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BSI Standards Publication

Aluminium and aluminium alloys — Specifications for wrought and cast products for marine applications (shipbuilding, marine and offshore)

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National foreword

This British Standard is the UK implementation of EN 13195:2013. It supersedes BS EN 13195:2009 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee NFE/35, Light metals and their alloys.

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

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Aluminium and aluminium alloys - Specifications for wrought and cast products for marine applications (shipbuilding, marine and offshore)

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Aluminium und Aluminiumlegierungen - Spezifikationen für Kneterzeugnisse und Gussstücke für Seewasseranwendungen (Schiffbau, Meeres- und Offshoretechnik)

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This document (EN 13195:2013) has been prepared by Technical Committee CEN/TC 132 “Aluminium and aluminium alloys”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2014, and conflicting national standards shall be withdrawn at the latest by April 2014.

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This document supersedes EN 13195:2009.

The main changes in this revision are the addition of the alloy EN AW-5456 in 6.4, in Table 1, in A.2.2.1, in A.2.2.3 and in Table A.1.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard specifies properties and technical conditions for inspection and delivery of wrought and cast aluminium and aluminium alloy products recommended for marine applications, including shipbuilding and offshore applications.

Additional information is given about high magnesium alloys, with special regard to their sensitivity to intergranular and exfoliation corrosion.

This European Standard is intended to be used in conjunction with relevant European, national or international regulations as applicable, to which it comes in support.

For products intended to be used in marine constructions to be classified by a Classification Society, the relevant requirements of this Society apply.

This European Standard covers:

— wrought products in aluminium alloys (see Clause 6);

— castings in aluminium alloys (see Clause 7).

Information is given in Annex A to guide the user in the selection of aluminium and aluminium alloys and tempers for various applications.

This European Standard does not cover:

— execution and design, covered by the rules of the Classification Societies or EN 1090-3 and EN 1999-1-1 to EN 1999-1-5;

— welding, covered by EN 1011-4.

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.

EN 485-1, *Aluminium and aluminium alloys — Sheet, strip and plate — Part 1: Technical conditions for inspection and delivery*

EN 485-2, *Aluminium and aluminium alloys — Sheet, strip and plate — Part 2: Mechanical properties*

EN 485-3, *Aluminium and aluminium alloys — Sheet, strip and plate — Part 3: Tolerances on dimensions and form for hot-rolled products*

EN 485-4, *Aluminium and aluminium alloys — Sheet, strip and plate — Part 4: Tolerances on shape and dimensions for cold-rolled products*

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

EN 573-3, *Aluminium and aluminium alloys — Chemical composition and form of wrought products — Part 3: Chemical composition and form of products*

EN 586-1, *Aluminium and aluminium alloys — Forgings — Part 1: Technical conditions for inspection and delivery*

EN 586-2, *Aluminium and aluminium alloys — Forgings — Part 2: Mechanical properties and additional property requirements*

EN 586-3, *Aluminium and aluminium alloys — Forgings — Part 3: Tolerances on dimensions and form*

EN 754-1, *Aluminium and aluminium alloys — Cold drawn rod/bar and tube — Part 1: Technical conditions for inspection and delivery*

EN 754-2, *Aluminium and aluminium alloys — Cold drawn rod/bar and tube — Part 2: Mechanical properties*

EN 754-3, *Aluminium and aluminium alloys — Cold drawn rod/bar and tube — Part 3: Round bars, tolerances on dimensions and form*

EN 754-4, *Aluminium and aluminium alloys — Cold drawn rod/bar and tube — Part 4: Square bars, tolerances on dimensions and form*

EN 754-5, *Aluminium and aluminium alloys — Cold drawn rod/bar and tube — Part 5: Rectangular bars, tolerances on dimensions and form*

EN 754-6, *Aluminium and aluminium alloys — Cold drawn rod/bar and tube — Part 6: Hexagonal bars, tolerances on dimensions and form*

EN 754-7, *Aluminium and aluminium alloys — Cold drawn rod/bar and tube — Part 7: Seamless tubes, tolerances on dimensions and form*

EN 754-8, *Aluminium and aluminium alloys — Cold drawn rod/bar and tube — Part 8: Porthole tubes, tolerances on dimensions and form*

EN 755-1, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 1: Technical conditions for inspection and delivery*

EN 755-2, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 2: Mechanical properties*

EN 755-3, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 3: Round bars, tolerances on dimensions and form*

EN 755-4, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 4: Square bars, tolerances on dimensions and form*

EN 755-5, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 5: Rectangular bars, tolerances on dimensions and form*

EN 755-6, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 6: Hexagonal bars, tolerances on dimensions and form*

EN 755-7, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 7: Seamless tubes, tolerances on dimensions and form*

EN 755-8, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 8: Porthole tubes, tolerances on dimensions and form*

EN 755-9, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 9: Profiles, tolerances on dimensions and form*

EN 1301-1, *Aluminium and aluminium alloys — Drawn wire — Part 1: Technical conditions for inspection and delivery*

EN 1301-2, *Aluminium and aluminium alloys — Drawn wire — Part 2: Mechanical properties*

EN 1301-3, *Aluminium and aluminium alloys — Drawn wire — Part 3: Tolerances on dimensions*

EN 1559-1, *Founding — Technical conditions of delivery — Part 1: General*

EN 1559-4, *Founding — Technical conditions of delivery — Part 4: Additional requirements for aluminium alloy castings*

EN 1592-1, *Aluminium and aluminium alloys — HF seam welded tubes — Part 1: Technical conditions for inspection and delivery*

EN 1592-2, *Aluminium and aluminium alloys — HF seam welded tubes — Part 2: Mechanical properties*

EN 1592-3, *Aluminium and aluminium alloys — HF seam welded tubes — Part 3: Tolerances on dimensions and form for circular tubes*

EN 1592-4, *Aluminium and aluminium alloys — HF seam welded tubes — Part 4: Tolerances on dimensions and form for square, rectangular and shaped tubes*

EN 1706, *Aluminium and aluminium alloys — Castings — Chemical composition and mechanical properties*

EN 10204, *Metallic products — Types of inspection documents*

EN 12258-1:2012, *Aluminium and aluminium alloys — Terms and definitions — Part 1: General terms*

ASTM B928/B928M, *Standard Specification for High Magnesium Aluminum-Alloy Sheet and Plate for Marine Service and Similar Environments*

ASTM G66, *Standard Test Method for Visual Assessment of Exfoliation Corrosion Susceptibility of 5xxx Series Aluminium Alloys (ASSET Test)*

ASTM G67, *Standard Test Method for Determining the Susceptibility to Intergranular Corrosion of 5XXX Series Aluminum Alloys by Mass Loss After Exposure to Nitric Acid (NAMLT Test)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12258-1:2012 apply.

4 Selection of materials

Aluminium alloys recommended for wrought products are given in Table 1. The chemical composition of these alloys shall be as specified in EN 573-3. For each wrought alloy and product form available, the recommended tempers are given in Table 1. The available product form of each alloy shall be as given in EN 573-3. Temper designations for wrought products shall be used as specified in EN 515. An explanation of the specified tempers for the relevant products is given in Annex C.

The series 5xxx alloys for marine applications shall be used only in the tempers specified in Table 1.

Aluminium alloys recommended for castings are given in Table 2. The chemical composition of these alloys shall be as specified in EN 1706. The recommended tempers are given in Table 2 for each alloy and casting process type available.

Further information on materials selection and the proper use of certain alloys and tempers is given in Annex A.

5 Ordering information

The ordering information for the various products shall be as specified in the relevant European Standards for general engineering applications: EN 485-1, EN 586-1, EN 754-1, EN 755-1, EN 1301-1 and EN 1592-1.

It shall be indicated on the order document whether frequent direct contact with seawater is expected for the product. When relevant the manufacturer shall specify which corrosion test method has been applied.

It shall be indicated on the order document whether or not the constructions in which the ordered products are incorporated are intended to be inspected by a Classification Society, together with a reference of additional relevant standard(s) of this Classification Society.

Classification Societies may put stricter requirements.

An inspection certificate 3.1 in accordance with EN 10204 shall be issued.

6 Wrought aluminium alloy products for marine applications

6.1 Technical conditions for inspection and delivery

The technical conditions for inspection and delivery for the various products shall be as specified in the European Standards for general engineering applications: EN 485-1, EN 586-1, EN 754-1, EN 755-1, EN 1301-1 and EN 1592-1.

6.2 Mechanical properties

The mechanical properties of the different products shall be as specified in the following European Standards for general engineering applications: EN 485-2, EN 586-2, EN 754-2, EN 755-2, EN 1301-2 and EN 1592-2.

For aluminium alloy EN AW-5383 for extruded products, the mechanical properties shall be as specified in Annex B.

6.3 Tolerances on dimensions and form

The tolerances on dimensions and form for each form of product shall be as specified in the following European Standards for general engineering applications: EN 485-3, EN 485-4, EN 586-3, EN 754-3, EN 754-4, EN 754-5, EN 754-6, EN 754-7, EN 754-8, EN 755-3, EN 755-4, EN 755-5, EN 755-6, EN 755-7, EN 755-8, EN 755-9, EN 1301-3, EN 1592-3 and EN 1592-4.

In specific cases, the permissible under-thicknesses of sheet, strip and plate can be agreed between supplier and purchaser (see Table 3), while the total tolerance range shall conform to the requirements of the relevant parts of EN 485 (Part 3 or 4).

6.4 Special requirements for corrosion-testing of EN AW-5059, EN AW-5083, EN AW-5086, EN AW-5383, EN AW-5456 alloys

H116 applies to products made of those alloys of the 5xxx group in which the magnesium content is 3 % nominal or more. These products are strain-hardened at the last operation to specified stable tensile property limits, and to meet specified levels of corrosion resistance in accelerated-type corrosion tests. Corrosion tests include inter-granular and exfoliation tests. This temper is suitable for continuous service at temperatures not greater than 65 °C (150 °F).

H321 applies to products made of those alloys of the 5xxx group in which the magnesium content is 3 % nominal or more. These products are thermally stabilised at the last operation to specified stable tensile property limits, and to meet specified levels of corrosion resistance in accelerated-type corrosion tests. Corrosion tests include inter-granular and exfoliation tests. This temper is suitable for continuous service at temperatures not greater than 65 °C (150 °F).

Alloys supplied in the H116 or H321 temper in the form of sheet, strip and plate shall be subjected to testing as specified in EN 485-2 supplemented to assess their resistance to intergranular corrosion susceptibility based on ASTM G67 (NAMLT Test) and to exfoliation corrosion susceptibility based on ASTM G66 (ASSET Test).

EN AW-5383 alloys supplied in the H112 temper in the form of extrusions can be subjected to testing to assess their resistance to intergranular corrosion susceptibility based on ASTM G67 (NAMLT Test) and to exfoliation corrosion susceptibility based on ASTM G66 (ASSET Test), when agreed upon between manufacturer and purchaser.

The manufacturers shall establish the relationship between microstructure and resistance to corrosion. A reference photomicrograph taken at 500x, shall be established for each of the alloy-tempers and thickness ranges relevant. The reference photographs shall be taken from samples which have exhibited no evidence of exfoliation corrosion and a pitting rating of PB or better, when subjected to the test described in ASTM G66 (ASSET). The samples shall also have exhibited resistance to intergranular corrosion at a mass loss no greater than 15 mg/cm^2, when subjected to the test described in ASTM G67. Upon satisfactory establishment of the relationship between microstructure and resistance to corrosion, the master photomicrographs shall be approved. Production practices shall not be changed after approval of the reference micrographs.

NOTE Pitting rating of PB is described in ASTM G66.

For batch acceptance of 5xxx-alloys in the H116 and H321 tempers, metallographic examination of one sample selected from mid-width at one end of a coil or random sheet or plate shall be carried out. The microstructure of the sample shall be compared to the reference photomicrograph of acceptable material. A longitudinal section perpendicular to the rolled surface shall be prepared for metallographic examination. If the microstructure shows evidence of continuous grain boundary network of aluminium-magnesium precipitate in excess of the reference photomicrographs of acceptable material, the batch shall either be rejected or tested for exfoliation-corrosion resistance and intergranular corrosion resistance. The corrosion tests shall be in accordance with ASTM G66 and ASTM G67. If the results from testing satisfy the acceptance criteria the batch is accepted, else it shall be rejected.

As an alternative to metallographic examination, each batch may be tested for exfoliation corrosion resistance and intergranular corrosion resistance, in accordance with ASTM G66 and ASTM G67. The pass/fail requirements for the alternative to metallographic examination shall be in accordance with ASTM B928/B928M.

7 Castings

7.1 Mechanical properties

The mechanical properties of sand, chill (permanent mould), investment or pressure die castings shall be in accordance with EN 1706.

7.2 Technical conditions for delivery of castings

The technical conditions for delivery of aluminium castings shall be in accordance with EN 1559-1 and EN 1559-4.

Table 1 — Wrought aluminium alloy products - Recommended alloys, product forms and tempers

Alloy designation	Sheet, strip and plate	Extruded products			Cold drawn products		Forgings
		Bar/Rod	Tube	Profile	Bar/Rod	Tube	
EN AW-5052	O	-	-	-	-	-	-
[Al Mg2,5]	H111	-	-	-	-	-	-
	H112	-	-	-	-	-	-
EN AW-5059	O	-	-	-	-	-	-
[Al Mg5,5MnZnZr]	H111	-	-	-	-	-	-
	H116 [a]	-	-	-	-	-	-
	H321 [a]	-	-	-	-	-	-
EN AW-5083	O	O	O	-	O	O	-
[Al Mg4,5Mn0,7]	H111	H111	H111	-	H111	H111	-
	H116 [a]	-	-	-	-	-	-
	H321 [a]	-	-	-	-	-	-
EN AW-5086	O	O	O	-	O	O	-
[Al Mg4]	H111	H111	H111	-	H111	H111	-
	H116 [a]	-	-	-	-	-	-
	H321 [a]	-	-	-	-	-	-
EN AW-5383	O	O	O	-	O	O	-
[Al Mg4,5Mn0,9]	H111	H111	H111	-	H111	H111	-
	-	H112	H112	H112	-	-	-
	H116 [a]	-	-	H116	-	-	-
	H321 [a]	-	-	-	-	-	-
EN AW-5454	O	O	O	-	-	-	-
[Al Mg3Mn]	H111	H111	H111	-	-	-	-
	H112	H112	H112	H112	-	-	-
EN AW-5456	O	-	-	-	-	-	-
[Al Mg5Mn1]	H116 [a]	-	-	-	-	-	-
	H321 [a]	-	-	-	-	-	-
EN AW-5754	O	O	O	-	O	O	-
[Al Mg3]	H111 [c]	H111 [c]	H111 [c]	-	H111 [c]	H111 [c]	-
	H112 [c]	H112 [c]	H112 [c]	H112 [c]	-	-	H112
EN AW-6005A	-	-	-	T4 [b]	-	-	-
[Al SiMg(A)]	-	T6 [b]	T6 [b]	T6 [b]	-	-	-
EN AW-6060	-	T6	T6	T6	-	-	-
[Al MgSi]	-	T66	T66	T66	-	-	-
EN AW-6063	-	T6	T6	T6	-	-	-
[Al Mg0,7Si]	-	T66	T66	T66	-	-	-
EN AW-6082	T4	-	-	-	-	-	-
[Al Si1MgMn]	T6	T6 [b]	T6 [b]	T6 [b]	T6 [b]	T6 [b]	T6
EN AW-6106	-	-	-	T6 [b]	-	-	-
[Al MgSiMn]							

[a] See 6.4 and Annex A for recommendation for the proper use of certain alloys.

[b] Properties may be obtained by press quenching.

[c] Only applicable for compositions with magnesium content lower than 3,0 %.

Table 2 — Castings - Recommended alloys and tempers

Alloy designation	Sand casting	Chill or permanent mould casting	Investment casting	Pressure die casting
EN AC-41000 [Al Si2MgTi]	F T6	F T6	- -	- -
EN AC-42100 [Al Si7Mg0,3]	T6 -	T6 T64	T6 -	- -
EN AC-42200 [Al Si7Mg0,6]	T6	T6 T64	T6 -	- -
EN AC-43100 [Al Si10Mg(b)]	F T6 -	F T6 T64	- - -	- - -
EN AC-43300 [Al Si9Mg]	T6 -	T6 T64	- -	- -
EN AC-44000 [Al Si11]	F	F	-	-
EN AC-44200 [Al Si12(a)]	F	F	-	-
EN AC-51100 [Al Mg3(a)]	F	F	-	-
EN AC-51200 [Al Mg9]	-	-	-	F
EN AC-51300 [Al Mg5]	F	F	F	-
EN AC-51400 [Al Mg5(Si)]	F	F	-	-

Table 3 — Wrought aluminium alloy products – Permissible under-thickness for sheet, strip and plate

Dimensions in millimetres

Nominal thickness	Permissible under-thickness for sheet, strip and plate		
	Width of product		
	Up to and including 1 500	Over 1 500 up to 2 000	Over 2 000
From 2 to 4	- 0,10	- 0,15	- 0,15
Over 4 to 8	- 0,20	- 0,20	- 0,25
Over 8 to 12	- 0,25	- 0,25	- 0,25
Over 12 to 20	- 0,35	- 0,40	- 0,50
Over 20 to 50	- 0,45	- 0,50	- 0,65

Annex A
(informative)

Recommendations for the proper use of certain alloys

A.1 Materials selection

The choice of a suitable aluminium or aluminium alloy for any application in the marine field is determined by a combination of factors: strength, durability, corrosion-resistance, corrosion-protection, physical properties, weldability, formability and commercial availability both of the alloy and the particular form required. The wrought alloys in Table 1 and casting alloys listed in Table 2 are described below subdivided into heat treatable and non-heat treatable alloys.

The properties and characteristics of these alloys can be compared in Table A.1 for wrought alloys, Table A.2 for casting alloys and Table A.3 for rivets.

When connections are to be made to other metals, specialist advice should be sought on the protective measures necessary to avoid galvanic corrosion.

An appropriate corrosion protection through use of sacrificial anodes avoids corrosion on corrosion susceptible alloys. Specialist advice should be sought on the protective measures necessary to avoid corrosion.

It is recommended that material to be used for welded components be produced from ingots or billets with a hydrogen level no greater than 0,2 ml per 100 g aluminium, measured on liquid metal during casting.

A.2 Wrought alloys

A.2.1 Wrought heat treatable alloys

A.2.1.1 General

Within the 6xxx series alloys, the alloys EN AW-6082, EN AW-6005A, EN AW-6060, EN AW-6063 and EN AW-6106 are recommended.

A.2.1.2 Alloy EN AW-6082

EN AW-6082 is one of the most widely used heat treatable alloys and often the principal alloy used in many countries for welded and non-welded applications. It is a high strength alloy available in most forms, solid and hollow extrusions, tube and finds increasing use in components exposed to the marine environment. It is normally used in the fully heat treated condition T6.

The choice of this alloy as a structural material is based on a favourable combination of properties: high strength after heat treatment, good corrosion resistance, good weldability by both the MIG and TIG processes, good formability in the T4 temper and good machining properties. Care shall be taken to account for the loss of strength in the heat affected zone (HAZ) of welded joints (see EN 1999-1-1 and EN 1999-1-3). Strength can be recovered to a limited degree by post weld natural ageing. When used in extrusions it is generally restricted to thicker less intricate shapes than with the other 6xxx series alloys EN AW-6005A, EN AW-6060, EN AW-6063 and EN AW-6106. EN AW-6082 is a common alloy for extrusions, from stock. The alloy can be riveted using alloys EN AW-5754 or EN AW-5154A in O tempers. Filler metals for welding are specified in EN 1011-4.

A.2.1.3 Alloys EN AW-6005A, EN AW-6060, EN AW-6063 and EN AW-6106

EN AW-6005A, EN AW-6060, EN AW-6063 and EN AW-6106 alloys are available in extruded forms only and combine medium strength with the ability to be extruded into shapes more complex than those obtainable with EN AW-6082. This is particularly true for thin-walled hollow shapes. Such as EN AW-6082, these alloys are readily welded by the TIG and MIG processes and have similar loss of strength in the HAZ in welded joints (see EN 1999-1-1 and EN 1999-1-3). Filler metals for welding these alloys are specified in EN 1011-4.

The corrosion resistance in the marine environment of welded and unwelded components is similar or better than EN AW-6082. The machining properties are similar to those of EN AW-6082.

A.2.2 Wrought non-heat treatable alloys

A.2.2.1 General

Within the 5xxx series alloys, the alloys EN AW-5052, EN AW-5059, EN AW-5083, EN AW-5086, EN AW-5383, EN AW-5454, EN AW-5456 and EN AW-5754 are recommended.

A.2.2.2 Alloys EN AW-5052, EN AW-5754 and EN AW-5454

EN AW-5052, EN AW-5754 and EN AW-5454 show similar properties and both are suitable for welded or mechanically joined structural parts subjected to moderate stress. The alloys are ductile in the annealed condition, but loose ductility rapidly with cold forming. They are readily welded by MIG and TIG processes using filler metals specified in EN 1011-4 and offer very good resistance to corrosive attack, especially in a marine environment. Available principally as rolled products, their reduced magnesium content also allows simple extruded solid and hollow shapes.

The use of these alloys is recommended where the material is to be subjected to further heavy cold working (for example bending) and/or where the service temperature is expected to be above 65 °C.

A.2.2.3 Alloys EN AW-5456, EN AW-5086, EN AW-5383, EN AW-5083 and EN AW-5059

EN AW-5456, EN AW-5086, EN AW-5383, EN AW-5083 and EN AW-5059 are the strongest non-heat treatable alloys in general use, including marine applications, possessing good as-welded properties and very good corrosion resistance in the marine environment. They are ductile in the soft condition with good forming properties but loose ductility very rapidly with cold forming, becoming extremely hard.

The alloys EN AW-5456, EN AW-5086, EN AW-5383, EN AW-5083 and EN AW-5059 are easily welded by both MIG and TIG processes using the filler metals specified in EN 1011-4. When strain hardened materials are welded, the properties in the HAZ revert to the annealed value. For EN AW-5456, EN AW-5059, EN AW-5083, EN AW-5086 and EN AW-5383, the available form of products is given in Table 1. Due to the high magnesium content they are particularly hard to extrude in hollow or complex sections and so are limited to simple full extruded sections. They have good machining qualities in all tempers. For riveting, alloy EN AW-5754 in tempers O is suggested.

The use of these alloys is not recommended where the material is to be subjected to further heavy cold working (for example bending) and/or where the service temperature is expected to be above 65 °C.

A.3 Casting alloys

Casting alloys are recommended for use in marine environments. Their principal characteristics are compared in Table A.2. All can be welded using the filler metals specified in EN 1011-4, but some alloy combinations of cast and wrought products are not recommended because of the formation of brittle intermetallics. The castings obtained by die casting are generally not weldable due to the formation of bubbles in and close to the welding seam.

The alloys EN AC-42100 and EN AC-42200 have good casting properties, which allows casting of thin walled pieces with complex shapes and various dimensions. After heat treatment, they have good mechanical properties. The choice between the two alloys depends on the compromise between resistance and ductility required. They give a good surface finish after machining and buffing, but present a grey surface aspect after anodising. Their corrosion resistance is good. They are used for stressed mechanical pieces.

EN AC-43100 and EN AC-43300 have the same properties and disadvantages of the preceding alloys. Due to their very high castability, thin walled pieces can be obtained.

EN AC-44000 and EN AC-44200 have the same casting properties of the preceding alloys but have still higher castability. They cannot be heat treated. The finished surface aspect after machining is lower. These alloys are used to make very thin pieces. Therefore, their mechanical properties are lower.

EN AC-41000 can be heat treated and can give a very good surface finish after machining, buffing and decorative anodisation, with good corrosion resistance. Its casting properties are poor compared to the above mentioned alloys, which limits the possibility to cast thin wall pieces with complex shapes. It is mainly used for permanent mould casting in order to manufacture pieces for taps or marine fittings with limited dimensions.

EN AC-51100 can have an excellent surface finish after machining, buffing and anodising and a very good corrosion resistance. Its casting properties are inferior to those of the preceding alloys. It cannot be heat treated and its mechanical properties are inferior.

EN AC-51300 and EN AC-51400 exhibit casting properties similar to the preceding alloy. Their mechanical properties are slightly higher.

EN AC-51200 has poor casting properties and is only used for high pressure die casting. It has a very good corrosion resistance.

A.4 Welding

Guidelines for welding of aluminium and aluminium alloys are given in EN 1011-4. This European Standard covers provisions for quality aspects, welding processes, welding consumables, qualification of welders and welding processes, precautions before, during and after welding and inspections of welded joints.

Recommendations for welding are:

— quality requirements for welding in accordance with EN ISO 3834-2;

— qualification of welders in compliance with EN ISO 9606-2;

— qualification of welding processes in accordance with EN ISO 15614-2;

— selection of filler materials in accordance with Table B.2 of EN 1011-4:2000 and EN 1090-3;

— criteria for quality level of welded joints in accordance with EN ISO 10042;

— consideration of environmental aspects according to EN 14717.

Table A.1 — Comparison of characteristics and other properties for wrought alloys

Alloys designation	Products form and temper availability							Strength	Resistance to corrosion	Formability	Machinability	Weldability
	Sheet, strip and plate	Extruded products			Cold drawn products		Forging					
		Bar/Rod	Tube	Profile	Bar/Rod	Tube						
EN AW-5052	O or H111	-	-	-	-	-	-	D	A	B	C	A
[Al Mg2,5]	H112	-	-	-	-	-	-	D	A	B	C	A
EN AW-5059	O or H111	-	-	-	-	-	-	B	A [a]	B	C	A
[Al Mg5,5MnZnZr]	H112	-	-	-	-	-	-	B	A [a]	B	C	A
	H116	-	-	-	-	-	-	A	A [a]	C	B	A
	H321	-	-	-	-	-	-	A	A [a]	C	B	A
EN AW-5083	O or H111	O or H111	O or H111	-	O or H111	O or H111	-	B	A [a]	B	C	A
[Al Mg4,5Mn0,7]	H116	-	-	-	-	-	-	A	A [a]	C	B	A
	H321	-	-	-	-	-	-	A	A [a]	C	B	A
EN AW-5086	O or H111	O or H111	O or H111	-	O or H111	O or H111	-	C	A	B	C	A
[Al Mg4]	H116	-	-	H116	-	-	-	B	A [a]	C	B	A
	H321	-	-	-	-	-	-	B	A [a]	C	B	A
EN AW-5383	O or H111	O or H111	O or H111	-	O or H111	O or H111	-	B	A [a]	B	C	A
[Al Mg4,5Mn0,9]	-	H112	H112	H112	-	-	-	B	A [a]	B	C	A
	H116	-	-	-	-	-	-	A	A [a]	C	B	A
	H321	-	-	-	-	-	-	A	A [a]	C	B	A
EN AW-5454	O or H111	O or H111	O or H111	-	-	-	-	C	A	A	D	A
[Al Mg3Mn]	H112	H112	H112	H112	-	-	-	C	A	B	C	A
EN AW-5456	O	-	-	-	-	-	-	B	A [a]	B	C	A
[Al Mg5Mn1]	H116	-	-	-	-	-	-	A	A [a]	C	B	A
	H321	-	-	-	-	-	-	A	A [a]	C	B	A

Table A.1 *(continued)*

Alloys designation	Products form and temper availability							Strength	Resistance to corrosion	Formability	Machinability	Weldability
	Sheet, strip and plate	Extruded products			Cold drawn products		Forging					
		Bar/Rod	Tube	Profile	Bar/Rod	Tube						
EN AW-5754	O or H111	O or H111	O or H111	-	O or H111	O or H111	-	D	A	B	C	A
[Al Mg3]	H112	H112	H112	H112	-	-	H112	D	A	B	C	A
EN AW-6005A [Al SiMg(A)]	-	-	-	T4	-	-	-	D	B	B	B	A
	-	T6	T6	T6	-	-	-	B	B	C	B	A
EN AW-6060 [Al MgSi]	-	T6	T6	T6	-	-	-	B/D	B	B/C	B/C	A
	-	T66	T66	T66	-	-	-	B/D	B	B/C	B/C	A
EN AW-6063 [Al Mg0,7Si]	-	T6	T6	T6	-	-	-	B/D	B	B/C	B/C	A
	-	T66	T66	T66	-	-	-	B/D	B	B/C	B/C	A
EN AW-6082	T4	-	-	-	-	-	-	C	B	C	B	A
[Al Si1MgMn]	T6	T6	T6	T6	T6	T6	T6	A	B	C	B	A
EN AW-6106 [Al MgSiMn]	-	-	-	T6	-	-	-	B	B	C	B	A

These indications are for guidance only and each ranking is only applicable in the column concerned. A = Excellent B = Good C = Fair D = Poor

[a] See 6.4 for assessment of corrosion resistance.

Table A.2 — Comparison of characteristics and other properties for casting alloys

Casting alloy designation	Form of casting				Castabililty			Strength	Machinability		Resistance to corrosion	Decorative anodising	Weldability
	Sand	Chill or permanent mould	Investment	Pressure die	Fluidity	Resistance to hot tearing	Pressure tightness		as cast	after Heat treatment			
EN AC-41000 [Al Si2MgTi]	o	o	-	-	C	C	C	B	C	B	B	B	B
EN AC-42100 [Al Si7Mg0,3]	o	o	o	-	B	A	B	A	-	B	B	D	B
EN AC-42200 [Al Si7Mg0,6]	o	o	o	-	B	A	B	A	-	B	B	D	B
EN AC-43100 [Al Si10Mg(b)]	o	o	-	-	A	A	B	B	B/C	B	B/C	E	A
EN AC-43300 [Al Si9Mg]	o	o	-	-	A	A	B	A	B/C	B	B	E	A
EN AC-44000 [Al Si11]	o	o	-	-	A	A	A	D	C [a]	-	B	E [b]	A
EN AC-44200 [Al Si12(a)]	o	o	-	-	A	A	A	D	C	-	B	E	A
EN AC-51100 [Al Mg3(a)]	o	o	-	-	C	D	D	D	A	-	A	A	C
EN AC-51200 [Al Mg9]	-	-	-	o	C	D	D	C	A	-	A	B	E
EN AC-51300 [Al Mg5]	o	o	o	-	C	D	D	D	A	-	A	A	C
EN AC-51400 [Al Mg5(Si)]	o	o	-	-	C	D	D	D	A	-	A	B	C

These indications are for guidance only and each ranking is only applicable in the column concerned. A = Excellent B = Good C = Fair D = Poor E = Not recommended

o Indicates casting process commonly used.

[a] Mg > 0,1 this alloy is indicated B.

[b] In the areas without porosity the weldability of this alloy is indicated C.

Table A.3 — Alloys and products forms recommended for standard rivets, self-pierce rivets and screws

Alloy designation	Standard rivets	Self-pierce rivets	Screws
EN AW-5086 H14 or H16	**X**		
EN AW-6056 T6	**X**	**X**	**X**
EN AW-6082 T6	**X**		**X**
EN AW-7075 T6		**X**	
Alloys recommended (X) for application.			

Annex B
(normative)

Mechanical properties of aluminium alloy EN AW-5383 for extruded products

The following mechanical properties of aluminium alloy EN AW-5383 apply to extruded products.

Table B.1 — Mechanical properties of aluminium alloy EN AW-5383 [Al Mg4,5Mn0,9]

Temper	Wall thickness t mm	Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Hardness HBW Typical value
		min.	max.	min.	max.	$A_{50\ mm}$	A	
O	All	290	-	145	-	-	17	70
H111	All	290	-	145	-	-	17	70
H112	All	310	-	190	-	-	12	70
H116	2 to 8	310	365	190	-	-	12	70

Annex C
(informative)

Explanation of temper designations

Table C.1 — Explanation of temper designations used in Table 1, Table 2, Table A.1 and Table A.3 based on definitions of EN 515

Temper designations	Explanation
F	As fabricated, this designation applies to the products of shaping processes in which no special control over thermal conditions or strain-hardening is employed. For this temper, there are no mechanical property limits specified.
O	Annealed - products achieving the required annealed properties after hot forming processes may be designated as O temper.
H111 H112 H116	Annealed and slightly strain-hardened (less than H11) during subsequent operations such as stretching or levelling. Slightly strain-hardened from working at an elevated temperature or from a limited amount of cold work (mechanical property limits specified). Applies to aluminium-magnesium alloys that have been slightly strain-hardened at the last operation and for which exfoliation and intergranular corrosion resistance are specified.
H14	Strain-hardened – 1/2 hard.
H16	Strain-hardened – 3/4 hard.
H321	Strain-hardened and stabilised - 1/4 hard, applies to aluminium-magnesium alloys and for which exfoliation and intergranular corrosion resistance are specified.
T4	Solution heat-treated and naturally aged to a substantially stable condition.
T6	Solution heat-treated and then artificially aged.
T64	Solution heat-treated and then artificially aged in underageing conditions (between T6 and T61) to improve formability.
T66	Solution heat-treated and then artificially aged – mechanical property level higher than T6 achieved through special control of the process (6 000 series alloys).

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[3] EN 1999-1-1, *Eurocode 9: Design of aluminium structures — Part 1-1: General structural rules*

[4] EN 1999-1-2, *Eurocode 9: Design of aluminium structures — Part 1-2: Structural fire design*

[5] EN 1999-1-3, *Eurocode 9: Design of aluminium structures — Part 1-3: Structures susceptible to fatigue*

[6] EN 1999-1-4, *Eurocode 9: Design of aluminium structures — Part 1-4: Cold-formed structural sheeting*

[7] EN 1999-1-5, *Eurocode 9 - Design of aluminium structures — Part 1-5: Shell structures*

[8] EN ISO 3834-2, *Quality requirements for fusion welding of metallic materials — Part 2: Comprehensive quality requirements (ISO 3834-2)*

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