INTERNATIONAL STANDARD

**ISO 19288**

First edition
2016-05-15

# Welding consumables — Solid wire electrodes, solid wires and rods for fusion welding of magnesium and magnesium alloys — Classification

*Produits consommables pour le soudage — Fils-électrodes pleins, fils pleins et baguettes pleines pour le soudage par fusion du magnésium et des alliages de magnésium — Classification*

Reference number
ISO 19288:2016(E)



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# 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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*.

Requests for official interpretations of any aspect of this International Standard should be directed to the Secretariat of ISO/TC 44/SC 3 via your national standards body. A complete listing of these bodies can be found at www.iso.org.

# Introduction

This International Standard proposes a classification in order to designate solid wire electrodes, solid wires and rods in terms of their chemical composition.

There is no unique relationship between the product form (solid wire electrodes, solid wires or rods) and the welding process used (gas-shielded metal arc welding, tungsten inert gas arc welding, plasma arc welding or laser beam welding). For this reason, solid wire electrodes, solid wires and rods may be classified in terms of their chemical composition.

In this International Standard, the symbol of the welding process is not used because

a) different joining processes are performed with the same chemical component consumable, and

b) the producer is not able to determine the process symbol before shipping.

Mechanical properties of all-weld metal test specimens or welded joints will vary from those obtained in production due to differences in welding procedure and the parent material. Mechanical properties of all-weld metal or welded joints are consequently not specified.

# Welding consumables — Solid wire electrodes, solid wires and rods for fusion welding of magnesium and magnesium alloys — Classification

## 1 Scope

This International Standard specifies requirements for the classification of solid wire electrodes, solid wires and rods for fusion welding of magnesium and magnesium alloys. The classification is based on their chemical composition.

The compositions of solid wire electrodes for metal inert gas (MIG) welding are the same as solid wire electrodes, solid wires and rods for tungsten inert gas (TIG) arc welding, plasma arc welding, laser beam welding, laser-MIG hybrid welding and other fusion welding processes.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 544, *Welding consumables — Technical delivery conditions for filler materials and fluxes — Type of product, dimensions, tolerances and markings*

ISO 14344, *Welding consumables — Procurement of filler materials and fluxes*

ISO 80000-1:2009, *Quantities and units — Part 1: General*. Corrected by ISO 80000-1:2009/Cor 1:2011

## 3 Classification

The classification is divided into two parts as follows:

a) the first part gives a symbol indicating the product to be identified (see 4.1);

b) the second part gives a symbol indicating the chemical composition of the solid wire electrodes, solid wires and rods (see Table 1).

## 4 Symbols and requirements

### 4.1 Symbol for the product

The symbol for the solid wire electrodes, solid wires and rods shall be S.

### 4.2 Symbol for the chemical composition

The numerical symbols in Table 1 indicate the chemical composition of a solid wire or rod, determined under the conditions given in Clause 6. The first two digits indicate the alloy group. See Annex A for an explanation of the numerical symbols.

The optional additional chemical symbols in Table 1 indicate the chemical composition and include an indication of the characteristic alloying elements.

## 5 Mechanical properties

Mechanical properties of all-weld metal or welded joints are not part of this classification.

## 6 Chemical analysis

Chemical analysis shall be performed on specimens of the product or the stock from which it is made. Any analytical technique may be used but, in cases of dispute, reference shall be made to established published methods.

## 7 Rounding procedure

For purposes of determining compliance with the requirements of this International Standard, the actual test values obtained shall be subject to ISO 80000-1:2009, B.3, Rule A. If the measured values are obtained by equipment calibrated in units other than those of this International Standard, the measured values shall be converted to the units of this International Standard before rounding. If an arithmetic average value is to be compared with the requirements of this International Standard, rounding shall be done only after calculating the arithmetic average. The rounded results shall fulfil the requirements of the appropriate table for the classification under test.

## 8 Retest

If any test fails to meet the requirement, that test shall be repeated twice. The results of both retests shall meet the requirement. Specimens for the retest may be taken from the original test sample or from a new test sample. For chemical analysis, retests need be only for those specific elements that failed to meet their test requirement. If the results of one or both retests fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this specification for that classification. In the event that, during preparation or after completion of any test, it is clearly determined that prescribed or proper procedures were not followed in preparing the weld test sample or test specimen(s), or in conducting the tests, the test shall be considered invalid, without regard to whether the test was actually completed, or whether the test results met, or failed to meet, the requirement. That test shall be repeated, following proper prescribed procedures. In this case, the requirement for doubling the number of test specimens does not apply.

## 9 Technical delivery conditions

Technical delivery conditions shall meet the requirements of ISO 544 and ISO 14344 (but when Schedule 4 is specified, only chemical composition is required).

## Table 1 — Chemical composition requirements

| Alloy symbols | | Chemical composition, % (by mass)[a] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Numerical** | **Chemical** | **Mg** | **Al** | **Zn** | **Mn** | **Si** | **Cu** | **Ni** | **Fe** | **Ca** | **Be** | **Others[b]** |
| Mg 0602A | MgAl6Mn | bal. | 5,5 to 6,5 | 0,30 | 0,24 to 0,6 | 0,10 | 0,01 | 0,002 | 0,005 | — | — | 0,30 |
| Mg 0602B | MgAl6Ca2Mn | bal. | 5,6 to 6,4 | 0,20 | 0,26 to 0,50 | 0,08 | 0,008 | 0,001 | 0,004 | 1,5 to 2,5 | — | 0,01 |
| Mg 1101 | MgAl10Zn1Mn | bal. | 9,5 to 10,5 | 0,75 to 1,25 | 0,15 to 0,5 | 0,05 | 0,05 | 0,005 | 0,005 | — | 0,0002 to 0,0008 | 0,30 |
| Mg 1313 | MgAl3Zn1Mn | bal. | 2,4 to 3,6 | 0,50 to 1,50 | 0,15 to 1,00 | 0,10 | 0,05 | 0,005 | 0,005 | 0,04 | — | 0,30 |
| Mg 1313A | MgAl3Zn1Ca1Mn | bal. | 2,4 to 3,6 | 0,50 to 1,50 | 0,15 to 1,00 | 0,10 | 0,05 | 0,005 | 0,005 | 0,5 to 1,5 | — | 0,05 |
| Mg 1611 | MgAl7Zn1Mn | bal. | 5,8 to 7,2 | 0,40 to 1,5 | 0,15 to 0,5 | 0,05 | 0,05 | 0,005 | 0,005 | — | 0,0002 to 0,0008 | 0,30 |
| Mg 1611A | MgAl6Zn1 | bal. | 5,5 to 6,5 | 0,50 to 1,50 | 0,15 to 0,40 | 0,10 | 0,05 | 0,005 | 0,005 | — | — | 0,30 |
| Mg 1611B | MgAl6Zn1Ca2 | bal. | 5,5 to 6,5 | 0,50 to 1,50 | 0,05 to 0,40 | 0,08 | 0,025 | 0,001 | 0,004 | 1,5 to 2,5 | — | 0,01 |
| Mg 1611C | MgAl6Zn1Ca1 | bal. | 5,5 to 6,5 | 0,50 to 1,50 | 0,15 to 0,40 | 0,10 | 0,05 | 0,005 | 0,005 | 0,5 to 1,5 | — | 0,05 |
| Mg 1911A | MgAl9Zn1 | bal. | 8,3 to 9,7 | 0,35 to 1,0 | 0,15 to 0,50 | 0,10 | 0,03 | 0,002 | 0,005 | — | — | 0,30 |
| Mg 1911B | MgAl9Zn1Ca1 | bal. | 8,3 to 9,7 | 0,35 to 1,0 | 0,15 to 0,50 | 0,10 | 0,03 | 0,002 | 0,005 | 0,5 to 1,5 | — | 0,30 |
| Mg 1911C | MgAl9Zn1Ca2 | bal. | 8,3 to 9,7 | 0,35 to 1,0 | 0,15 to 0,50 | 0,10 | 0,03 | 0,002 | 0,005 | 1,5 to 2,5 | — | 0,30 |
| Mg 1922 | MgAl9Zn2Mn | bal. | 8,3 to 9,7 | 1,7 to 2,3 | 0,15 to 0,5 | 0,05 | 0,05 | 0,005 | 0,005 | — | 0,0002 to 0,0008 | 0,30 |
| Mg 2331[c] | MgRE3Zn3Zr | bal. | — | 2,0 to 3,1 | — | — | — | — | — | — | 0,0008 | 0,30 |
| Z[d] | | Any other agreed composition | | | | | | | | | | |

[a] Single values are maxima, unless otherwise noted.

[b] Need not be reported unless specifically required by purchaser.

[c] Zr 0,45 % to 1,0 %, rare earths (RE) 2,5 % to 4,0 %.

[d] Consumables for which the chemical composition is not listed in this table shall be symbolized similarly and prefixed by the letter Z. The chemical composition ranges are not specified and therefore it is possible that two electrodes with the same Z classification are not interchangeable.

## 10 Designation

The designation of solid wire electrodes, solid wires and rods shall follow the principles given in the examples below.

EXAMPLE 1

A solid wire (S) for fusion welding that has a chemical composition within the limits for the alloy symbol Mg 0602A (MgAl6Mn) of Table 1, is designated:

**ISO 19288 - S Mg 0602A**

or alternatively:

**ISO 19288 - S Mg 0602A (MgAl6Mn)**

where

| | |
|---|---|
| ISO 19288 | is the number of this International Standard; |
| S | is the product form (see 4.1); |
| Mg 0602A | is the chemical composition of welding consumable (see Table 1); |
| MgAl6Mn | is the optional chemical symbol for chemical composition Mg 0602A (see Table 1). |

EXAMPLE 2

A solid wire (S) for fusion welding with a chemical composition Al10 Be0,005 base magnesium that is not listed in Table 1, is designated:

**ISO 19288 - S Mg Z (MgAl10Be0,005)**

where

| | |
|---|---|
| ISO 19288 | is the number of this International Standard; |
| S | is the product form (see 4.1); |
| Mg Z | is the chemical composition as agreed between manufacturer and customer (Magnesium with 10 % Aluminium and Beryllium 0,005 %). |

# Annex A
(informative)

# Explanation of classification symbols for chemical composition

**Mg 1611**

This alloy contains nominally 6,5 % Al, 0,3 % Mn, 1 % Zn and a small amount of Be. It can be used to weld base metals of similar composition and AZ61A / UNS M11610. Mg 1611 is generally preferred for welding wrought base metals of those alloys because of lower cracking tendencies.

**Mg 1922**

This alloy contains nominally 9 % Al, 0,3 % Mn, 2 % Zn and a small amount of Be. It can be used to weld base metals of similar composition. However, welds made in cast Mg-Al-Zn and AM100A / UNS M10100 base metals with Mg 1922 filler metal show less crack sensitivity. The weld metal will respond to the precipitation heat treatments normally applied to repaired castings.

**Mg 1101**

This alloy contains nominally 10 % Al, 0,3 % Mn, 1 % Zn and a small amount of Be. It can also be used to weld the cast base metals described for AZ92A / UNS M11920.

**Mg 2331**

This alloy contains nominally no Al or Mn, 2,5 % Zn, 0,75 % Zr, 3,2 % Rare Earths and a small amount of Be. It is used to weld wrought iron and cast base metals designed for elevated temperature service such as UNS M12330; however, this alloy should not be used for welding aluminium-bearing magnesium alloys because of severe cracking problems.

**Mg 1313, Mg 1611A, Mg 1911A**

Consumables of these classifications are used for welding Magnesium-Aluminum-Zinc alloys, e.g.

— MgAl3Zn1 / / UNS M11311, UNS M11312 and UNS M11313,

— MgAl6Zn1 / UNS M11610 and UNS M11611, and

— MgAl9Zn1 / UNS M11910, UNS M11911, UNS M11912, UNS M11913, UNS M11914, UNS M11915, UNS M11916, UNS M11917, UNS M11918 and UNS M11919.

These alloys are used for electrodes and printed circuit boards. The aluminium content contributes to increase their strength.

**Mg 0602A**

Consumables of this classification are used for welding Magnesium-Aluminum-Manganese alloys, e.g. MgAl6Mn / UNS M10600, UNS M10602 and UNS M10603. This alloy provides improved corrosion resistance over MgAl6Zn1 / UNS M11610 and UNS M11611.

**Mg 1313A, Mg 1611B, Mg 1611C, Mg 1911B, Mg 1911C**

Consumables of these classifications are used for welding Magnesium-Aluminum-Zinc-Calcium alloys, e.g.

— MgAl3Zn1Ca1Mn / UNS M11311, UNS M11312 and UNS M11313,

— MgAl6Zn1Ca2,

— MgAl6Zn1Ca1 / UNS M11610 and UNS M11611,

— MgAl9Zn1Ca1 / UNS M11910, UNS M11911, UNS M11912, UNS M11913, UNS M11914, UNS M11915, UNS M11916, UNS M11917, UNS M11918 and UNS M11919, and

— MgAl9Zn1Ca2.

These alloys provide increased ignition temperature over MgAl3Zn1, MgAl6Zn1, MgAl9Zn1, respectively. Alloys containing 2 % Ca have superior resistance to flammability compared to alloys containing 1 % Ca but have lower comparative plastic formability.

**Mg 0602B**

Consumables of this classification are used for welding Magnesium-Aluminum-Manganese-Calcium alloys (e.g. MgAl6MnCa2). This alloy has improved resistance to flammability of MgAl6Mn.

Mg alloys containing Ca have ignition temperatures greater than 700 °C.

**ICS 25.160.20**

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