INTERNATIONAL STANDARD

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Aluminium and aluminium alloys — Castings — Chemical composition and mechanical properties

Aluminium et alliages d'aluminium — Pièces moulées — Composition chimique et caractéristiques mécaniques

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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 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 3522 was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys*, Subcommittee SC 7, *Aluminium and cast aluminium alloys*.

This fourth edition cancels and replaces the third edition (ISO 3522:2006), of which Table 1 has been technically revised concerning the chemical composition of AlSi9Cu3(Fe).

Aluminium and aluminium alloys — Castings — Chemical composition and mechanical properties

1 Scope

This International Standard specifies the chemical composition limits for aluminium casting alloys and mechanical properties of separately cast test bars for these alloys.

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 2378, *Aluminium alloy chill castings — Reference test bar*

ISO 2379, *Aluminium alloy sand castings — Reference test bar*

ISO 6506-1:2005, *Metallic materials — Brinell hardness test — Part 1: Test method*

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

3 Terms and definitions

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

3.1
casting
general term for products at or near their finished shape, formed by solidification of a metal or alloy in a mould

3.2
sand casting
casting formed in a sand mould

3.3
permanent-mould casting
chill casting
casting formed in a metal mould, the molten metal being introduced by gravity and solidification under atmospheric pressure

3.4
low pressure die-casting
process in which molten metal is injected into a permanent metal mould and solidified under low pressure (typically 0,7 bar above atmospheric pressure)

3.5
pressure die-casting
die-casting
casting formed in a metal mould, the molten metal being introduced under high pressure

3.6
investment casting (lost wax)
two-step process comprising fabrication of a ceramic mould around a wax or thermoplastic pattern, which is lost during this process, and pouring of metal into this mould

3.7
fluidity
ability of an alloy to make thin wall castings and reproduce fine detail

3.8
hot tearing
tendency for a crack to form in a casting due to the development of internal stress during solidification

3.9
pressure tightness
tendancy not to leak during pressure testing

3.10
impurities
metallic or non-metallic element present, but not intentionally added to a metal, and the minimum content of which is not controlled

4 Designation

4.1 Alloy designation

The alloy designation shall be in accordance with Annex A.

4.2 Temper designations

The following abbreviations shall be used for the conditions of heat-treatment, referred to in Tables 2, 3, 4 and B.1:

F as cast;

O annealed;

T1 controlled cooling from casting and naturally aged;

T4 solution heat-treated and naturally aged, where applicable;

T5 controlled cooling from casting and artificially aged or over-aged;

T6 solution heat-treated and fully artificially aged;

T64 solution heat-treated and artificially under-aged;

T7 solution heat-treated and artificially over-aged (stabilized).

NOTE For aluminium casting alloys, solution heat-treatment involves quenching from elevated temperatures and distortion may occur.

4.3 Casting processes

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

S sand casting;

K chill or permanent mould casting;

D pressure die-casting;

L investment casting.

4.4 Product designation

The designation shall appear on the drawings.

An example of full standard, material designation, casting process and temper is:

ISO AC-AlSi7Mg-K-T6, which indicates aluminium casting alloy AC-AlSi7Mg chill cast, solution heat-treated and fully artificially aged.

5 Chemical composition

5.1 General

Chemical composition shall be expressed in accordance with the writing rules given in Annex A. The chemical composition of the casting is specified in Table 1.

When specified, analysis of elements for which specific limits are given in Table 1 shall be carried out. Analysis for other elements shall be carried out only when agreed between the manufacturer and purchaser. This particularly applies to modifying or refining elements such as sodium, strontium, antimony and phosphorus. Alloying elements, impurities and aluminium shall be expressed in the following sequence: silicon, iron, copper, manganese, magnesium, chromium, nickel, zinc, titanium, total of other elements, aluminium.

Additional specified elements with specific limits shall be inserted, in alphabetical order, with respect to their chemical symbols between zinc and titanium, or are specified in footnotes, and that order shall include lead and tin.

5.2 Samples for chemical analysis of castings

When samples are required to determine the chemical analysis of castings by emission spectrometry, they shall be taken from the melt at the time the castings are made and shall be cast into a metallic die.

If analysis by emission spectrometry is to be carried out on a casting, it is recommended that a part of the casting is remelted and cast into a metallic die to avoid the effects of segregation. The level of certain elements, such as sodium, strontium and magnesium, may be reduced by remelting, and analysis for such elements should be made directly on the casting.

For sampling and analysis, the use of existing rules or standards is recommended.

6 Mechanical properties

6.1 General

The minimum mechanical properties for separately cast test pieces for sand cast, chill cast, investment-cast and pressure die-cast conditions shall be in accordance with Tables 2, 3, 4 and B.1.

For each alloy, mechanical properties are only specified for the commonly used methods of casting and for commonly used tempers. For other processes and tempers, characteristics shall be agreed between the manufacturer and purchaser.

NOTE The mechanical properties of pressure die-castings are very dependent on injection parameters, and the properties in Table B.1 are for guidance only.

6.2 Test pieces

6.2.1 Separately cast test bars

6.2.1.1 General

When tensile tests are required on separately cast test bars then the test bars shall be cast at the same time and from the same melt or melts as the castings. When applicable, they shall be heat-treated with the castings.

6.2.1.2 Sand-cast test bars

The sand-cast test bars shall be in accordance with ISO 2379, or an equivalent published standard.

The sand-cast pieces shall be cast in sand moulds without artificial chilling, using the same sand system as used for the castings.

6.2.1.3 Chill-cast test pieces

The following conditions shall apply to chill-cast pieces:

a) they shall be cast into metallic moulds;

b) the as-cast diameter shall be a minimum of 12,0 mm;

c) the gauge length and parallel length shall conform to ISO 2378, or an equivalent published standard.

NOTE Test pieces may be tested in the machined or unmachined condition.

6.2.1.4 Investment-cast test pieces

The following conditions shall apply to investment-cast test pieces:

a) they shall be cast entirely in a ceramic mould without artificial chilling;

b) as cast diameter shall be a minimum of 5,0 mm;

c) the gauge length and parallel length shall conform to ISO 2378, or an equivalent published standard.

NOTE Test pieces may be tested in the machined or unmachined condition.

6.2.1.5 Pressure die-cast test bars

Pressure die-cast test bars are not normally produced. The values given in Table B.1 are for guidance only. These are not typical values but are the minimum values that may be expected from separately pressure die-cast test pieces of 20,0 mm^2 cross-sectional area with a minimum thickness of 2,0 mm.

6.2.2 Test pieces taken from castings

6.2.2.1 If test pieces are taken from castings then their geometry, location, test frequency and relevant values shall be agreed between the manufacturer and purchaser.

NOTE Separately cast test pieces have a valuable function as a check on melt quality. However, the values obtained from castings can differ from the minimum ultimate tensile strength, yield strength and elongation values specified in the tables, because of variations in structure arising from differences in section thickness and soundness (see 6.2.1.1).

6.2.2.2 For circular test pieces, the minimum diameter shall be 4,0 mm.

NOTE This does not apply to pressure die-castings.

6.3 Tensile tests

Tensile tests shall be carried out in accordance with ISO 6892, or an equivalent published standard.

6.4 Retests

6.4.1 Need for retest

Retests shall be carried out if a test is not valid (see 6.4.2).

Retests are permitted to be carried out if a test result does not meet the mechanical property requirements for the specified grade (see 6.4.3).

6.4.2 Test validity

A test is not valid if there is:

a) a faulty mounting of the test piece or defective operation of the test machine;

b) a defective test piece because of incorrect pouring or incorrect machining;

c) a fracture of the tensile test piece outside the gauge length;

d) a casting defect in the test piece, evident after fracture.

In the above cases, a new test piece shall be taken from the same sample or from a duplicate sample cast at the same time. The result of the retest shall be substituted for the result of the invalid test.

6.4.3 Non-conforming test result

If any test gives results which do not conform to the specified requirements, for reasons other than those given in 6.4.2, the manufacturer shall have the option to conduct retests. If the manufacturer conducts retests, two retests shall be carried out for each failed test.

If the results of both retests meet the specified requirements, the material shall be regarded as conforming to this International Standard.

If the results of one or both retests fail to meet the specified requirements, the material shall be regarded as not conforming to this International Standard.

6.4.4 Re-heat-treatment of samples and castings

In the case of castings which have undergone a heat-treatment and for which the test results are not satisfactory, the manufacturer shall be permitted to re-heat-treat the castings and the representative samples. In this event, the samples shall receive the same number of heat-treatments as the castings. If the results of the tests carried out on the test pieces machined from the re-heat-treated samples are satisfactory, then the re-heat-treated castings shall be regarded as conforming to this International Standard.

The number of re-heat-treatment cycles shall not exceed two.

6.5 Hardness tests

Hardness tests shall be carried out in accordance with ISO 6506-1, or an equivalent published standard on porosity free areas of castings, or on the portion of a broken test piece which has not been stressed.

7 Rounding rules for determination of compliance

In recording the results of chemical analysis or mechanical properties, 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 following rounding rules shall be used for determination of compliance with this International Standard:

a) when the figure immediately after the last figure to be retained is less than 5, the last figure to be retained remains unchanged;

b) when the figure immediately after the last figure to be retained is greater than 5, or equal to 5 and followed by at least one figure other than zero, the last figure to be retained is increased by one;

c) when the figure immediately after the last figure to be retained is equal to 5 and followed by zeros only, the last figure to be retained remains unchanged if even, and is increased by one if odd.

Table 1 — Chemical compositions of casting alloys

Alloy group	Chemical symbols	Chemical composition, % (mass fraction)													
		Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Pb	Sn	Ti	Others [a] Each	Others [a] Total	Aluminium
Al	Al 99,7	0,10	0,20	0,01	0,05	0,02	0,004	—	0,04	—	—	—	0,03	—	Al ⩾ 99,7
	Al 99,5	0,15	0,30	0,02	0,03	0,005	—	—	0,05	—	—	0,02	0,03	—	Al ⩾ 99,5
AlCu	Al Cu4Ti	0,18 (0,15)	0,19 (0,15)	4,2 to 5,2	0,55	—	—	—	0,07	—	—	0,15 to 0,30 (0,15 to 0,25)	0,03	0,10	Remainder
	Al Cu4MgTi	0,20 (0,15)	0,35 (0,30)	4,2 to 5,0	0,10	0,15 to 0,35 (0,20 to 0,35)	—	0,05	0,10	0,05	0,05	0,15 to 0,30 (0,15 to 0,25)	0,03	0,10	Remainder
	Al Cu5MgAg [b]	0,05	0,10	4,0 to 5,0	0,20 to 0,40	0,15 to 0,35 (0,20 to 0,35)	—	—	0,05	—	—	0,15 to 0,35	0,03	0,10	Remainder
AlSi	Al Si9	8,0 to 11,0	0,65 (0,55)	0,10 (0,08)	0,50	0,10	—	0,05	0,15	0,05	0,05	0,15	0,05	0,15	Remainder
	Al Si11	10,0 to 11,8	0,19 (0,15)	0,05 (0,03)	0,10	0,45	—	—	0,07	—	—	0,15	0,03	0,10	Remainder
	Al Si12(a)	10,5 to 13,5	0,55 (0,40)	0,05 (0,03)	0,35	—	—	—	0,10	—	—	0,15	0,05	0,15	Remainder
	Al Si12(b)	10,5 to 13,5	0,65 (0,55)	0,15 (0,10)	0,55	0,10	—	0,10	0,15	0,10	—	0,20 (0,15)	0,05	0,15	Remainder
	Al Si12(Fe)	10,5 to 13,5	1,0 (0,45 to 0,90)	0,10 (0,08)	0,55	—	—	—	0,15	—	—	0,15	0,05	0,25	Remainder
AlSiMgTi	Al Si2MgTi	1,6 to 2,4	0,60 (0,50)	0,10 (0,08)	0,30 to 0,50	0,45 to 0,65 (0,50 to 0,65)	—	0,05	0,10	0,05	0,05	0,05 to 0,20 (0,07 to 0,15)	0,05	0,15	Remainder
AlSi7Mg	Al Si7Mg	6,5 to 7,5	0,55 (0,45)	0,20 (0,15)	0,35	0,20 to 0,65 (0,25 to 0,65)	—	0,15	0,15	0,15	0,05	0,05 to 0,25 (0,05 to 0,20)	0,05	0,15	Remainder
	Al Si7Mg0,3	6,5 to 7,5	0,19 (0,15)	0,05 (0,03)	0,10	0,25 to 0,45 (0,30 to 0,45)	—	—	0,07	—	—	0,08 to 0,25 (0,10 to 0,18)	0,03	0,10	Remainder
	Al Si7Mg0,6	6,5 to 7,5	0,19 (0,15)	0,05 (0,03)	0,10	0,45 to 0,70 (0,50 to 0,70)	—	—	0,07	—	—	0,08 to 0,25 (0,10 to 0,18)	0,03	0,10	Remainder