INTERNATIONAL STANDARD

**ISO 3116**

Fourth edition
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# Magnesium and magnesium alloys — Wrought magnesium alloys

*Magnésium et alliages de magnésium — Alliages de magnésium corroyés*

Reference number
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# 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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

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 fourth edition cancels and replaces the third edition (ISO 3116:2001), which has been technically revised. The reason for this fourth edition is to clarify that requirements for chemical composition relate to cast analysis, and to adjust elongation values for some alloys and tempers.

# 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 referenced documents are indispensable for the application 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 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 are to be specified in addition.

## 4 Requirements

### 4.1 Chemical composition

The chemical composition of wrought magnesium alloys, taken as cast analysis at the time the material is cast, 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

Conditions 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 | | Product form [a] | Composition % (mass fraction) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Symbol | Numbers | | 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<br>mm | Tensile strength<br>$R_m$<br>N/mm$^2$<br>min. | 0,2 % Proof stress<br>$R_{p0,2}$<br>N/mm$^2$<br>min. | Elongation<br>$A$<br>%<br>min. |
|---|---|---|---|---|
| **Bars and solid sections** | $t = D$ for solid round bars | | | |
| F | $1 \leqslant t \leqslant 10$ | 220 | 140 | 10 |
| | $10 < t \leqslant 65$ | 240 | 150 | 10 |
| **Tubes and hollow sections** | | | | |
| F | $1 \leqslant t \leqslant 10$ | 220 | 140 | 10 |
| **Forgings** | | | | |
| F | All | 235 | 130 | 8 |
| **Plate and sheet** | | | | |
| O | $0,5 \leqslant t \leqslant 6$ | 220 | 105 | 11 |
| | $6 < t \leqslant 25$ | 210 | 105 | 9 |
| H×2 | $0,5 \leqslant t \leqslant 6$ | 250 | 160 | 5 |
| | $6 < t \leqslant 25$ | 220 | 120 | 8 |
| H×4 | $0,5 \leqslant t \leqslant 6$ | 260 | 200 | 4 |
| | $6 < t \leqslant 25$ | 250 | 160 | 6 |
| NOTE Values for separately forged test pieces must be agreed between the manufacturer and customer. | | | | |

**Table 3 — Alloy ISO-MgAl6Zn1**

| Temper | Thickness<br>mm | Tensile strength<br>$R_m$<br>N/mm$^2$<br>min. | 0,2 % Proof stress<br>$R_{p0,2}$<br>N/mm$^2$<br>min. | Elongation<br>$A$<br>%<br>min. |
|---|---|---|---|---|
| **Bars and solid sections** | $t = D$ for solid round bars | | | |
| F | $1 \leqslant t \leqslant 10$ | 260 | 160 | 6 |
| | $10 < t \leqslant 40$ | 270 | 180 | 10 |
| | $40 < t \leqslant 65$ | 260 | 160 | 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 the manufacturer and customer. | | | | |

**Table 4 — Alloy ISO-MgAl8Zn**

| Temper | Thickness<br>mm | Tensile strength<br>$R_m$<br>N/mm$^2$<br>min. | 0,2 % Proof stress<br>$R_{p0,2}$<br>N/mm$^2$<br>min. | Elongation<br>$A$<br>%<br>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 the manufacturer and customer. | | | | |

**Table 5 — Alloy ISO-MgMn2**

| Temper | Thickness<br>mm | Tensile strength<br>$R_m$<br>N/mm$^2$<br>min. | 0,2 % Proof stress<br>$R_{p0,2}$<br>N/mm$^2$<br>min. | Elongation<br>$A$<br>%<br>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<br>mm | Tensile strength<br>$R_m$<br>N/mm$^2$<br>min. | 0,2 % Proof stress<br>$R_{p0,2}$<br>N/mm$^2$<br>min. | Elongation<br>$A$<br>%<br>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 the manufacturer and customer. | | | | |

**Table 7 — Alloy ISO-MgZn6Zr**

| Temper | Thickness<br>mm | Tensile strength<br>$R_m$<br>N/mm$^2$<br>min. | 0,2 % Proof stress<br>$R_{p0,2}$<br>N/mm$^2$<br>min. | Elongation<br>$A$<br>%<br>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 the manufacturer and customer. | | | | |

**Table 8 — Alloy ISO-MgZn2Mn1**

| Temper | Thickness<br>mm | Tensile strength<br>$R_m$<br>N/mm$^2$<br>min. | 0,2 % Proof stress<br>$R_{p0,2}$<br>N/mm$^2$<br>min. | Elongation<br>$A$<br>%<br>min. |
|---|---|---|---|---|
| **Bars and solid sections** | $t = D$ for solid round bars | | | |
| F | $t \leqslant 10$ | 230 | 150 | 8 |
| | $10 < t \leqslant 75$ | 245 | 160 | 10 |
| **Tubes and hollow sections** | | | | |
| F | $t \leqslant 10$ | 230 | 150 | 8 |
| | $10 < t \leqslant 75$ | 245 | 160 | 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 the manufacturer and customer. | | | | |

**Table 9 — Alloy ISO-MgZn7Cu1**

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

**Table 11 — Alloy ISO-MgY4RE3Zr**

| Temper | Thickness<br>mm | Tensile strength<br>$R_m$<br>N/mm$^2$<br>min. | 0,2 % Proof stress<br>$R_{p0,2}$<br>N/mm$^2$<br>min. | Elongation<br>$A$<br>%<br>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 | 6 |
| | $50 < t \leqslant 100$ | 220 | 130 | 6 |
| **Forgings** | | | | |
| T5 | All | 280 | 150 | 6 |
| T6 | All | 255 | 160 | 6 |
| NOTE Values for separately forged test pieces must be agreed between the manufacturer and customer. | | | | |

# Annex A
(informative)

# List of national designations corresponding to the ISO designation

**Table A.1**

| 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

**Table B.1**

| Alloy | Specific gravity<br><br>(20 °C) | Coefficient of thermal expansion<br>$10^{-6}K^{-1}$<br>(20 °C to 200 °C) | Thermal conductivity<br>$Wm^{-1}K^{-1}$<br>(20 °C) | Electrical resistivity<br>nΩm<br>(20 °C) | Specific heat<br>$Jkg^{-1}K^{-1}$<br>(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

**Table C.1**

| 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 |

ICS 77.120.20

Price based on 12 pages