INTERNATIONAL STANDARD

ISO 26202

Second edition
2019-10

Magnesium and magnesium alloys — Magnesium alloys for cast anodes

Magnésium et alliages de magnésium — Alliages de magnésium pour anodes coulées

Reference number
ISO 26202:2019(E)

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Published in Switzerland

Contents

Page

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).

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For an explanation of 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 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 second edition cancels and replaces the first edition (ISO 26202:2007), which has been technically revised. The main changes compared with the previous edition are as follows:

a) a note has been added in 4.1;

b) in Clause 5, the compositions in Tables 1 and 2 have been updated;

c) in Clause 5, EN-MBMgAl6Zn1 has been deleted and the designations “EN-” have been replaced with “ISO-”;

d) “Sampling” has been included as 6.1;

e) “Packaging and surface protection” has been added as Clause 8;

f) in Annex C, cross-references of grade designations of this document to other standard grades of magnesium alloys for cast anodes have been added.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document classifies magnesium alloys for cast anodes into a number of grades suitable for the applications for which they might be used. Annexes A and B describe methods for electrochemical tests with corresponding recommended values. Annex C gives cross-references of grade designations of this document to other standard grades of magnesium alloys for cast anodes.

Magnesium and magnesium alloys — Magnesium alloys for cast anodes

1 Scope

This document specifies the grades and the corresponding requirements for magnesium alloy ingots for anodes and for magnesium alloy cast anodes.

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.

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

EN 1559-1, *Founding — Technical conditions of delivery — Part 1: General*

EN 1559-5, *Founding — Technical conditions 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:

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

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

4 Designations

4.1 Material

The material shall be designated either by symbol or by number (see Tables 1 and 2).

NOTE Cross-references of grade designations of this document to other standard grades of magnesium alloys for cast anodes are given in Annex C.

4.2 Casting process

The following symbols shall be used for the different casting processes:

— S: sand casting;

— K: permanent mould casting (gravity);

— C: continuous casting.

5 Requirements

5.1 General

The requirements for technical delivery conditions given in EN 1559-1 and EN 1559-5 shall apply, and/or any other technical requirements specified in the order agreed between the purchaser and the manufacturer.

5.2 Chemical composition

The chemical composition of magnesium alloy ingots for cast anodes shall conform to the requirements given in Table 1. The chemical composition of magnesium cast anodes shall conform to the requirements given in Table 2.

Table 1 — Chemical composition of magnesium alloy ingots for anode castings

Alloy group	Material designation		Composition in percent (mass fraction)										
	Symbol	Number	Element	Al	Zn	Mn	Si	Fe	Cu	Ni	Others each	Others total	Mg
MgAlZn	ISO-MBMgAl3Zn1	ISO-MB21130	min. max.	2,6 3,5	0,7 1,4	0,20 1,0	— 0,08	— 0,004	— 0,02	— 0,001	— 0,05	— 0,30	Remainder
	ISO-MBMgAl6Zn3	ISO-MB21150	min. max.	5,1 7,0	2,1 4,0	0,20 1,0	— 0,08	— 0,004	— 0,02	— 0,001	— 0,05	— 0,30	Remainder
MgMn	ISO-MBMgMn1	ISO-MB40010	min. max.	— 0,01	— 0,05	0,50 1,3	— 0,05	— 0,01	— 0,02	— 0,001	— 0,05	— 0,30	Remainder
	ISO-MBMgMn2	ISO-MB40020	min. max.	— 0,01	— 0,05	1,20 2,5	— 0,05	— 0,01	— 0,02	— 0,001	— 0,05	— 0,30	Remainder

Table 2 — Chemical composition of magnesium alloy anode castings

Alloy group	Material designation		Casting process[a]	Composition in percent (mass fraction)										
	Symbol	Number		Element	Al	Zn	Mn	Si	Fe	Cu	Ni	Others each	Others total	Mg
MgAlZn	ISO-MAMgA3Zn1	ISO-MA21130	S, K, C	min. max.	2,5 3,5	0,6 1,4	0,2 1,0	— 0,1	— 0,005	— 0,02	— 0,001	— 0,05	— 0,30	Remainder
	ISO-MAMgAl6Zn3	ISO-MA21150	S, K, C	min. max.	5,0 7,0	2,0 4,0	0,2 1,0	— 0,1	— 0,005	— 0,02	— 0,002	— 0,05	— 0,30	Remainder
MgMn	ISO-MAMgMn1	ISO-MA40010	S, K, C	min. max.	— 0,01	— 0,05	0,5 1,3	— 0,05	— 0,01	— 0,02	— 0,001	— 0,05	— 0,30	Remainder
	ISO-MAMgMn2	ISO-MA40020	S, K, C	min. max.	— 0,01	— 0,05	1,2 2,5	— 0,05	— 0,01	— 0,02	— 0,001	— 0,05	— 0,30	Remainder
For anodes used in potable (drinking) water, the following specifications shall be met (all in mass fraction): (As + Pb +Cr(VI) + Ni) % ≤ 0,1 % and (Cd + Sb + Se + Hg) % ≤ 0,01 %.														
[a] S = sand casting, K = permanent mould casting (gravity), C = continuous casting														

6 Testing

6.1 Sampling

Samples that are representative of the material shall be produced at a frequency, form and quantity in accordance with the process quality assurance procedures adopted by the manufacturer or as agreed between the manufacturer and the purchaser. Samples shall be taken from the molten metal at the time of casting.

6.2 Determination of the chemical composition

The methods used to determine the chemical composition of the material shall be in accordance with standardized methods or validated procedures.

NOTE ASTM B953 and ASTM B954 can be used for this purpose.

6.3 Electrochemical testing

If applicable, electrochemical testing shall be carried out in accordance with Annexes A and B.

7 Rounding of numbers

The number representing the result for any value specified in this document shall be expressed to the same number of decimal places as the corresponding number in this document. Rounding shall be carried out as specified in ISO 80000-1:2009, B.2 and B.3. In B.3, it is left to the discretion of the manufacturer as to whether to use rule A or rule B, unless the use of one of the rules has been agreed by the time of the acceptance of the order.

8 Packaging and surface protection

The manufacturer shall provide proper packaging and/or surface protection for the product to avoid damage, contamination, corrosion, etc. during transportation or during an agreed reasonable storage time, unless a special agreement has been made with the purchaser at the time of the acceptance of the order.

Annex A
(normative)

Test method for the determination of the electrode potential of galvanic anodes

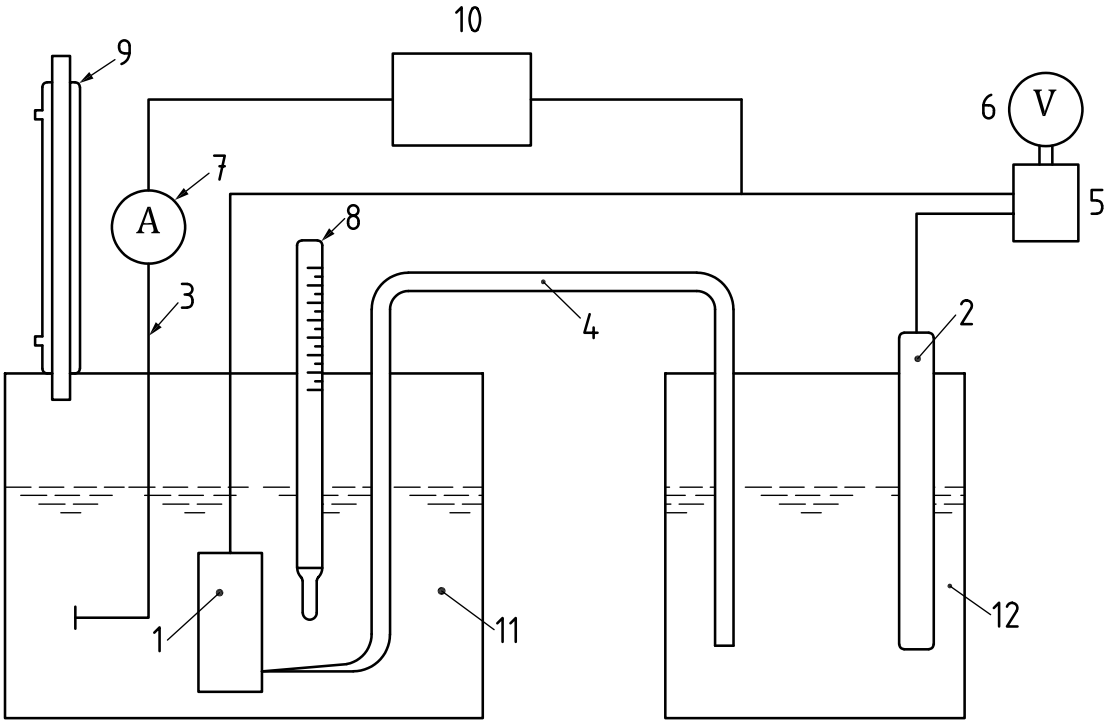
A.1 Test pieces

The test pieces shall be sections of the anodes where the core is removed.

Before starting the test, the test pieces shall be degreased with a solvent (e.g. xylol), then cleaned in running tap water with a plastic brush, then washed with ethanol and finally dried in air at room temperature.

A.2 Test apparatus

The test shall be carried out with the apparatus shown schematically in Figure A.1.



Key

1	measuring electrode (test piece)	7	amperemeter
2	reference electrode	8	thermometer
3	counter electrode	9	return condenser
4	Haber-Luggin capillary tube	10	current I, constant
5	measuring amplifier	11	measuring cell
6	voltmeter	12	reference cell

Figure A.1 — Apparatus for testing the electrode potential of galvanic anodes

A.3 Test solution

The test solution is 0,001 0 mol/l sodium chloride solution in de-ionized water.

A.4 Electrical connection

A galvanostatical polarization connection shall be used.

A.5 Test procedure

Four single measurements shall be made on four different test pieces.

After introducing the test piece into a measuring cell filled with sodium chloride solution (see A.3), the temperature of the electrolyte solution shall be adjusted to (60 ± 3) °C.

The reference electrode (e.g. a saturated calomel electrode) shall be connected to the measuring cell by means of an electrolyte bridge and a Haber-Luggin capillary tube.

The capillary tube shall be moved towards, and located as near as possible to, the test piece surface. This distance should not be more than twice the outside diameter of the capillary tube.

The application of the current is galvanostatically effected by using a galvanostat or a 12 V battery.

After a 24 h test, the potential of electrodes shall be read from the voltmeter.

The four single values and the mean value, each related to the standard hydrogen electrode, shall be given in the test report.

With a current density of (50 ± 1) $\mu A/cm^2$ in a 0,001 0 mol/l sodium chloride solution in de-ionized water at (60 ± 3) °C, an average of the electrode potential of the anodes more negative than UH = −0,9 V is recommended. This is to make sure that there is no passivation of the anode in low conductivity electrolytes.

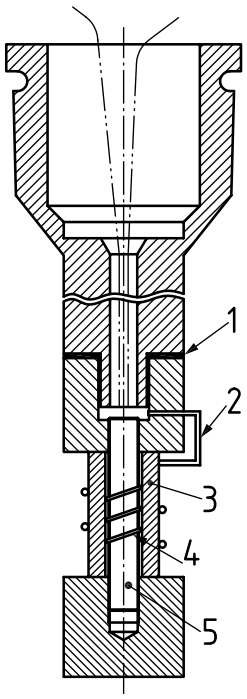
Annex B
(normative)

Test method for the determination of the rate of mass loss of galvanic anodes

B.1 Test pieces

The test pieces shall be sections of the anodes where the steel core is removed. The test piece surface area exposed to the test solution should be about 30 cm^2. Both end surfaces shall be covered by a suitable test piece support (see Figure B.1).

Before starting the test, the test pieces shall be degreased with a solvent, then cleaned in running tap water with a plastic brush, then washed with ethanol and finally dried in air at room temperature.



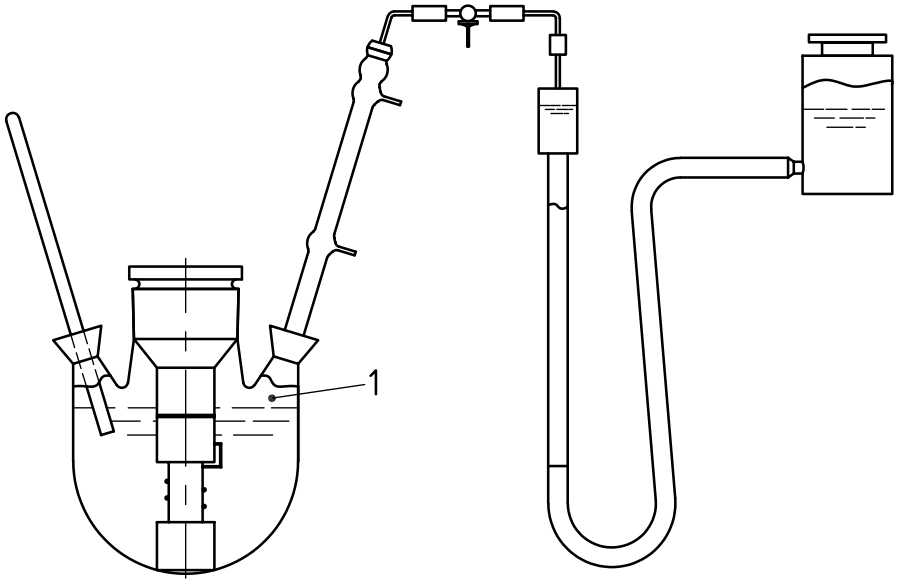
Key

1 sealing gasket
2 platinum counter electrode
3 magnesium anode
4 metallic contact by helical spring
5 threaded steel rod

Figure B.1 — Test piece support for the measurement of the mass loss rate

B.2 Test apparatus

The test shall be carried out with the apparatus shown schematically in Figure B.2. A suitable test piece support is shown in Figure B.1.



Key

1 dead volume (V_{t0})

Figure B.2 — Apparatus for the determination of the mass loss of galvanic anodes by measuring the formation of hydrogen

B.3 Test solution

The test solution is a 0,01 mol/l sodium chloride solution in de-ionized water.

B.4 Electrical connection

A galvanostatical polarization connection shall be used.

B.5 Test procedure

Four single measurements shall be made on four different test pieces.

After introducing the test piece into a measuring cell filled with sodium chloride solution (see B.3), the temperature of the electrolyte solution shall be adjusted to (60 ± 3) °C. Apply galvanostatically a current of 50 mA per square centimetre of the anode test piece surface. The determination of the mass loss is based on the volume of the formed hydrogen. At the beginning of the test, the level of sealing liquid in the gas burette shall be adjusted to the upper mark and the tap shall be closed. After 24 h, the tap shall be opened again. The level shall be once more adjusted to the upper mark and the tap shall be closed. The atmospheric pressure and test temperature shall be noted. After 24 h, the volume of the formed hydrogen, atmospheric pressure and room temperature at the end of the test shall be noted.

B.6 Evaluation

The volume of the formed hydrogen under normal conditions, V_0, expressed in litres, shall be reduced according to Formula (B.1) to normal conditions:

$$V_0 = \frac{T_0}{p_0}\left[\frac{(V_0 + \Delta V)\cdot p_2}{T_2} - \frac{V_{t0}\cdot p_1}{T_1}\right] \tag{B.1}$$

where

V_{t0} is the dead volume as shown in Figure B.2, expressed in millilitres;

ΔV is the volume of the formed hydrogen, expressed in millilitres;

p_0 is 1 013 hPa;

p_1 is the atmospheric pressure at the beginning of the test, expressed in hectopascals;

p_2 is the atmospheric pressure at the end of the test, expressed in hectopascals;

T_1 is the temperature at the beginning of the test, expressed in Kelvin;

T_2 is the temperature at the end of the test, expressed in Kelvin;

T_0 is 273 K.

The mass loss rate related to the surface, *v*, expressed in grams per square metre per day, is the result of Formula (B.2):

$$v = \frac{V_0 \cdot M_{Mg} \cdot 21{,}4}{A \cdot t \cdot Z_{Mg}} \tag{B.2}$$

where:

V_0 is the volume of hydrogen under normal conditions, expressed in litres;

M_{Mg} is the mol mass of magnesium = 24,312 g/mol;

21,4 is a calculation factor;

A is the test surface area of the anodes, expressed in square centimetres;

t is the duration of the test, expressed in hours;

Z_{Mg} is the magnesium valence = 2.

The mass loss rate gives an indication of the anode quality and life time. To be sure to have a sufficient anode alloy in a 0,01 mol/l sodium chloride solution in de-ionized water at (60 ± 3) °C, a mass loss rate not greater than 30 g/m^2 per day is recommended.

Annex C
(informative)

Cross-references of grade designations of this document to other standard grades of magnesium alloy ingots for cast anodes and magnesium alloys for cast anodes

Tables C.1 and C.2 list some international designations of both magnesium alloy ingots for cast anodes and magnesium alloy cast anodes.

Table C.1 — Material designations of magnesium alloy ingots for cast anodes

Material designation		List of corresponding designations					
		USA	China	Australia	Japan	EU	
Symbol	Number	ASTM B843	GB/T 17731	AS 2239	JIS H6125	EN 12438	
						Symbol	Number
ISO-MBMgAl3Zn1	ISO-MB21130	—	—	—	—	EN-MBMgAl3Zn1	3.5212
ISO-MBMgAl6Zn3	ISO-MB21150	—	—	—	—	EN-MBMgAl6Zn3	3.5214
ISO-MBMgMn1	ISO-MB40010	—	—	—	—	EN-MBMgMnl	3.5230
ISO-MBMgMn2	ISO-MB40020	—	—	—	—	EN-MBMgMn2	3.5231

Table C.2 — Material designations of magnesium alloy cast anodes

Material designation		List of corresponding designations					
		USA	China	Australia	Japan	EU	
Symbol	Number	ASTM B843	GB/T 17731	AS 2239	JIS H6125	EN 12438	
						Symbol	Number
ISO-MAMgAl3Zn1	ISO-MA21130	AZ31	AZ31	M2	MGA4	EN-MAMgAl3Zn1	3.5112
ISO-MAMgAl6Zn3	ISO-MA21150	AZ63	AZ63	—	MGA2	EN-MAMgAl6Zn3	3.5114
ISO-MAMgMn1	ISO-MA40010	M1	M1	M1	—	EN-MAMgMnl	3.5130
ISO-MAMgMn2	ISO-MA40020	—	—	—	—	EN-MAMgMn2	3.5131

Bibliography

[1] ASTM B843, *Standard specification for magnesium alloy anodes for cathodic protection*

[2] ASTM B953, *Standard Practice for Sampling Magnesium and Magnesium Alloys for Spectrochemical Analysis*

[3] ASTM B954, *Standard Test Method for Analysis of Magnesium and Magnesium Alloys by Atomic Emission Spectrometry*

[4] GB/T 17731, *Magnesium alloy sacrificial anode*

[5] AS 2239, *Galvanic (sacrificial) anodes for cathodic protection*

[6] JIS H6125, *Magnesium galvanic anodes for cathodic protection*

[7] EN 12438, *Magnesium and magnesium alloys — Magnesium alloys for cast anodes*

ICS 77.120.20

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