

JIS

JAPANESE INDUSTRIAL STANDARD

**Recommended practice for
magnesium alloy sand castings**

JIS H 9161—1990

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alloy sand castings

H 9161-1990

1. Scope

This Japanese Industrial Standard specifies the recommended practice for magnesium alloy sand castings of JIS H 5203, hereinafter referred to as the "castings".

Remarks 1. Applicable Standards to this Standard are as follows:

JIS G 2311	Manganese Metal
JIS G 3103	Carbon Steel and Molybdenum Alloy Steel Plates for Boilers and Other Pressure Vessels
JIS G 5901	Molding Silica Sand
JIS G 5902	Molding Natural Sand
JIS H 2102	Virgin Aluminium Ingots
JIS H 2107	Zinc Metal
JIS H 5203	Magnesium Alloy Castings
JIS H 8651	Processes for Corrosion Protection of Magnesium Alloys

2. The units and numerical values given in { } in this Standard are based on the International System of Units (SI) and are appended for informative reference.

Further, the traditional units and values shall be replaced by the accompanying SI units and the relevant converted values given in { } on January 1, 1991 as shown in Annex.

2. Materials

2.1 Magnesium Ingots For magnesium ingots, pure ingots with little harmful impurities, the origine of which is known, shall be used.

2.2 Magnesium Alloy Reproduced Ingots When magnesium alloy reproduced ingot is used, the analysis test shall be necessarily carried out.

2.3 Virgin Aluminium Ingots For the virgin aluminium ingots, those of not less than Grade 1 (99.0 % min. in purity) of JIS H 2102 or superior thereto shall be used.

2.4 Manganese Metals For the manganese metals, those of not inferior to the electrolytic manganese (99.9 % min. in purity) of JIS G 2311 shall be used.

2.5 Zinc Metals For the zinc metals, those of not inferior to the ordinary zinc metal (99.97 % min. in purity) of JIS H 2107 shall be used.

2.6 Scrap Metal When alloy scraps excepting those of home factory are used, the ingot of a suitable size is once casted after melting them and the chemical analysis thereof shall be carried out. The return materials of home factory shall be necessarily strictly selected and controlled. Especially, alloys containing copper, silicon and nickel shall not be mixed.

Further, the sand adhering to castings reacts on magnesium in melting, the content of silicon is increased and the mechanical properties are injured. Therefore, those cleaned shall be used.

2.7 Mother Alloy of Aluminium and Manganese That of 90 : 10 in the ratio of aluminium to manganese shall be used. The surfaces of the aluminium ingots and manganese ingots used for manufacture of mother alloy should preferably be clean.

For melting, a graphite crucible shall be used and preheated dry manganese of about 15 mm square shall be little by little added into the graphite crucible where aluminium is melted. After alloying, the melt shall be sufficiently mixed with stirring not to generate segregation and thinly solidified in a cast iron mould.

3. Melting Operation

3.1 Admixing Method The proportion of raw materials of melting shall be 50 % min. in new ingots and 50 % max. in return scraps in factory and reproduced ingot scraps accepted for the analytical test.

The aimed composition in the case of ingots admixture shall conform to Table 1.

Table 1. Aimed Composition

Classification	Symbol	Aimed composition %		
		Al	Zn	Mn
Magnesium alloy casting Grade 1	MC1	6.0	3.0	0.3
Magnesium alloy casting Grade 2	MC2	8.7	0.7	0.3
Magnesium alloy casting Grade 3	MC3	9.0	2.0	0.3
Magnesium alloy casting Grade 4	MC4	—	—	1.5

3.2 Smelting Furnace The furnace used for smelting should preferably be easy to be controlled on temperature and shall be so constructed that the combustion gas does not come in contact with the molten metal. Though the heavy oil furnace and the gas furnace are easily controlled on temperature, the coke furnace is comparatively difficult to be controlled. Therefore, in the case of using coke furnace, care shall be necessarily taken about overheat.

3.3 Crucible for Smelting For the crucible for smelting, the rolled steel for boilers of 6.0 to 15.0 mm of JIS G 3103 shall be welded and used. For the dimensions of crucible, the crucible of about 1 to 2 in the ratio of diameter to height shall be used. The bottom plate shall be especially thickened to prevent thermal corrosion.

Informative

Reference: Further, for the crucible of large size, it is economical that the damaged bottom part is repaired by welding with new bottom plate and reused.

3.4 Apparatus for Melting The stirring rod, ladle, skin scraper, thermocouple protecting tube, etc., may be made of mild steel. When stainless steel is used, that containing no nickel shall be used. Those devices and ingot cases (especially the inner surfaces) shall be sufficiently heated before use and the water content shall be removed.

The thermometer shall be inspected periodically.

3.5 Melting Temperature For the melting temperature, to prevent the formation of oxides in mixing with stirring, the molten bath shall be stirred to be mixed refined at 680 to 730°C, and then heated at 900°C for the purpose of grain refining.

3.6 Flux The quality of flux has important relation to the yield of ingots and the quality of products in melting operation. The flux for melting shall be of good fluidity for the purposes of prevention of oxidation and combustion in melting.

Though this flux has sufficient refining capacity, it is easy to flow out in casting due to excessively good fluidity. Therefore, when a great amount of flux is used for refining, the flux for refining shall be used. The flux for refining is solidified to a suitable degree in heating thereafter.

Approximately 1 to 2 % of the flux shall be used in melting and 2 to 3 % of the flux in refining. Examples of flux are given as follows:

For melting	Magnesium chloride	43 %
	Potassium chloride	43 %
	Calcium chloride	5 %
	Common salt	9 %
For refining	Magnesium chloride	50 %
	Potassium chloride	30 %
	Magnesium oxide	10 %
	Calcium fluoride	10 %

To prevent the oxidation and combustion during pouring, the mixed powders given as follows should preferably be sprinkled over.

Sulfur	78 %
Boric acid	19.5 %
Ammonium borofluoride	2.5 %

3.7 Melting Method A small amount of flux is melted after red-heating an iron crucible and scrap metals, reproduced ingots, fresh ingots and mother alloy in this order shall be charged thereto. As they are melted, the surface of molten metal is covered by always sprinkling the flux and prevented from oxidation. After the ingots are completed to be melted, molten metal is separated from slag by carrying out the refining process, further the surface of molten metal being covered with flux for refining and the temperature of molten metal is raised to a fixed temperature. The molten metal is processed with grain refining treatment and casted.

3.7.1 Flux Refining Method When melting is completed, the molten metal is stirred with adding the flux for refining. Because the oxides in molten metal come in contact with flux and entangled thereto, it should be preferable that the surface of molten metal is always covered with flux, stirring to mix being carried out in the same direction and the molten metal comes quietly and sufficiently in contact with flux to form vortexes. The molten metal is stirred at a temperature of 700 to 730°C for 5 to 10 min.

After completing refining operation, the slag is removed with skin scraper and further the surface of molten metal is covered with the flux for refining.

3.7.2 Chlorine Refining Method The chlorine refining method may be carried out instead of the flux refining method. In the chlorine refining method hydrogen gas in molten metal is removed at the same time the molten metal is refined by the formed magnesium chloride. Its temperature shall be about 720°C and the time shall be 5 to 15 min. Chlorine shall be as deeply as possible inducted into the metal to a degree that the metal is not dispersed by a graphite tube from bomb. The tip of graphite tube shall not come in too near contact with the crucible. In that case, used flux should preferably contain a rather greater amount of fluorides.

3.7.3 Grain Refining For the overheating operation, after addition of beryllium, the metal is kept at about 850°C for about 15 min.

Informative
Reference:

A portion of the effect of grain refining is lost by slow cooling in furnace. A method for grain refining by zirconium is recently developed. However, because zirconium dislikes its coexistence with aluminium, manganese, etc., special treatment is required.

4. Casting Operation

4.1 Patterns The wooden pattern or metal mould (metallic pattern) is used according to the shape and the number of manufacturing castings. The shrinkage rule thereof shall be 10/1000 to 13/1000.

The standards of finish allowance for working of castings are shown in Table 2.

Table 2. Finish Allowance

		Unit: mm								
Classi- fication of moulds	Size of casting	150 max.			150 to 600			600 min.		
		Rough finish	Common finish	Best finish	Rough finish	Common finish	Best finish	Rough finish	Common finish	Best finish
		▽	▽▽	▽▽▽	▽	▽▽	▽▽▽	▽	▽▽	▽▽▽
Sand mould		2.0	2.5 to 3.5		2.5 to 3.5	3.0 to 4.0		3.0 to 4.0	5.0 min.	

4.2 Moulding Sand For the moulding sand for magnesium alloys, natural sand (JIS G 5902) or synthetic sand (JIS G 5901) shall be used.

Informative
Reference:

The synthetic sand is suitable for magnesium alloys because an optional required moulding sand can be accurately obtained and keeping the casting condition constant by suitably changing the particle size of silica sand and the admixture amount of binder or the like.

Because the specific gravity of magnesium alloy is very light, when sand with inferior permeability is used, defects in castings are easily produced due to the pressure produced in the mould. Because alloys are liable to be oxidized in pouring and oxides are liable to be produced by reaction of the water vapour especially generated from the mould with the molten metal, the sand is decreased in moisture the permeability of which is made good and is mixed with a suitable amount of oxidation inhibitor to be used.

Further, because this alloy has high temperature brittleness, care shall be taken about the degree of ramming the mould.

4.2.1 Sand for Master Mould For the sand for master mould, natural sand or synthetic sand shall be used. The synthetic sand shall be prepared by compounding silica sand with 2 to 4 % binder such as bentonite or the like and a suitable amount of water.

As the oxidation inhibitor in mould, sulphur, boric acid, etc. are added. An example of the sand for master mould is given in Table 3. (Applicable till the end of 1990)

Table 3. An Example of Sand for Master Mould

				Unit:	Mass %
Grain fineness number	{	N.I.K. method	120	Boric acid	0.5 to 1.0 %
		A.F.A. method	60	Ammonium fluoride	2 to 4 %
Green-sand mould	kgf/cm ²	0.3 to 0.5	Bentonite	2 to 4 %	
deflection strength	{N/cm ² }	{2.9 to 4.9}			
Green-sand mould permeability		60 to 90	Water	5 %	
Sulphur		3 to 6 %	Sand	Remainder	

4.2.2 Sand for Core For the sand for core, silica sand shall be used and bentonite or drying oil shall be used as binder. An example of the sand for core is given in Table 4. (Applicable till the end of 1990)

Table 4. An Example of Sand for Core

				Unit: Mass %	
Grain fineness number	N.I.K. method	120	Sulphur	1 to 3 %	
	A.F.A. method	60		Boric acid	
Green-sand mould deflection strength	kgf/cm ²	0.3 to 0.5	Ammonium fluoride	0.5 to 1.0 %	
	{N/cm ² }	{2.9 to 4.9}		0.5 to 1.0 %	
Dry sand mould strength	kgf/cm ²	1.7 to 5.7	Bentonite	2 to 6 %	
	{N/cm ² }	{16.7 to 55.9}		5 %	
Green-sand mould permeability	70 to 100		Water	5 %	
Dry permeability	90 to 110		Sand	Remainder	

When the mould is rammed too strongly, the drying strength becomes high, free contraction being disturbed during solidification of casting and cracks become liable to be produced in casting.

Further, because water content is liable to be absorbed when allowing to stand for a long time after drying the core, it shall be necessarily covered quickly and poured.

4.2.3 Oxidation Inhibitor Though the additional amount of oxidation inhibitor is changed according to the used sand, wall thickness or the like, it is almost 3 to 6 % (mass ratio) and especially in the case of sand with inferior permeability or of a very large article, its more amount than this shall be added. Because green-sand mould generates a great amount of water vapour in pouring and molten metal is easily oxidized, the additional amount of oxidation inhibitor shall be increased within the above-mentioned range.

Because the concentration of oxidation inhibitor decreases as sand is used, the deficient content thereof shall be measured and at times supplemented.

Further, 0.001 to 0.004 % beryllium should preferably be put in molten metal as oxidation inhibitor.

Informative

Reference:

The oxidation inhibitors currently used, are boric acid, sulphur and ammonium salt.

4.3 Moulding Method

4.3.1 Sprue, Runner and Gate Magnesium alloys have, as a rule, large solidification shrinkage and is liable to produce hot crackings or oxidized film. Especially in case where the sprue, runner and gate are inappropriate, it becomes the cause producing defects such as shrinkage hole, crack and oxides mixing and therefore, precautions shall be taken about that. These shall be so arranged that the solidification is, as a rule, taken place at first in the most remote part from the sprue, next in succession following nearer thereto and at last at the sprue. The sprue of plate state is, as a rule, used and the casting method is made of lifting up type with lowering it to the lowest part of casting. A number of sprues are simultaneously arranged and the pouring should preferably be carried out at a comparatively low temperature.

Informative
Reference:

Thus, respective parts of casting can be quickly and quietly filled up, the superheating of sand being lessened and the generation of oxides can be prevented.

The sprue should preferably be annular surrounding the circumference of casting, the sectional shape thereof being made, for example, plate state or triangular and oxides are let to float above the top of plate or triangle.

Further, the slag reservoir is sometimes provided at a suitable position and the mixing-in of oxides are prevented.

For the purpose of decreasing the pressure in mould in pouring molten metal, a suitable flow off and vent hole are provided above the runner. Those are especially effective for the mould poured at a high temperature. Generally the gate shall be necessarily so arranged that molten metal do not perpendicularly hit the master mould and core so as to be able to uniformly pour from the surrounding of casting.

Total sectional area of gate is smaller than the sectional area of sprue and the sectional area of runner should preferably be a little larger than that of gate or sprue to lessen the flow rate of molten metal.

4.3.2 Feeder Head The feeder head should preferably be so positioned that it is capable of easily removed in finishing the casting as well as gate.

Informative
Reference:

Because magnesium alloys have small heat capacity and the feeder head and flow off are rapidly cooled, the feeder head of magnesium alloy is liable to be larger than that of aluminium alloy.

4.3.3 Chilling Blocks When the shrinkage holes in castings are generated only due to the gate and feeder head, the cooling of that part shall preferably be promoted by burying chilling blocks into that part of mould.

For the materials of chilling blocks; cast iron, steel products, etc. are used. Though the size is worked to a suitable shape to be used, the use of a number of small type chilling blocks is better than the use of a small number of large type chilling blocks. Further, it is necessary that the surface in contact with molten metal is provided with suitable grooves to have good permeability and the occurrence of defects such as blow or the like is prevented.

Furthermore, the surface of chilling block shall always be cleaned and not attached with oxides. In the case of using chilling blocks, after removing the water content or the like adhered to the surface by sufficiently heating, the surface is coated with light oil and the absorption of water content in mould shall be prevented. In the case of coating mould, the mica flour and talc powder added with water shall be used.