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Magnesium and magnesium alloys — Magnesium alloy ingots and castings

Magnésium et alliages de magnésium — Lingots et pièces moulées en alliage de magnésium

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www. iso. org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www. iso. org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso. org/iso/foreword. html.

This document was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys*, Subcommittee SC 5, *Magnesium and alloys of cast or wrought magnesium*.

This third edition cancels and replaces the second edition (ISO 16220:2005), which has been technically revised by the addition of new alloys. It also incorporates the amendment ISO 16220:2005/Amd.1:2007.

Introduction

This document classifies the magnesium alloys into a number of grades suitable for the applications to which they might be used.

Some of the alloys referenced in this document can be the subject of a patent or of patent applications and their listing herein is not to be construed in any way as the granting of a licence under such patent rights.

Magnesium and magnesium alloys — Magnesium alloy ingots and castings

1 Scope

This document specifies the chemical composition of magnesium alloy ingots and castings. It also specifies the mechanical properties of separately cast samples of these alloys (see Clause 7). By agreement, it also specifies the mechanical properties of magnesium alloy castings determined from samples cut from a casting.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE For information on equivalent International Standards see Annex A.

ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 80000-1:2009, *Quantities and units — Part 1: General*

EN 1559-5, *Founding — Technical condition of delivery — Part 5: Additional requirements for magnesium alloy castings*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 Material designation

4.1 General

The material shall be designated as given in Tables 1 to 5.

4.2 Temper designation

The following symbols for temper designation shall be used.

— F: as-cast; applies to products that require no heat treatment following the casting processes.

— T4: solution heat-treated and naturally aged; applies to products that have no further treatment after solution heat treatment.

— T5: as-cast and artificially aged; applies to products that are cooled from the casting process, and then artificially aged to improve mechanical properties or dimensions.

— T6: solution heat-treated and artificially aged; applies to products that are solution heat treated followed by artificially aging.

4.3 Casting process designation

The following symbols shall be used for the designation of the different casting processes.

— S: sand casting.

— K: permanent mould casting.

— D: pressure die casting.

— L: investment casting.

4.4 Designation for ordering

The designation used for ordering shall include, in the following order, the number of castings, a mention of this document, the ISO alloy designation, the designation for the heat treatment process (temper), and the designation for the casting process.

EXAMPLE An order for 20 castings, conforming to this document, of magnesium alloy ISO-MC21120, delivered in as-cast (F temper) and made by sand casting (S) is as follows:

20 castings – ISO 16220 - ISO-MgAl9Zn1(A) (or ISO-MC21120 or ISO-AZ91D)-F-S

5 Requirements

5.1 Chemical composition

The chemical composition of magnesium alloy ingots shall conform to the requirements for the appropriate material given in Table 1.

The chemical composition of magnesium alloy castings shall conform to the requirements for the appropriate material given in Table 2.

Conformance shall be determined by the manufacturer by analysing samples taken at the time the ingots or castings are produced.

NOTE For additional information regarding the manganese and iron contents see Annex B.

5.2 Mechanical properties of castings

The mechanical properties obtained from test pieces prepared from separately cast samples for sand castings and permanent mould castings shall meet the requirements given in Tables 3 and 4. As appropriate, the tests shall be carried out in accordance with Clause 8.

NOTE 1 Mechanical properties obtained from test pieces prepared from separately cast samples for investment castings are not specified, as experience is limited. As a general rule they are similar to those for permanent mould castings.

NOTE 2 The values obtained from test pieces cut from castings can differ from the minimum values specified in the tables because of imperfections (gas pores, shrinkage cavities, inclusions) and the machining process applied. Variation in the casting structure can also affect the property values.

NOTE 3 For pressure-die castings, the mechanical properties strongly depend on the process parameters; therefore, the properties given in Table 5 are for guidance only.

The Brinell hardness test shall be carried out on sound areas of castings or on a test piece that has not been stressed. Hardness tests are only to be carried out where appropriate and when there is a real difference between the different states of heat treatment.

5.3 Frequency of testing

The frequency of testing shall be in accordance with EN 1559-5.

5.4 General condition of the product

Ingots shall be free of dust, burrs, salty inclusions and be homogeneous in thickness and weight to a standard agreed with the purchaser.

Castings shall have a clean surface and shall be free from visible and internal imperfections to a standard also agreed between the manufacturer and the purchaser.

6 Sampling

Conditions for sampling, formation of batches and frequency of verification shall be as specified in EN 1559-5.

7 Test pieces for mechanical properties

7.1 Design

The design of test pieces shall be subject to an agreement between the manufacturer and the purchaser.

7.2 Test pieces obtained from separately cast samples

7.2.1 Sand-cast samples

Test pieces may be in the machined or unmachined condition.

The following conditions shall apply:

— samples shall be cast in sand moulds and without artificial chilling;

— the minimum diameter of the test piece shall be 12 mm;

— the gauge length and the parallel length shall conform to ISO 6892-1.

7.2.2 Permanent-mould cast samples

Test pieces may be in the machined or unmachined condition.

The following conditions shall apply:

— the minimum diameter of the test piece shall be 12 mm;

— the gauge length and parallel length shall conform to ISO 6892-1.

7.2.3 Pressure-die cast samples

For pressure die castings, it is not recommended to test mechanical properties on separately cast bars or coupons. It is more appropriate to test the whole casting under conditions comparable to the ones expected in service.

The values given in Table 5 are for guidance only. These are not typical, but they are the minimum values that can be expected on separately pressure cast bars (with none or very limited machining) and with a cross section of 20 mm^2 and a typical thickness of 2 mm.

7.2.4 Investment cast samples

Test pieces may be in the machined or unmachined condition.

The following conditions shall apply:

— the minimum diameter of the test piece shall be 5 mm;

— the gauge length and parallel length shall conform to ISO 6892-1.

7.3 Test pieces cut from castings

The geometry and location of test pieces cut from castings shall be specified by agreement between the manufacturer and the purchaser.

If it is agreed between the manufacturer and the purchaser to use circular cross-section test pieces, the minimum diameter shall be 4 mm.

8 Test methods

8.1 Tensile test

Tensile tests shall be carried out in accordance with ISO 6892-1.

8.2 Brinell hardness test

Brinell hardness tests shall be carried out in accordance with ISO 6506-1.

A test ball of 5 mm diameter is recommended. By agreement between the manufacturer and the purchaser, a smaller ball diameter may be used for thin-wall castings.

9 Retests

Retests shall be carried out in accordance with EN 1559-5.

10 Rounding of numbers

The number representing the result for any value specified in this document shall be expressed with the same number of decimal places as the corresponding number in this document. The rounding of numbers shall meet the requirements of ISO 80000-1:2009, B.3, rule A or B. The choice shall be left to the discretion of the manufacturer, unless the use of one of the rules is agreed by the time of acceptance of the order.

Table 1 — Chemical composition of magnesium alloy ingots

Alloy group	Material designation			Composition % mass fraction																	
	Designation by symbols	Designation by numbers	ASTM designation	Min. or max.	Mg	Al	Zn	Mn[a]	RE[b]	Zr	Ag	Y	Gd	Li	Sr	Ca	Si	Fe	Cu	Ni	Other each
MgAlZn	ISO-MgAl8Zn1	ISO-MB21110	AZ81	min. max.	Rem.	7,2 8,5	0,45 0,9	0,17 0,4									– 0,05	– 0,004	– 0,025	– 0,001	– 0,05
	ISO-MgAl9Zn1(A)	ISO-MB21120	AZ91	min. max.	Rem.	8,5 9,5	0,45 0,9	0,17 0,40									– 0,08	– 0,004	– 0,025	– 0,001	– 0,01
	ISO-MgAl9Zn1(B)	ISO-MB21121	AZ91	min. max.	Rem.	8,0 10,0	0,3 1,0	0,1 0,50									– 0,3	– 0,03	– 0,020	– 0,01	– 0,05
	ISO-MgAl9Zn-1Ca	ISO-MB21122	AZ91	min max	Rem.	8,5 9,5	0,45 0,9	0,17 0,40								0,5 2,5	– 0,08	– 0,004	– 0,025	– 0,001	– 0,01
	ISO-MgAl6Zn3	ISO-MB21130	AZ63	min. max.	Rem.	5,5 6,5	2,7 3,3	0,15 0,35									– 0,05	– 0,005	– 0,015	– 0,001	– 0,05
MgAlMn	ISO-MgAl2Mn	ISO-MB21210	AM20	min. max.	Rem.	1,7 2,5	– 0,20	0,35 0,60									– 0,08	– 0,004	– 0,008	– 0,001	– 0,01
	ISO-MgAl5Mn	ISO-MB21220	AM50	min. max.	Rem.	4,5 5,3	– 0,30	0,28 0,50									– 0,08	– 0,004	– 0,008	– 0,001	– 0,01
	ISO-MgAl6Mn	ISO-MB21230	AM60	min. max.	Rem.	5,6 6,4	– 0,30	0,26 0,50									– 0,2	– 0,004	– 0,008	– 0,001	– 0,01
	ISO-MgAl10Mn	ISO-MB21240	AM100	min. max.	Rem.	9,4 10,6	– 0,20	0,13 0,35									0,7 1,2	– 0,004	– 0,008	– 0,001	– 0,01
MgAlSi	ISO-MgAl2Si	ISO-MB21310	AS21	min. max.	Rem.	1,9 2,5	– 0,20	0,2 0,6									0,7 1,2	– 0,004	– 0,008	– 0,001	– 0,01
	ISO-MgAl4Si	ISO-MB21320	AS41	min. max.	Rem.	3,7 4,8	– 0,20	0,2 0,6									– 0,08	– 0,004	– 0,008	– 0,001	– 0,01
MgAlRE	ISO-MgAl4RE4	ISO-MB21410	AE44	min. max.	Rem.	3,6 4,4	– 0,20	0,15 0,50	3,6 4,6								– 0,08	– 0,004	– 0,008	– 0,001	– 0,01
MgAlSr	ISO-MgAl5Sr2	ISO-MB21510	AJ52	min. max.	Rem.	4,6 5,5	– 0,20	0,24 0,6							1,8 2,3		– 0,08	– 0,004	– 0,008	– 0,001	– 0,01
	ISO-MgAl6Sr2	ISO-MB21520	AJ62	min. max.	Rem.	5,5 6,6	– 0,20	0,24 0,6							2,1 2,8		– 0,08	– 0,004	– 0,008	– 0,001	– 0,01
MgAlCa	ISO-MgAl-6Ca2RE2	ISO-MB25120	AE62	min. max.	Rem.	6,1 6,7	– 0,4	0,13 0,35	2,2 2,8							2,0 2,4	– 0,08	– 0,004	– 0,05	– 0,001	– 0,01