K		COMBUSTIBLE COOKING MEDIA

BEFORE USING A FIRE EXTINGUISHER LOOK FOR ONE OF THE FOLLOWING SYMBOLS THESE SYMBOLS INDICATE WHAT TYPES OF FIRES AN EXTINGUISHER IS MEANT TO BE USED ON



The mission of the **International Magnesium Association (IMA)** is to promote the use of the metal *Magnesium* in material selection and encourage innovative applications of the versatile metal.

IMA's members consist of primary producers of the metal, recyclers, foundries, fabricators, end-users and suppliers. As the global voice of the magnesium industry, IMA serves the industry and its membership through its Annual World Magnesium Conference, seminars, statistical programs, research and publications.

Through IMA's efforts, manufacturers and consumers are increasingly aware of the numerous options and benefits the metal *Magnesium* provides.

IMA MISSION STATEMENT





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