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Wrought magnesium and magnesium alloys — Extruded rods/bars and tubes

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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).

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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.*

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 the commercially available magnesium and magnesium alloy extruded rods/bars and tubes into a number of grades suitable for the application to which they might be put.

Wrought magnesium and magnesium alloys — Extruded rods/bars and tubes

1 Scope

This document specifies the technical conditions for inspection and delivery of wrought magnesium and magnesium alloy rods/bars and tubes for general engineering applications.

It is applicable to wrought magnesium and magnesium alloy extruded round, square and hexagonal rods/bars and seamless round tubes (hereafter referred to as "tubes").

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 3116:2019, *Magnesium and magnesium alloys — Wrought magnesium and magnesium alloys*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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/

3.1
rod/bar
solid wrought product of uniform cross-section along its whole length, supplied in straight lengths

Note 1 to entry: The cross-sections are in the shape of circles, squares, rectangles or regular hexagons. Products with a square, rectangular or hexagonal cross-section can have corners rounded along their whole length.

Note 2 to entry: A rod is normally less than 6 mm in diameter or minor dimension. In North America, the minimum diameter of a rod is 9,525 mm (0,375 in). Below this limit, the product is called "wire".

Note 3 to entry: For rectangular bars, the thickness exceeds one-tenth of the width. The term "rectangular bar" includes "flattened circles" and "modified rectangles", of which two opposite sides are convex arcs, the other two sides being straight, of equal length and parallel.

3.2
tube
hollow wrought product of uniform cross-section with only one enclosed void along its whole length, and with a uniform wall thickness, supplied in straight lengths or in coiled form, provided the inner and outer cross-sections are concentric and have the same form and orientation

Note 1 to entry: The cross-sections are in the shape of circles, squares, rectangles or regular hexagons. Hollow products with square, rectangular or regular hexagonal cross-sections can have corners rounded along their whole length.

3.3
sample
quantity of molten metal, product or products which is used for the production of *specimens* (3.4)

3.4
specimen
one or more pieces taken from each product in the *sample* (3.3) for the purpose of producing *test pieces* (3.5)

3.5
test piece
piece taken from each *specimen* (3.4) and suitably prepared for a *test* (3.6)

3.6
test
operation to which the *test piece* (3.5) is subjected in order to measure or classify properties

4 Orders or tenders

The order or tender shall define the product required and shall contain the following details:

a) the type and form of the product:

   1) the designation of the magnesium or magnesium alloy;

   2) the form of the product (sheet, plate, etc.);

b) the metallurgical temper (degree of hardness or heat treatment condition) of the material for delivery and, if different, the metallurgical temper for use;

c) the number of this document, i.e. ISO 23694, the specification number or, where none exists, the properties agreed between the supplier and the purchaser;

d) the dimensions and shape of the product (thickness, width, length, diameter of the coil);

e) the tolerances of the dimensions and form, with reference to the appropriate clause or subclause of this document;

f) the quantity;

g) any requirements for certificates of conformity, test and/or analysis;

h) any special requirements agreed between the supplier and the purchaser (e.g. drawings).

5 Requirements

5.1 Designation

The alloy designation and temper shall be in accordance with Table 1. If the alloy to be used is not specified in Table 1, the alloy designation and temper shall be in accordance with ISO 3116:2019 or be agreed upon between the supplier and purchaser and stated in the order.

Table 1 — Alloy designation and temper

Alloy symbol	Alloy designation	Temper	Product type	Diameter or thickness mm
ISO-MgAl4Zn	MAZ40	H112, F	rods/bars	$D \leq 130$
ISO-MgMn2(A)	MM2a	H112, F	rods/bars	$D \leq 130$
ISO-MgZn6Zr(A)	MZK60a	T5	rods/bars	$D \leq 130$
ISO-MgGd7Y5RE1	MVWE751	T5	bars	$D \leq 160$
ISO-MgGd9Y2Nd1Zr	MVW92	H112, T5, T6	bars	$D \leq 50$
ISO-MgGd8Y2ZrAgEr	MVW93M	T5	bars	$D \leq 160$
ISO-MgGd9Y4Zn1Zr	MVW94M	H112	bars	$D \leq 160$
		T5	bars	$D \leq 80$

5.2 Production and manufacturing processes

Unless otherwise specified in the order, the production and manufacturing processes shall be left to the discretion of the producer. Unless it is explicitly stated otherwise in the order, no obligation shall be placed on the producer to use the same processes for subsequent and similar orders.

5.3 Quality control

The supplier shall be responsible for the performances of all inspection and tests required by the relevant International Standard, specification or customer requests, prior to shipment of the product.

If the purchaser wishes to inspect the product at the supplier's works, he or she shall notify the supplier at the time of placing the order.

5.4 Chemical composition

The chemical composition of ISO-MgAl4Zn, ISO-MgMn2(A), ISO-MgZn6Zr(A), ISO-MgGd9Y2Nd1Zr, ISO-MgGd8Y2ZrAgEr and ISO-MgGd9Y4Zn1Zr shall conform to the requirements specified in Table 2. The chemical composition of other alloys shall conform to the requirements specified in ISO 3116:2019. If the purchaser requires content limits for elements not specified in ISO 3116:2019, these limits shall be stated in the order document.

Table 2 — Chemical composition of ISO-MgAl4Zn, ISO-MgMn2(A), ISO-MgZn6Zr(A), ISO-MgGd9Y2Nd1Zr, ISO-MgGd8Y2ZrAgEr and ISO-MgGd9Y4Zn1Zr

Alloy group	Material designation		Composition % (mass fraction)																			
	Symbol	Designation	Element	Mg	Al	Zn	Mn	Gd	Ce	Nd	Er	Li	Zr	Y	Be	Ag	Si	Fe	Cu	Ni	Others	
																					each	total
MgMn	ISO-MgMn2(A)	MM2a	min.	Rem.	—	—	1,3	—	0,15	—	—	—	—	—	—	—	—	—	—	—	—	—
			max.	—	0,20	0,30	2,2		0,35						0,01		0,10	0,05	0,05	0,007	0,01	0,30
MgAl	ISO-MgAl4Zn	MAZ40	min.	Rem.	3,0	0,20	0,15	—	—			—	—	—	—	—	—	—	—	—	—	—
			max.	—	4,0	0,80	0,50								0,01		0,10	0,05	0,05	0,005	0,01	0,30
MgZn	ISO-MgZn6Zr(A)	MZK60a	min.	Rem.	—	5,0	—	—	—			—	0,30	—	—	—	—	—	—	—	—	—
			max.	—	0,05	6,0	0,10						0,90		0,01		0,05	0,05	0,05	0,005	0,01	0,30
MgGdY	ISO-MgGd9Y2Nd1Zr	MVW92	min.	Rem.	—	1,6	—	8,8		0,7		—	0,4	1,6	—	—	—	—	—	—	—	—
			max.	—		2,4		9,8		1,4			1,0	2,4				0,01	0,02	0,005	0,02	0,20
	ISO-MgGd8Y2ZrAgEr	MVW93M	min.	Rem.	—	—	—	8,0			0,02	—	0,3	1,8		0,02	—	—	—	—	—	—
			max.	—				9,6			0,30		0,7	3,2		0,50	0,02	0,02	0,005	0,003	0,01	0,1
	ISO-MgGd9Y4Zn1Zr	MVW94M	min.	Rem.	—	0,8	—	8,5	—			—	0,4	3,5	—		—	—	—	—	—	—
			max.	—		1,5		9,5					0,7	4,5				0,005	0,005	0,005	0,02	0,3

Key

Rem.: subtract the percentage of all elements except Mg from 100 %.

5.5 Dimensional tolerances

5.5.1 The dimensions and tolerances for extruded round, square and hexagonal bars

5.5.1.1 Tolerances on diameter and width across flats

Tolerances on diameter and width across flats shall be in accordance with Table 3.

Table 3 — Dimensional tolerances

Dimensions in millimetres

Diameter of circumscribing circle	Tolerances
> 6 to 10	±0,35
> 10 to 18	±0,55
> 18 to 30	±0,65
> 30 to 50	±0,80
> 50 to 80	±0,95
> 80 to 120	±1,10
> 120 to 180	±1,25
> 180 to 250	±1,45
> 250 to 300	±2,65

5.5.1.2 Circularity of round bars

Circularity is measured by the difference between the maximum and minimum diameters measured in the same cross-section.

The permissible circularity is included in the tolerances on diameter specified in Table 3.

5.5.1.3 Corner radii of square and hexagonal bars

The maximum corner radii of square and hexagonal bars shall be in accordance with Table 4.

Table 4 — Maximum corner radii

Dimensions in millimetres

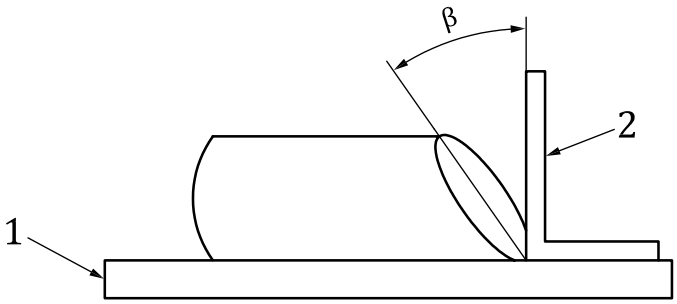
Diameter of circumscribing circle	Maximum value of corner radii
< 25	2,0
≥ 25 to 50	3,0
> 50	5,0

5.5.1.4 Fixed-length tolerances

If fixed lengths are supplied, they shall be agreed between the supplier and purchaser. The permissible tolerance on fixed lengths is $^{+20}_{0}$ millimetres.

5.5.1.5 Squareness of cut ends

The squareness of cut ends shall be within 3° for both fixed and random lengths. The squareness of cut ends β shall be measured as shown in Figure 1.



Key

1 base plate

2 ruler

Figure 1 — Squareness of cut ends

5.5.1.6 Straightness tolerances

The straightness tolerances shall be in accordance with Table 5.

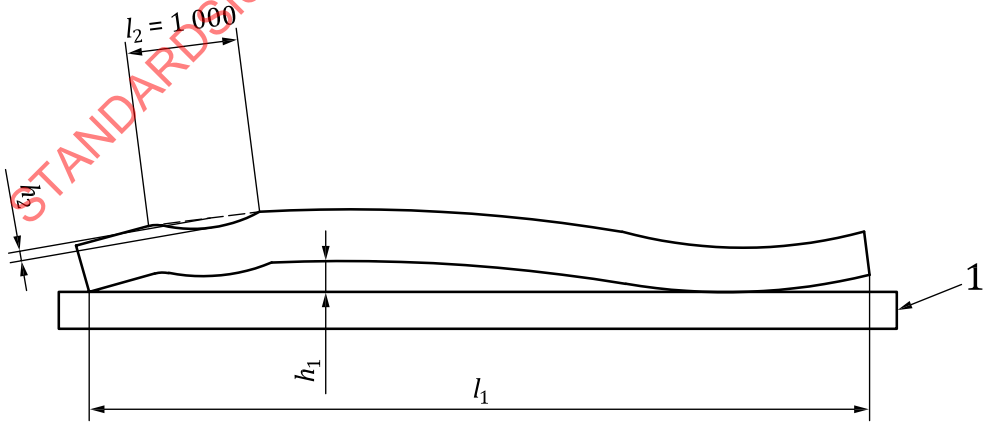
Table 5 — Straightness tolerances

Dimensions in millimetres

Diameter of circumscribing circle	Straightness tolerances	
	Over the total length (l_1)	In any 1 000 mm (l_2)
	h_1	h_2
> 6 to 100	$2{,}0 \times l_1$	2,0
> 100 to 120	$5{,}0 \times l_1$	5,0
> 120 to 200	$7{,}0 \times l_1$	7,0
> 200 to 300	$10{,}0 \times l_1$	10,0

The deviations from straightness h_1 and h_2 shall be measured as shown in Figure B.2, with the bar placed on a horizontal base plate so that its mass decreases the deviation.

Dimensions in millimetres



Key

1 base plate

Figure 2 — Measurement of deviation from straightness

5.5.1.7 Twist tolerances

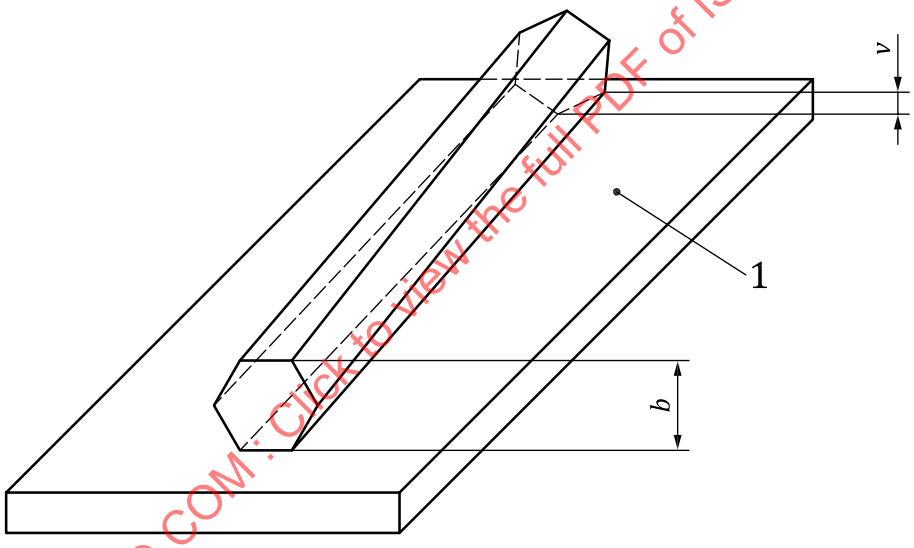
Twist tolerances shall be in accordance with Table 6.

Table 6 — Twist tolerances

Dimensions in millimetres

Diameter of circumscribing circle	Straightness tolerances	
	Over the total length (l_1)	In any 1 000 mm (l_2)
	h_1	h_2
≤ 14	6,0 × l_1	6,0
> 14 to 30	16,0 × l_1	16,0
> 30 to 50	24,0 × l_1	24,0
> 50 to 100	36,0 × l_1	36,0
> 100 to 300	50,0 × l_1	50,0

The twist *v* shall be measured in accordance with Figure 3.



Key

b width

v measurement position of twist

1 base plate

Figure 3 — Measurement of twist

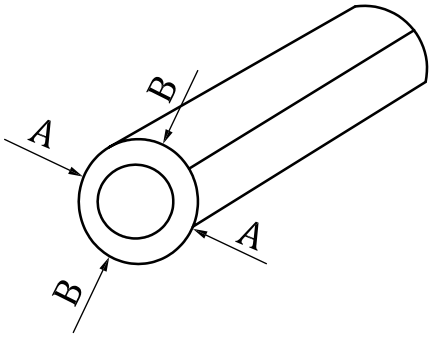
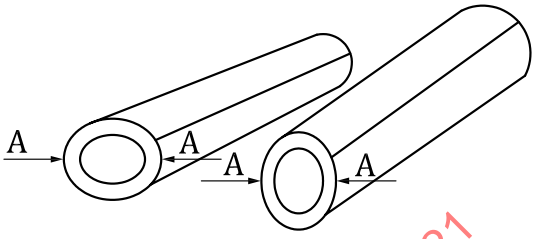
5.5.2 The dimensions and tolerances for extruded tubes

5.5.2.1 Tolerances on diameter for tubes

Tolerances on the diameter for tubes shall be in accordance with Table 7.

Table 7 — Tolerances on diameter for tube

Dimensions in millimetres

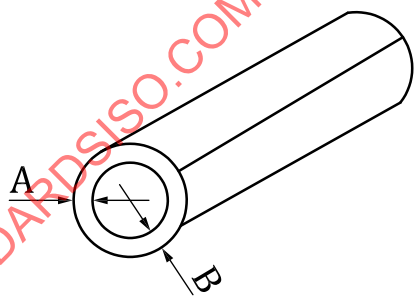
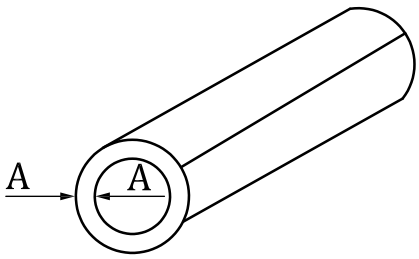
Outside diameter	Maximum allowable deviation of mean diameter from specified diameter	Maximum allowable deviation of diameter at any point from specified diameter
	 Difference between 1/2 (AA + BB) and specified diameter	 Difference between AA and specified diameter
> 10 to 30	±0,25	±0,50
> 30 to 50	±0,35	±0,60
> 50 to 80	±0,45	±0,80
> 80 to 120	±0,65	±1,20

5.5.2.2 Tolerances on wall thickness for tubes

The tolerances on wall thickness for tubes shall be in accordance with Table 8.

Table 8 — Tolerances on wall thickness for tubes

Dimensions in millimetres

Specified wall thickness	Maximum allowable deviation of mean wall thickness from specified wall thickness	Maximum allowable deviation of wall thickness at any point from specified wall thickness
	 Difference between 1/2 (AA + BB) and specified wall thickness	 Difference between AA and mean wall thickness
> 1,00 to 2,00	±0,20	±0,25
> 2,00 to 3,00	±0,25	±0,30
> 3,00	±0,30	±0,35

5.5.2.3 Length

If fixed lengths are to be supplied, this shall be stated in the order document. The tolerances on fixed length are $^{+20}_{0}$ millimetres.

The length range and the tolerances on the random length shall be subject to agreement between the supplier and purchaser.

5.5.2.4 Squareness of cut ends

The squareness of cut ends shall be within 3° for both fixed and random lengths. The squareness of cut ends β shall be measured as shown in Figure 1.

5.5.2.5 Straightness

Deviations from straightness h_1 and h_2 shall be measured as shown in Figure 2 with the profile placed on a horizontal base plate so that its own mass decreases the deviation.

The tolerances on straightness shall be in accordance with Table 9.

Table 9 — Tolerance on straightness

Dimensions in millimetres

Maximum wall thickness	Tolerances	
	Over the total length (l_1) h_1	In any 1 000 mm (l_1) h_2
≤ 4	$10{,}0 \times l_1$	10,0
> 4 to 10	$4{,}0 \times l_1$	4,0
> 10	$2{,}0 \times l_1$	2,0

5.6 Mechanical properties

The mechanical properties of rods/bars shall be in accordance with Table 10. The mechanical properties of tubes shall be in accordance with Table 11. If the alloy to be used is not specified in Tables 10 and 11, the mechanical properties shall be in accordance with ISO 3116:2019 or be agreed upon between the supplier and purchaser and stated in the order.

Table 10 — Mechanical properties of rods/bars

Symbol	Temper	Diameter of circumscribing circle mm	Tensile strength Rm MPa	0,2 % proof stress Rp0,2 MPa	Elongation A %
			min.		
ISO-MgAl4Zn	H112, F	≤ 100	245	—	6,0
		> 100 to 130	245	—	5,0
ISO-MgMn2(A)	H112, F	≤ 50	215	—	4,0
		> 50 to 100	205	—	3,0
		> 100 to 130	195	—	2,0
ISO-MgZn6Zr(A)	T5	≤ 100	315	245	6,0
		> 100 to 130	305	235	6,0
ISO-MgGd7Y5RE1	T5	≤ 20	450	355	6,0
		> 20 to 80	430	350	5,0
		> 80 to 160	350	250	3,0
ISO-MgGd9Y2Nd1Zr	H112	≤ 50	350	280	10,0
	T5	≤ 50	360	260	8,0
	T6	≤ 50	380	270	6,0
ISO-MgGd8Y2ZrAgEr	T5	≤ 160	350	280	5,0

Table 10 *(continued)*

Symbol	Temper	Diameter of circumscribing circle mm	Tensile strength Rm MPa	0,2 % proof stress Rp0,2 MPa	Elongation A %
			min.		
ISO-MgGd9Y4Zn1Zr	H112	≤ 80	360	280	10,0
		> 80 to 160	350	260	8,0
	T5	≤ 80	400	310	8,0
		> 80 to 160	380	300	5,0

Table 11 — Mechanical properties of tubes

Symbol	Temper	Wall thickness mm	Tensile strength Rm MPa	0,2 % proof stress Rp0,2 MPa	Elongation A %
			min.		
ISO-MgAl3Zn1(A)	H112	> 1 to 10	220	140	10,0

5.7 Surface finish

The products shall be free from defects detrimental to their required use and performance.

While an operation designed to mask a fault is not permitted, the elimination of a superficial fault is permissible, provided that the dimensional tolerances remain.

6 Test procedure

6.1 Sampling

6.1.1 Specimens for chemical analysis

The specimens for chemical analysis shall be cast from molten metal samples taken at the time of casting.

Their shape and conditions of production (mould design, cooling rate, mass, etc.) shall be so designed that their composition is homogeneous, and is suitable for the method of analysis which is agreed between the supplier and the purchaser.

6.1.2 Specimens for mechanical testing

6.1.2.1 Location and size

Specimens shall be taken from samples in such a way that it is possible to orientate the test pieces in relation to the product, as specified in 6.1.2.2.

The specimens shall be large enough to allow manufacture of sufficient test pieces for the required tests, and for any retests which are required.

6.1.2.2 Orientation of specimens

Specimens shall generally be taken in the longitudinal direction, unless otherwise agreed upon between the supplier and purchaser and stated in the order.