BRITISH STANDARD

BS ISO
3116:2001

Magnesium and magnesium alloys — Wrought magnesium alloys

ICS 77.120.20

National foreword

This British Standard reproduces verbatim ISO 3116:2001 and implements it as the UK national standard. It supersedes BS 3370:1970, BS 3372:1970 and BS 3373:1970, which are withdrawn.

The UK participation in its preparation was entrusted by Technical Committee NFE/35, Light metals and their alloys, to Subcommittee NFE/35/4, Magnesium and magnesium alloys, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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This British Standard, having been prepared under the direction of the Engineering Sector Committee was published under the authority of the Standards Committee and comes into effect on 15 June 2001

Summary of pages

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Magnesium and magnesium alloys — Wrought magnesium alloys

Magnésium et alliages de magnésium — Alliages de magnésium corroyés

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 3116 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 3116:1981) which has been technically revised.

Annexes A, B and C of this International Standard are for information only.

Introduction

This International Standard classifies the commercially available magnesium alloys into a number of grades suitable for the application to which they might be put.

Some of the alloys referenced in this International Standard 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 — Wrought magnesium alloys

1 Scope

This International Standard specifies the chemical composition and mechanical properties of magnesium alloys for wrought products in the form of bars and solid sections, tubes and hollow sections, forgings, and plate and sheet.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 31-0:1992, *Quantities and units — Part 0: General principles.*

ISO 2092, *Light metals and their alloys — Code of designation based on chemical symbols.*

ISO 6892, *Metallic materials — Tensile testing at ambient temperature.*

EN 515, *Aluminium and aluminium alloys — Wrought products — Temper designations.*

3 Designation

3.1 Material

The material shall be designated by symbols as given in Tables 1 to 11.

The material symbol designations are in accordance with ISO 2092.

NOTE A list of national designations corresponding to this International Standard is given in annex A and a table of physical properties of the listed alloys is given in annex B.

3.2 Temper designation

The following symbols shall be used for temper designation:

— O: annealed;

— F: as fabricated;

— H×8: fully hardened (strain hardened to give maximum ultimate tensite strength);

— H×4: half hardened (strain hardened to give an ultimate tensile strength approximately midway between that of annealed and H×8 temper);

— H×2: quarter hardened (strain hardened to give an ultimate tensile strength approximately midway between that of annealed and H×4 temper);

— T5: cooled from an elevated temperature shaping process and then artificially aged;

— T6: solution heat treated and then artificially aged.

The temper designations are in accordance with EN 515.

3.3 Designations of product form

The following symbols shall be used for product form:

— B: Bars and solid sections;

— T: Tubes and hollow sections;

— F: Forgings;

— P: Plate and sheet.

3.4 Designation for ordering

EXAMPLE

An order for magnesium bars, conforming to this International Standard of magnesium alloy ISO-WD 21150, delivered in the as-fabricated condition (F) is as follows:

ISO 3116 - ISO-MgAl3Zn1 (A) (or WD21150) - F - B

Tonnage and dimensions to be specified in addition.

4 Requirements

4.1 Chemical composition

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

4.2 Mechanical properties

The minimum values of the mechanical properties of wrought products in magnesium alloys in the defined temper conditions shall be as given in Tables 2 to 11.

4.3 Frequency of testing

The frequency of testing shall be subject to an agreement between the manufacturer and the purchaser.

5 Sampling

Conditions for sampling, formation of batches and frequency of verification shall be subject to an agreement between the manufacturer and the purchaser.

6 Test pieces

Test pieces shall be taken in the longitudinal direction. For rolled flat products of thickness > 0,6 mm, test pieces may be taken in the long transverse direction.

7 Test methods

7.1 Chemical composition

The determination of the alloying elements given in Table 1 shall be performed in accordance with normal practice.

7.2 Tensile test

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

8 Retests

Condition for retests shall be subject to an agreement between the manufacturer and the purchaser.

9 Rounding of results

The number representing the result for any value specified in this International Standard shall be expressed to the same number of decimal places as the corresponding number in this International Standard. The rounding of numbers shall meet the requirements of annex B, clause B.3, rule A or B in ISO 31-0:1992. 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 wrought magnesium alloys

Alloy group	Material designation		Composition % (mass fraction)															
	Symbol	Numbers	Product form [a]	Element	Mg	Al	Zn	Mn	RE[b]	Zr	Y	Li	Si	Fe	Cu	Ni	Others each	Others total
MgAlZn	ISO-MgAl3Zn1(A)	ISO-WD21150	B,T,F,P	min.	Rem.[c]	2,4	0,50	0,15	–	–	–	–	–	–	–	–	–	–
				max.	–	3,6	1,5	0,40	–	–	–	–	0,10	0,005	0,05	0,005	0,05	0,30
	ISO-MgAl3Zn1(B)	ISO-WD21151	B,T,F,P	min.	Rem.	2,4	0,5	0,05	–	–	–	–	–	–	–	–	–	–
				max.	–	3,6	1,5	0,4	–	–	–	–	0,1	0,05	0,05	0,005	0,05	0,30
	ISO-MgAl6Zn1	ISO-WD21160	B,T,F	min.	Rem.	5,5	0,50	0,15	–	–	–	–	–	–	–	–	–	–
				max.	–	6,5	1,5	0,40	–	–	–	–	0,10	0,005	0,05	0,005	0,05	0,30
	ISO-MgAl8Zn	ISO-WD21170	B,F	min.	Rem.	7,8	0,20	0,12	–	–	–	–	–	–	–	–	–	–
				max.	–	9,2	0,8	0,40	–	–	–	–	0,10	0,005	0,05	0,005	0,05	0,30
MgMn	ISO-MgMn2	ISO-WD43150	B,T	min.	Rem.	–	–	1,2	–	–	–	–	–	–	–	–	–	–
				max.	–	–	–	2,0	–	–	–	–	0,10	–	0,05	0,01	0,05	0,30
MgZnZr	ISO-MgZn3Zr	ISO-WD32250	B,T,F	min.	Rem.	–	2,5	–	–	0,45	–	–	–	–	–	–	–	–
				max.	–	–	4,0	–	–	0,8	–	–	–	–	–	–	0,05	0,30
	ISO-MgZn6Zr	ISO-WD32260	B,T,F	min.	Rem.	–	4,8	–	–	0,45	–	–	–	–	–	–	–	–
				max.	–	–	6,2	–	–	0,8	–	–	–	–	–	–	0,05	0,30
MgZnMn	ISO-MgZn2Mn1	ISO-WD32350	B,T,F,P	min.	Rem.	–	1,75	0,6	–	–	–	–	–	–	–	–	–	–
				max.	–	0,1	2,3	1,3	–	–	–	–	0,10	0,06	0,1	0,005	0,05	0,30
MgZnCu	ISO-MgZn7Cu1	ISO-WD32150	B	min.	Rem.	–	6,0	0,5	–	–	–	–	–	–	1,0	–	–	–
				max.	–	0,2	7,0	1,0	–	–	–	–	0,10	0,05	1,5	0,01	0,05	0,30
MgYREZr	ISO-MgY5RE4Zr	ISO-WD95350	B,F	min.	Rem.	–	–	–	1,5	0,4	4,75	–	–	–	–	–	–	–
				max.	–	–	0,20	0,03	4,0	1,0	5,5	0,2	0,01	0,010	0,02	0,005	0,01	0,30
	ISO-MgY4RE3Zr	ISO-WD95360	B,F	min.	Rem.	–	–	–	2,4	0,4	3,7	–	–	–	–	–	–	–
				max.	–	–	0,20[d]	0,03	4,4	1,0	4,3	0,2	0,01	0,010	0,02	0,005	0,01	0,30

a B = Bars and solid sections; T = Tubes and hollow sections; F = Forgings; P = Plate and sheet.

b RE = Neodymium and other heavy rare earth metals.

c Remainder.

d Zn + Ag.

Table 2 — Alloy ISO-MgAl3Zn1

Temper	Thickness mm	Tensile strength R_m N/mm^2 min.	0,2 % proof stress $R_{p0,2}$ N/mm^2 min.	Elongation A % min.
Bars and solid sections	$t = D$ for solid round bars			
F	$1 \leqslant t \leqslant 10$ $10 < t \leqslant 65$	220 240	140 150	10 10
Tubes and hollow sections				
F	$1 \leqslant t \leqslant 10$	220	140	10
Forgings				
F	All	235	130	8
Plate and sheet				
O	$0,5 \leqslant t \leqslant 6$ $6 < t \leqslant 25$	220 210	105 105	11 9
H×2	$0,5 \leqslant t \leqslant 6$ $6 < t \leqslant 25$	250 220	160 120	5 8
H×4	$0,5 \leqslant t \leqslant 6$ $6 < t \leqslant 25$	260 250	200 160	4 6
NOTE Values for separately forged test pieces must be agreed between manufacturer and customer.				

Table 3 — Alloy ISO-MgAl6Zn1

Temper	Thickness mm	Tensile strength R_m N/mm^2 min.	0,2 % proof stress $R_{p0,2}$ N/mm^2 min.	Elongation A % min.
Bars and solid sections	$t = D$ for solid round bars			
F	$1 \leqslant t \leqslant 10$ $10 < t \leqslant 40$ $40 < t \leqslant 65$	260 270 260	160 180 160	6 10 10
Tubes and hollow sections				
F	$1 \leqslant t \leqslant 10$	260	150	10
Forgings				
F	All	270	152	6
NOTE Values for separately forged test pieces must be agreed between manufacturer and customer.				

Table 4 — Alloy ISO-MgAl8Zn

Temper	Thickness mm	Tensile strength R_m N/mm^2 min.	0,2 % proof stress $R_{p0,2}$ N/mm^2 min.	Elongation A % min.
Bars and solid sections	$t = D$ for solid round bars			
F	$t \leqslant 40$	295	195	10
	$40 < t \leqslant 60$	295	195	8
	$60\ t \leqslant 130$	290	185	8
T5	$t \leqslant 6$	325	205	4
	$6 < t \leqslant 60$	330	230	4
	$60\ t \leqslant 130$	310	205	2
Tubes and hollow sections				
F	$t \leqslant 10$	295	195	7
Forgings				
F	All	290	200	6
NOTE Values for separately forged test pieces must be agreed between manufacturer and customer.				

Table 5 — Alloy ISO-MgMn2

Temper	Thickness mm	Tensile strength R_m N/mm^2 min.	0,2 % proof stress $R_{p0,2}$ N/mm^2 min.	Elongation A % min.
Bars and solid sections	$t = D$ for solid round bars			
F	$t \leqslant 10$	230	120	3
	$10 < t \leqslant 50$	230	120	3
	$50 < t \leqslant 100$	200	120	3
Tubes and hollow sections				
F	$t \leqslant 2$	225	165	2
	$t > 2$	200	145	1,5

Table 6 — Alloy ISO-MgZn3Zr

Temper	Thickness mm	Tensile strength R_m N/mm^2 min.	0,2 % proof stress $R_{p0,2}$ N/mm^2 min.	Elongation A % min.
Bars and solid sections	$t = D$ for solid round bars			
F	$t \leqslant 10$	280	200	8
	$10 < t \leqslant 100$	300	225	8
T5	All	275	255	4
Tubes and hollow sections				
T5	All	275	255	4
Forgings				
F	All	290	205	7
NOTE Values for separately forged test pieces must be agreed between manufacturer and customer.				

Table 7 — Alloy ISO-MgZn6Zr

Temper	Thickness mm	Tensile strength R_m N/mm^2 min.	0,2 % proof stress $R_{p0,2}$ N/mm^2 min.	Elongation A % min.
Bars and solid sections	$t = D$ for solid round bars			
F	$t \leqslant 50$	300	210	5
T5	$t \leqslant 50$	310	230	5
Tubes and hollow sections				
F	All	275	195	5
T5	All	315	260	4
Forgings				
T5	$t \leqslant 75$	290	180	7
T6	$t \leqslant 75$	295	220	4
NOTE Values for separately forged test pieces must be agreed between manufacturer and customer.				

Table 8 — Alloy ISO-MgZn2Mn1

Temper	Thickness mm	Tensile strength R_m N/mm^2 min.	0,2 % proof stress $R_{p0,2}$ N/mm^2 min.	Elongation A % min.
Bars and solid sections	$t = D$ for solid round bars			
F	$t \leqslant 10$ $10 < t \leqslant 75$	230 245	150 160	8 10
Tubes and hollow sections				
F	$t \leqslant 10$ $10 < t \leqslant 75$	230 245	150 160	8 10
Forgings				
F	All	200	125	9
Plate and sheet				
O	$6 \leqslant t \leqslant 25$	220	120	8
H×4	$6 \leqslant t \leqslant 25$	250	165	5
NOTE Values for separately forged test pieces must be agreed between manufacturer and customer.				

Table 9 — Alloy ISO-MgZn7Cu1

Temper	Thickness mm	Tensile strength R_m N/mm^2 min.	0,2 % proof stress $R_{p0,2}$ N/mm^2 min.	Elongation A % min.
Bars and solid sections	$t = D$ for solid round bars			
F	$10 \leqslant t \leqslant 130$	250	160	7
T6	$10 \leqslant t \leqslant 130$	325	300	3

Table 10 — Alloy ISO-MgY5RE4Zr

Temper	Thickness mm	Tensile strength R_m N/mm^2 min.	0,2 % proof stress $R_{p0,2}$ N/mm^2 min.	Elongation A % min.
Bars and solid sections	$t = D$ for solid round bars			
T5	$10 \leqslant t \leqslant 50$	250	170	8
	$50 < t \leqslant 100$	250	160	6
T6	$10 \leqslant t \leqslant 50$	250	160	8
	$50 < t \leqslant 100$	250	160	6
Forgings				
T5	All	290	155	2
T6	All	260	165	4
NOTE Values for separately forged test pieces must be agreed between manufacturer and customer.				

Table 11 — Alloy ISO-MgY4RE3Zr

Temper	Thickness mm	Tensile strength R_m N/mm^2 min.	0,2 % proof stress $R_{p0,2}$ N/mm^2 min.	Elongation A % min.
Bars and solid sections	$t = D$ for solid round bars			
T5	$10 \leqslant t \leqslant 50$	230	140	5
	$50 < t \leqslant 100$	220	130	5
T6	$10 \leqslant t \leqslant 50$	220	130	8
	$50 < t \leqslant 100$	220	130	6
Forgings				
T5	All	280	150	3
T6	All	255	160	4
NOTE Values for separately forged test pieces must be agreed between manufacturer and customer.				

Annex A
(informative)

List of national designations corresponding to the ISO designation

Material designation in accordance with ISO 2092	USA ASTM	Germany DIN Number	United Kingdom BS Series	France NF
ISO-MgAl3Zn1	AZ31B	3.5312	MAG 110	G-A3Z1
ISO-MgAl6Zn1	AZ61A	3.5612	MAG 121	G-A6Z1
ISO-MgAl8Zn	AZ80A	3.5812	–	–
ISO-MgMn2	–	–	–	–
ISO-MgZn3Zr	–	–	MAG 151	–
ISO-MgZn6Zr	–	–	–	–
ISO-MgZn2Mn1	–	–	MAG 131	–
ISO-MgZn7Cu1	ZC71A	–	–	–
ISO-MgY5RE4Zr	WE54A	–	–	–
ISO-MgY4RE3Zr	WE43A	–	–	–

Annex B
(informative)

Physical properties of wrought magnesium alloys

Alloy	Specific gravity (20 °C)	Coefficient of thermal expansion $10^{-6}K^{-1}$ (20 °C to 200 °C)	Thermal conductivity $Wm^{-1}K^{-1}$ (20 °C)	Electrical resistivity nΩm (20 °C)	Specific heat $Jkg^{-1}K^{-1}$ (20 °C to 100 °C)
ISO-MgAl3Zn1	1,77	26,0	96	100	1 040
ISO-MgAl6Zn1	1,80	27,3	79	143	1 000
ISO-MgAl8Zn	1,80	26,0	78	145	1 050
ISO-MgMn2	–	–	–	–	–
ISO-MgZn3Zr	1,80	27,1	125	70	960
ISO-MgZn6Zr	–	–	–	–	–
ISO-MgZn2Mn1	1,78	26,0	125	70	1 040
ISO-MgZn7Cu1	1,87	26,0	123	54	960
ISO-MgY5RE4Zr	1,85	24,6	52	173	960
ISO-MgY4RE3Zr	1,84	26,7	51	148	966

Annex C
(informative)

Heat treatment schedules for wrought magnesium alloys

Alloy	Condition	Solution treatment	Quench	Age
ISO-MgAl3Zn1	F	–	–	–
ISO-MgAl6Zn1	F	–	–	–
ISO-MgAl8Zn	F	–	–	–
ISO-MgAl8Zn	T5	–	–	16 hours @ 180 °C
ISO-MgMn2	F	–	–	–
ISO-MnZn3Zr	F	–	–	–
ISO-MgZn3Zr	T5	–	–	24 hours@150 °C
ISO-MnZn6Zr	F	–	–	–
ISO-MnZn6Zr	T5	–	–	24 hours @ 150 °C
ISO-MnZn6Zr	T6	2 hours @ 500 °C	As required	24 hours @ 150 °C
ISO-MgZn2Mn1	F	–	–	–
ISO-MgZn7Cu1	F	–	–	–
ISO-MgZn7Cu1	T6	4-8 hours @ 430 °C	Hot water	16 hours @ 180 °C
ISO-MgY5RE4Zr	T5	–	–	16 hours @ 250 °C
ISO-MgY5RE4Zr	T6	8 hours @ 525 °C	Air cool or hot water	16 hours @ 250 °C
ISO-MgY4RE3Zr	T5	–	–	16 hours @ 250 °C
ISO-MgY4RE3Zr	T6	8 hours @ 525 °C	Air cool or hot water	16 hours @ 250 °C

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London
W4 4AL