PS ISO 3522:2011
ICS NO. 77.150.10

PAKISTAN STANDARD FOR:

Aluminum and aluminum alloys – castings – chemical composition and mechanical properties

(IDT: ISO 3522:2007)

0. FOREWORD

01. International Standards are widely adopted at the regional or national level and applied by manufacturers, trade organizations, purchasers, consumers, testing laboratories, authorities and other interested parties. Since these standards generally reflect the best experience of industry, researchers, consumers and regulators worldwide, and cover common needs in a variety of countries, they constitute one of the important bases for the removal of technical barriers to trade. This has been explicitly acknowledged in the Agreement on Technical Barriers to Trade of the World Trade Organization (WTO TBT Agreement).

02. PSQCA being the National Standards Body of Islamic Republic of Pakistan is also signatory of TBT/WTO agreement and has re-aligned its Standard Development activities to meet the opportunities as well as challenges of globalization.

03. To keep pace with the work of ISO member bodies, preparation of Pakistan Standard is also carried out through Technical Committees. The existing version of ISO is adopted after draft prepared by Technical Committee responsible for this document i.e. PSQCA/ SDC- Mechanical Technical Committee "Metal Alloys and Testing" (MTC-05) by taking into consideration, the views and the suggestions of the manufacturers, specialists, technologists and utilizing agencies, well in line with the technical barriers to trade agreement (WTO/TBT) which is duly approved and endorsed by the Mechanical National Standard Committee meeting held on 26.01.2011.

04. This Pakistan Standard No. PS- ISO. 3522:_____is identical to ISO 3522:2007 for "Aluminum and aluminum alloys – castings – chemical composition and mechanical properties" which is acknowledged with thanks.

05. This Standard is subject to periodical review in order to keep pace with development in technology. Any suggestion for improvement will be recorded and placed before the revising committee in due course.

INTERNATIONAL STANDARD

ISO 3522

Fourth edition
2007-10-15

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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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

Table 1 (*continued*)

Alloy group	Chemical symbols	Chemical composition, % (mass fraction)												
		Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Pb	Sn	Ti	Others [a]	Aluminium
													Each / Total	
AlSi10Mg	Al Si9Mg	9,0 to 10,0	0,19 (0,15)	0,05 (0,03)	0,10	0,25 to 0,45 (0,30 to 0,45)	—	—	0,07	—	—	0,15	0,03 / 0,10	Remainder
	Al Si10Mg	9,0 to 11,0	0,55 (0,45)	0,10 (0,08)	0,45	0,20 to 0,45 (0,25 to 0,45)	—	0,05	0,10	0,05	0,05	0,15	0,05 / 0,15	Remainder
	Al Si10Mg(Fe)	9,0 to 11,0	1,0 (0,45 to 0,9)	0,10 (0,08)	0,55	0,20 to 0,50 (0,25 to 0,50)	—	0,15	0,15	0,15	0,05	0,20 (0,15)	0,05 / 0,15	Remainder
	Al Si10Mg(Cu)	9,0 to 11,0	0,65 (0,55)	0,35 (0,30)	0,55	0,20 to 0,45 (0,25 to 0,45)	—	0,15	0,35	0,10	—	0,20 (0,15)	0,05 / 0,15	Remainder
AlSi5Cu	Al Si5Cu1Mg	4,5 to 5,5	0,65 (0,55)	1,0 to 1,5	0,55	0,35 to 0,65 (0,40 to 0,65)	—	0,25	0,15	0,15	0,05	0,05 to 0,25 (0,05 to 0,20)	0,05 / 0,15	Remainder
	Al Si5Cu3	4,5 to 6,0	0,60 (0,50)	2,6 to 3,6	0,55	0,05	—	0,10	0,20	0,10	0,05	0,25 (0,20)	0,05 / 0,15	Remainder
	Al Si5Cu3Mg	4,5 to 6,0	0,60 (0,50)	2,6 to 3,6	0,55	0,15 to 0,45 (0,20 to 0,45)	—	0,10	0,20	0,10	0,05	0,25 (0,20)	0,05 / 0,15	Remainder
	Al Si5Cu3Mn	4,5 to 6,0	0,8 (0,7)	2,5 to 4,0	0,20 to 0,55	0,40	—	0,30	0,55	0,20	0,10	0,20 (0,15)	0,05 / 0,25	Remainder
	Al Si6Cu4	5,0 to 7,0	1,0 (0,9)	3,0 to 5,0	0,20 to 0,65	0,55	0,15	0,45	2,0	0,30	0,15	0,25 (0,20)	0,05 / 0,35	Remainder
AlSi9Cu	Al Si7Cu2	6,0 to 8,0	0,8 (0,7)	1,5 to 2,5	0,15 to 0,65	0,35	—	0,35	1,0	0,25	0,15	0,25 (0,20)	0,05 / 0,15	Remainder
	Al Si7Cu3Mg	6,5 to 8,0	0,8 (0,7)	3,0 to 4,0	0,20 to 0,65	0,30 to 0,60 (0,35 to 0,60)	—	0,30	0,65	0,15	0,10	0,25 (0,20)	0,05 / 0,25	Remainder
	Al Si8Cu3	7,5 to 9,5	0,8 (0,7)	2,0 to 3,5	0,15 to 0,65	0,05 to 0,55 (0,15 to 0,55)	—	0,35	1,2	0,25	0,15	0,25 (0,20)	0,05 / 0,25	Remainder
	Al Si9Cu1Mg	8,3 to 9,7	0,8 (0,7)	0,8 to 1,3	0,15 to 0,55	0,25 to 0,65 (0,30 to 0,65)	—	0,20	0,8	0,10	0,10	0,10 to 0,20 (0,10 to 0,18)	0,05 / 0,25	Remainder

Table 1 (*continued*)

Alloy group	Chemical symbols	Chemical composition, % (mass fraction)													
		Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Pb	Sn	Ti	Others [a]		Aluminium
													Each	Total	
AlSi9Cu	Al Si9Cu3(Fe)	8,0 to 11,0	1,3 (0,6 to 1,2)	2,0 to 4,0	0,20 to 0,55	0,05 to 0,55 (0,15 to 0,55)	0,15	0,5	1,2	0,35	0,25	0,25 (0,20)	0,05	0,25	Remainder
	Al Si9Cu3(Fe)(Zn)	8,0 to 11,0	1,3 (0,6 to 1,2)	2,0 to 4,0	0,55	0,05 to 0,55 (0,15 to 0,55)	0,15	0,55	3,0	0,35	0,25	0,25 (0,20)	0,05	0,25	Remainder
	Al Si11Cu2(Fe)	10,0 to 12,0	1,1 (0,45 to 1,0)	1,5 to 2,5	0,55	0,30	0,15	0,45	1,7	0,25	0,25	0,25 (0,20)	0,05	0,25	Remainder
	Al Si11Cu3(Fe)	9,6 to 12,0	1,3	1,5 to 3,5	0,60	0,35	—	0,45	1,7	0,25	0,25	0,25	—	—	Remainder
AlSi12Cu	Al Si12(Cu)	10,5 to 13,5	0,8 (0,7)	1,0 (0,9)	0,05 to 0,55	0,35	0,10	0,30	0,55	0,20	0,10	0,20 (0,15)	0,05	0,25	Remainder
	Al Si12Cu1(Fe)	10,5 to 13,5	1,3 (0,6 to 1,2)	0,7 to 1,2	0,55	0,35	0,10	0,30	0,55	0,20	0,10	0,20 (0,15)	0,05	0,25	Remainder
	Al Si12CuMgNi	10,5 to 13,5	0,7 (0,6)	0,8 to 1,5	0,35	0,8 to 1,5 (0,9 to 1,5)	—	0,7 to 1,3	0,35	—	—	0,25 (0,20)	0,05	0,15	Remainder
AlSi17Cu	Al Si17Cu4Mg	16,0 to 18,0	1,3 (1,0)	4,0 to 5,0	0,50	0,45 to 0,65	—	0,3	1,5	—	0,3	—	—	—	Remainder

Table 1 (*continued*)

Alloy group	Chemical symbols	Chemical composition, % (mass fraction)												
		Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Pb	Sn	Ti	Others [a]	Aluminium
													Each / Total	
AlMg	Al Mg3	0,55 (0,45)	0,55 (0,45)	0,10 (0,08)	0,45	2,5 to 3,5 (2,7 to 3,5)	—	—	0,10	—	—	0,20 (0,15)	0,05 / 0,15	Remainder
	Al Mg5	0,55 (0,45)	0,55 (0,45)	0,10 (0,05)	0,45	4,5 to 6,5 (4,8 to 6,5)	—	—	0,10	—	—	0,20 (0,15)	0,05 / 0,15	Remainder
	Al Mg5(Si)	1,5 (1,3)	0,55 (0,45)	0,05 (0,03)	0,45	4,5 to 6,5 (4,8 to 6,5)	—	—	0,10	—	—	0,20 (0,15)	0,05 / 0,15	Remainder
	Al Mg9	2,5	1,0 (0,5 to 0,9)	0,10 (0,08)	0,55	8,0 to 10,5 (8,5 to 10,5)	—	0,10	0,25	0,10	0,10	0,20 (0,15)	0,05 / 0,15	Remainder
AlZnMg	Al Zn5Mg	0,30 (0,25)	0,80 (0,70)	0,15 to 0,35	0,40	0,40 to 0,70 (0,45 to 0,70)	0,15 to 0,60	0,05	4,50 to 6,00	0,05	0,05	0,10 to 0,25 (0,12 to 0,20)	0,05 / 0,15	Remainder
AlZnSiMg	Al Zn10Si8Mg	7,5 to 9,0 (7,7 to 8,3)	0,30 (0,27)	0,10 (0,08)	0,15 (0,10)	0,2 to 0,4 (0,25 to 0,4)	—	—	9,0 to 10,5	—	—	0,15	0,05 / 0,15	Remainder

NOTE 1 Figures in brackets are ingot compositions where they differ from the castings.

NOTE 2 Limits are expressed as a maximum, unless shown as a range.

[a] "Others" does not include modifying or refining elements such as Na, Sr, Sb and P.

[b] Ag = 0,4 to 1,0.

Table 2 — Mechanical properties of sand-cast alloys for separately cast test pieces

Alloy group	Alloy designation	Temper designation	Tensile strength R_m MPa min.	Proof stress $R_{p0,2}$ MPa min.	Elongation A [a] % min.	Brinell hardness HBW min.
AlCu	Al Cu4Ti	T6	300	200	3	95
		T64	280	180	5	85
	Al Cu4MgTi	T4	300	200	5	90
	Al Cu5MgAg	T6	480	430	3	115
AlSi	Al Si11	F	150	70	6	45
	Al Si12(a)	F	150	70	5	50
	Al Si12(b)	F	150	70	4	50
AlSiMgTi	Al Si2MgTi	F	140	70	3	50
		T6	240	180	3	85
AlSi7Mg	Al Si7Mg	F	140	80	2	50
		T6	220	180	1	75
	Al Si7Mg0,3	T6	230	190	2	75
	Al Si7Mg0,6	T6	250	210	1	85
AlSi10Mg	Al Si9Mg	T6	230	190	2	75
	Al Si10Mg	F	150	80	2	50
		T6	220	180	1	75
	Al Si10Mg(Cu)	F	160	80	1	50
		T6	220	180	1	75
AlSi5Cu	Al Si5Cu1Mg	T4	170	120	2	80
		T6	230	200	*a* [b]	100
	Al Si5Cu3Mn	F	140	70	1	60
		T6	230	200	*a* [b]	90
	Al Si6Cu4	F	150	90	1	60
AlSi9Cu	Al Si7Cu2	F	150	90	1	60
	Al Si8Cu3	F	150	90	1	60
	Al Si9Cu1Mg	F	135	90	1	60
AlSi12Cu	Al Si12(Cu)	F	150	80	1	50
AlMg	Al Mg3	F	140	70	3	50
	Al Mg5	F	160	90	3	55
	Al Mg5(Si)	F	160	100	3	60
AlZnMg	Al Zn5Mg	T1	190	120	4	60
AlZnSiMg	Al Zn10Si8Mg	T1	220	200	1	90

1 N/mm² = 1 MPa.

[a] The gauge length is defined in ISO 2379, or an equivalent published standard.

[b] *a* means elongation less than 1 % that cannot be measured with sufficient accuracy.

Table 3 — Mechanical properties of chill cast alloys for separately cast test pieces

Alloy group	Alloy designation	Temper designation	Tensile strength R_m MPa min.	Proof stress $R_{p0,2}$ MPa min.	Elongation A [a] % min.	Brinell hardness HBW min.
AlCu	Al Cu4Ti	T6	330	220	7	95
		T64	320	180	8	90
	Al Cu4MgTi	T4	320	200	8	95
	Al Cu5MgAg	T6	480	430	3	115
AlSi	Al Si11	F	170	80	7	45
	Al Si12(a)	F	170	80	6	55
	Al Si12(b)	F	170	80	5	55
AlSiMgTi	Al Si2MgTi	F	170	70	5	50
		T6	260	180	5	85
AlSi7Mg	Al Si7Mg	F	170	90	2,5	55
		T6	260	220	1	90
		T64	240	200	2	80
	Al Si7Mg0,3	T6	290	210	4	90
		T64	250	180	8	80
	Al Si7Mg0,6	T6	320	240	3	100
		T64	290	210	6	90
AlSi10Mg	Al Si9Mg	T6	290	210	4	90
		T64	250	180	6	80
	Al Si10Mg	F	180	90	2,5	55
		T6	260	220	1	90
		T64	240	200	2	80
	Al Si10Mg(Cu)	F	180	90	1	55
		T6	240	200	1	80
AlSi5Cu	Al Si5Cu1Mg	T4	230	140	3	85
		T6	280	210	*a* [b]	110
	Al Si5Cu3	T4	230	110	6	75
	Al Si5Cu3Mg	T4	270	180	2,5	85
		T6	320	280	*a* [b]	110
	Al Si5Cu3Mn	F	160	80	1	70
		T6	280	230	*a* [b]	90
	Al Si6Cu4	F	170	100	1	75
AlSi9Cu	Al Si7Cu2	F	170	100	1	75
	Al Si7Cu3Mg	F	180	100	1	80
	Al Si8Cu3	F	170	100	1	75
	Al Si9Cu1Mg	F	170	100	1	75
		T6	275	235	1,5	105
AlSi12Cu	Al Si12(Cu)	F	170	90	2	55
	Al Si12CuMgNi	T5	200	185	*a* [b]	90
		T6	280	240	*a* [b]	100
AlMg	Al Mg3	F	150	70	5	50
	Al Mg5	F	180	100	4	60
	Al Mg5(Si)	F	180	110	3	65
AlZnMg	Al Zn5Mg	T1	210	130	4	65
AlZnSiMg	Al Zn10Si8Mg	T1	280	210	2	105

1 N/mm^2 = 1 MPa.

[a] The gauge length is defined in ISO 2379, or an equivalent published standard.

[b] *a* means elongation less than 1 % that cannot be measured with sufficient accuracy.

Table 4 — Mechanical properties of investment-cast alloys for separately cast test bars

Alloy group	Alloy designation	Temper designation	Tensile strength R_m MPa min.	Proof stress $R_{p0,2}$ MPa min.	Elongation A [a] % min.	Brinell hardness HBW min.
AlCu	Al Cu4MgTi	T4	300	220	5	90
AlSi	Al Si12(b)	F	150	80	4	50
AlSi7Mg	Al Si7Mg	F	150	80	2	50
		T6	240	190	1	75
	Al Si7Mg0,3	T6	260	200	3	75
	Al Si7Mg0,6	T6	290	240	2	85
AlSi5Cu	Al Si5Cu3Mn	F	160	80	1	60
AlSi17Cu	Al Si17Cu4Mg	F	200	180	1	90
		T5	295	260	1	125
AlMg	Al Mg5	F	170	95	3	55

1 N/mm^2 = 1 MPa.

[a] The gauge length is defined in ISO 2379, or an equivalent published standard.

Annex A
(normative)

Writing rules for the designation and chemical composition of alloyed aluminium ingots for remelting and castings

A.1 Basis of codification

The chemical-symbol-based designation shall be constituted successively by the following:

a) the prefix ISO, followed by a blank space;

b) the letter A representing aluminium;

c) a letter representing the form of the product:

— the letter B representing ingots for remelting; or

— the letter C representing castings.

The letter B or C shall be separated from the following designation by a hyphen.

A.2 Distinguishing by nominal mass fraction

When several alloying elements are deemed to be required in the designation, they shall be arranged in order of decreasing nominal mass fractions.

EXAMPLE 1 ISO AB-Al Si5Cu3

If these mass fractions are equal, the alloying elements shall be arranged in the alphabetical order of the symbols, as specified in Table A.1.

EXAMPLE 2 ISO AB-Al Si12CuMgNi

The chemical symbols for alloying elements shall be restricted to a maximum of four elements.

EXAMPLE 3 ISO AB-Al Si12CuMgNi

EXAMPLE 4 ISO AC-Al Si12CuMgNi

The simplest possible designation shall be used.

A.3 Alloys with similar compositions

In the case of alloys with similar compositions, the following additional designation shall be used for distinguishing between alloys in decreasing priority.

The alloying element shall be distinguished by the nominal mass fraction (middle of the range) rounded to the nearest integer or, if necessary, to the nearest 0,5, or, for mass fractions less than 1 %, to the nearest 0,1.

EXAMPLE 1 ISO AB-Al Si7Mg0,3

EXAMPLE 2 ISO AB-Al Si7Mg0,6

A.4 Distinguishing by main impurities

The main impurity or impurities shall be added in parentheses.

EXAMPLE 1 ISO AB-Al Si10Mg(Cu)

EXAMPLE 2 ISO AB-Al Si10Mg(Fe)

EXAMPLE 3 ISO AB-Al Si9Cu3(Fe)(Zn)

A.5 Distinguishing by a suffix

If the above provision is not sufficient for differentiating between several alloys, a suffix shall be used: (a), (b), (c)…, according to the date of registration. This suffix shall consist of a lower-case letter placed in parentheses to avoid confusion with the chemical symbols.

EXAMPLE 1 EN AB-Al Si12(a)

EXAMPLE 2 EN AB-Al Si12(b)

Table A.1 — Designation of chemical elements

Silver	Ag	Molybdenum	Mo
Aluminium	Al	Sodium	Na
Boron	B	Niobium	Nb
Beryllium	Be	Nickel	Ni
Bismuth	Bi	Phosphorus	P
Calcium	Ca	Lead	Pb
Cadmium	Cd	Rare earths	RE
Cerium	Ce	Antimony	Sb
Cobalt	Co	Silicon	Si
Chromium	Cr	Tin	Sn
Copper	Cu	Strontium	Sr
Iron	Fe	Titanium	Ti
Gallium	Ga	Vanadium	V
Lithium	Li	Zinc	Zn
Magnesium	Mg	Zirconium	Zr
Manganese	Mn		

Annex B
(informative)

Mechanical properties of pressure die-cast alloys

Table B.1 — Mechanical properties of pressure die-cast alloys (see 6.2.1.5)

Alloy group	Alloy designation	Temper designation	Tensile strength R_m MPa min.	Proof stress $R_{p0,2}$ MPa min.	Elongation A [a] % min.	Brinell hardness HBW min.
AlSi	Al Si9	F	220	120	2	55
	Al Si12(Fe)	F	240	130	1	60
AlSi10Mg	Al Si10Mg(Fe)	F	240	140	1	70
AlSi9Cu	Al Si8Cu3	F	240	140	1	80
	Al Si9Cu3(Fe)	F	240	140	*a* [b]	80
	Al Si9Cu3(Fe)(Zn)	F	240	140	*a* [b]	80
	Al Si11Cu2(Fe)	F	240	140	*a* [b]	80
	Al Si11Cu3(Fe)	F	240	140	*a* [b]	80
AlSi12Cu	Al Si12Cu1(Fe)	F	240	140	1	70
AlSi17Cu	Al Si17Cu4Mg	F	200	180	*a* [b]	90
AlMg	Al Mg9	F	200	130	*a* [b]	70

1 N/mm^2 = 1 MPa.

[a] The gauge length is defined in ISO 2379, or an equivalent published standard.

[b] *a* means elongation less than 1 % that cannot be measured with sufficient accuracy.

Annex C
(informative)

Comparison of casting characteristics, mechanical and other properties

Table C.1 — Comparison of casting characteristics, mechanical and other properties

Alloy group	Alloy designation	Casting method				Castability [a]			Other properties										Mechanical properties [f]			
	Chemical symbols	Sand casting	Permanent mould casting	Pressure die-casting	Investment casting	Fluidity	Resistance to hot tearing	Pressure tightness	Machinability [a]		Resistance to corrosion [a]	Decorative anodizing [a]	Ability to be welded [a, b]	Ability to be polished [a]	Linear thermal expansion 10^{-6}/K 293 K to 373 K	Electrical conductivity MS/m	Thermal conductivity W/(m·K) [c]	Strength at room temperature [a, g]	Strength at elevated temperature to 200 °C [a, g]	Ductility (shock resistance) [a, g, h]	Fatigue strength MPA [i, j]
									As cast	After heat-treatment											
Al	Al 99.7		•	•		C	D	B	C	—	A	A	B	B	21	36	210	E	E	A	—
	Al 99.5		•	•		C	D	B	C	—	A	A	B	B	21	35	210	E	E	A	—
AlCu	Al Cu4Ti	•	•			C	D	D	—	A	D	C	D	B	23	16 to 23	120 to 150	B	B	A	80 to 110
	Al Cu4MgTi	•	•		•	C	D	D	—	A	D	C	D	B	23	16 to 23	120 to 150	A	B	A	80 to 110
	Al Cu5MgAg	•	•			C	D	D	—	A	D	A	D	A	23	16 to 23	120 to 150	A	B	A	80 to 110
AlSi	Al Si9			•		A	A	C	C	—	C	E	D	D	21	16 to 22	130 to 150	C	C	C	60 to 90
	Al Si11	•	•			A	A	A	C [d]	—	B	E	A	D	21	18 to 24	140 to 170	D	C	A	60 to 90
	Al Si12(a)	•	•			A	A	A	C	—	B	E	A	D	20	17 to 24	140 to 170	D	C	A	60 to 90
	Al Si12(b)	•	•		•	A	A	A	C	—	B/C	E	A	D	20	16 to 23	130 to 160	D	C	B	60 to 90
	Al Si12(Fe)			•		A	A	C	C	—	C	D	D	20	16 to 22	130 to 160	B	C	C	60 to 90
AlSiMgTi	Al Si2MgTi	•	•			C	C	C	C	B	B	B	B	B	23	19 to 25	140 to 160	B		B	—
AlSi7Mg	Al Si7Mg	•	•		•	B	A	B	B/C	B	B/C	D	B	C	22	19 to 25	150 to 170	B	C	C	80 to 110
	Al Si7Mg0,3	•	•		•	B	A	B	—	B	B	D	B	C	22	21 to 27	160 to 180	A	C	A	80 to 110
	Al Si7Mg0,6	•	•		•	B	A	B	—	B	B	D	B	C	22	20 to 26	150 to 180	A	C	A	80 to 110
AlSi10Mg	Al Si9Mg	•	•			A	A	B	—	B	B	E	A	D	21	20 to 26	150 to 180	A	C	A	80 to 110
	AlSi10Mg	•	•			A	A	B	B/C	B	B/C	E	A	D	21	18 to 25	140 to 170	B	C	C	80 to 110
	AlSi10Mg(Fe)					A	A	C	B	—	C	E	D	D	21	16 to 21	130 to 150	B	C	C	60 to 90
	AlSi10Mg(Cu)	•	•			A	A	B	B/C	B	C	E	A	C	21	16 to 24	130 to 170	B	C	C	80 to 110

Table C.1 (*continued*)

Alloy group	Alloy designation: Chemical symbols	Casting method: Sand casting	Permanent mould casting	Pressure die-casting	Investment casting	Castability [a]: Fluidity	Resistance to hot tearing	Pressure tightness	Other properties: Machinability [a]: As cast	After heat-treatment	Resistance to corrosion [a]	Decorative anodizing [a]	Ability to be welded [a, b]	Ability to be polished [a]	Linear thermal expansion 10^{-6}/K 293 K to 373 K	Electrical conductivity MS/m	Thermal conductivity W/(m·K) [c]	Mechanical properties [f]: Strength at room temperature [a, g]	Strength at elevated temperature to 200 °C [a, g]	Ductility (shock resistance) [a, g, h]	Fatigue strength MPA [i, j]
AlSi5Cu	Al Si5Cu1Mg	•	•			C	B	C	—	B	D	D	C	B	22	19 to 23	140 to 150	B	B	B	70 to 100
	Al Si5Cu3		•			B	B	B	—	B	D	D	C	B	22	16 to 19	120 to 130	B	A	A	70 to 100
	Al Si5Cu3Mg		•			B	B	B	B	A	D	D	C	B	22	16 to 19	130	A	A	C	80 to 110
	Al Si5Cu3Mn	•	•		•	B	B	B	B	B	D	D	C	B	22	15 to 19	120 à 130	A	A	C	70 to 100
	Al Si6Cu4	•	•			B	B	B	B	—	D	D	C	B	22	14 to 17	110 to 120	D	A	C	60 to 90
AlSi9Cu	Al Si7Cu2	•	•			B	B	B	B	—	D	E	C	C	21	15 to 19	120 to 130	D	B	C	50 to 70
	Al Si7Cu3Mg		•			B	B	B	C	—	C	E	B	C	21	14 to 17	110 to 120	D	A	C	60 to 90
	Al Si8Cu3	•	•	•		B	B	B [e]	B	—	D	E	B	C	21	14 to 18	110 to 130	B	A	C	60 to 90
	Al Si9Cu1Mg	•	•			B	B	B	B	B	D	E	B	D	21	16 to 22	130 to 150	A	B	C	60 to 90
	Al Si9Cu3(Fe)			•		B	B	C	B	—	D	E	F	C	21	13 to 17	110 to 120	B	B	D	60 to 90
	Al Si9Cu3(Fe) (Zn)			•		B	B	B	B	—	D	E	F	C	21	13 to 17	110 to 120	B	A	D	60 to 90
	Al Si11Cu2(Fe)			•		A	B	C	C	—	D	E	F	C	20	14 to 18	120 to 130	B	B	D	60 to 90
	Al Si11Cu3(Fe)			•		A	B	C	C	—	D	E	F	C	20	14 to 18	120 to 130	B	B	D	60 to 90
AlSi12Cu	Al Si12(Cu)	•	•			A	A	A	C	—	C	E	A	C	20	16 to 22	130 to 150	D	B	C	60 to 90
	Al Si12Cu1(Fe)			•		A	A	C	C	—	C	E	F	C	20	15 to 20	120 to 150	B	B	C	60 to 90
	Al Si12CuMgNi		•			A	A	A	—	B	C	E	A	C	20	15 to 23	130 to 160	A	A	D	80 to 110
AlSi17Cu	Al Si17Cu4Mg			•	•	D	C	B	E	B	D	D	D	D	18	24	139 to 190	B	B	E	60 to 90

Table C.1 *(continued)*

Alloy group	Alloy designation	Casting method				Castability [a]			Other properties										Mechanical properties [f]			
									Machinability [a]													
	Chemical symbols	Sand casting	Permanent mould casting	Pressure die-casting	Investment casting	Fluidity	Resistance to hot tearing	Pressure tightness	As cast	After heat-treatment	Resistance to corrosion [a]	Decorative anodizing [a]	Ability to be welded [a, b]	Ability to be polished [a]	Linear thermal expansion 10^{-6}/K 293 K to 373 K	Electrical conductivity MS/m	Thermal conductivity W/(m·K) [c]	Strength at room temperature [a, g]	Strength at elevated temperature to 200 °C [a, g]	Ductility (shock resistance) [a, g, h]	Fatigue strength MPA [i, j]
AlMg	Al Mg3	•	•			C	D	D	A	—	A	A	C	A	24	17 to 22	130 to 140	D	B	B	60 to 90
	Al Mg5	•	•		•	C	D	D	A	—	A	B	C	A	24	15 to 21	110 to 130	D	B	B	60 to 90
	Al Mg5(Si)	•	•			C	D	D	A	—	A	B	C	A	24	15 to 21	110 to 140	D	B	B	60 to 90
	Al Mg9			•	•	C	D	D	A	—	A	B	C	A	24	11 to 14	60 to 90	C	B	C	60 to 90
AlZnMg	Al Zn5Mg	•	•			C	D	D	A	A	B	B	C	B	24	19 to 21	130 to 140	C	D	B	60 to 90
AlZnSiMg	Al Zn10Si8Mg	•	•			A	A	B	A	—	B	E	A	A	21	17 to 20	120 to 130	B	C	C	80 to 110

NOTE Within a family of alloys, the use of two letters with an oblique stroke, for example B/C, allows small differences to be indicated.

1 N/mm^2 = 1 Mpa

• Indicates the casting process most commonly used for each alloy; A: Excellent; B: Good; C: Fair; D: Poor; E: Not recommended; F: Unsuitable.

a Rankings are only applicable in the column concerned.

b Ability to weld pressure die-castings depends on the amount of included gas and in most cases is very poor. With special die-casting processes, values from B to C may be obtained.

c Electrical and thermal conductivities are influenced by variations of chemical composition within a specification, the metallurgical structure, soundness, cooling rate and temper.

d With Mg > 0,1 the ranking is B.

e For alloy Al Si8Cu3, pressure tightness becomes C for the pressure die-cast version.

f Best available temper, the best strength and ductility are not found in the same temper.

g Rankings are derived from tensile and ductility values of the alloys, equally divided from A to D.

h The ductility (shock resistance) of an alloy is directly related to its elongation, the higher the elongation, the better the shock resistance. In contrast to ferrous alloys, aluminium alloys do not exhibit a transition temperature below which there is a sudden deterioration in shock resistance.

i Best available casting method.

j Values for rotating bending conditions up to 50×10^6 cycles (Wöhler curves).

Annex D
(informative)

Comparison between cast aluminium alloy designations

Table D.1 — ISO, AA, EN and JIS designation

ISO alloy designation	Corresponding AA alloy designation	Corresponding EN alloy designation	Corresponding JIS designation
Al Cu4Ti	—	EN AC-21100	Al-Cu4Ti
Al Cu4MgTi	204.0	EN AC-21000	AC1B
Al Cu5MgAg	A201.0	—	—
Al Si9	—	EN AC-44400	—
Al Si11	—	EN AC-44000	—
Al Si12(a)	—	EN AC-44200	
Al Si12(b)	B413.0	EN AC-44100	AC3A,Al-Si12
Al Si12(Fe)	A413.0	EN AC-44300	ADC1
Al Si2MgTi	—	EN AC-41000	—
Al Si7Mg	A356.0	EN AC-42000	AC4C
Al Si7Mg0.3	A356.0	EN AC-42100	AC4CH
Al Si7Mg0.6	357.0	EN AC-42200	—
Al Si9Mg	—	EN AC-43300	—
Al Si10Mg	—	EN AC-43100	AC4A,Al-Si10Mg
Al Si10Mg(Fe)	—	EN AC-43400	ADC3
Al Si10Mg(Cu)	—	EN AC-43200	—
Al Si5Cu1Mg	355.0	EN AC-45300	AC4D
Al Si5Cu3	—	EN AC-45400	Al-Si5Cu3
Al Si5Cu3Mg	363.0	EN AC-45100	—
Al Si5Cu3Mn	—	EN AC-45200	AC2A,AC2B
Al Si6Cu4	—	EN AC-45000	Al-Si6Cu4
Al Si7Cu2	—	EN AC-46600	—
Al Si7Cu3Mg	320.0	EN AC-46300	—
Al Si8Cu3	380.0	EN AC-46200	AC4B
Al Si9Cu1Mg	—	EN AC-46400	—
Al Si9Cu3(Fe)	—	EN AC-46000	ADC10
Al Si9Cu3(Fe) (Zn)	—	EN AC-46500	ADC10Z
Al Si11Cu2(Fe)	—	EN AC-46100	ADC12Z
Al Si11Cu3(Fe)	—	—	ADC12
Al Si12(Cu)	—	EN AC-47000	Al-Si12Cu
Al Si12Cu1(Fe)	—	EN AC-47100	—
Al Si12CuMgNi	—	EN AC-48000	AC8A
Al Si17Cu4Mg	B390.0	—	ADC14
Al Mg3	—	EN AC-51000	ADC6,Al-Mg3
Al Mg5	—	EN AC-51300	ADC5,AC7A,Al-Mg6
Al Mg5(Si)	—	EN AC-51400	Al-Mg5Si1
Al Mg9	518.0	EN AC-51200	Al-Mg10
Al Zn5Mg	712.0	EN AC-71000	Al-Zn5Mg
Al Zn10Si8Mg	—	—	—

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