BS EN 12392:2016

BSI Standards Publication

Aluminium and aluminium alloys — Wrought products and cast products — Special requirements for products intended for the production of pressure equipment

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National foreword

This British Standard is the UK implementation of EN 12392:2016. It supersedes BS EN 12392:2000 which is withdrawn.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 - Wrought products and cast products - Special requirements for products intended for the production of pressure equipment

Aluminium et alliage d'aluminium - Produits corroyés et moulés - Exigences particulières pour les produits destinés à la fabrication des appareils à pression

Aluminium und Aluminium Legierungen - Knet- und Gusserzeugnisse - Besondere Anforderungen an Erzeugnisse für die Fertigung von Druckgeräten

This European Standard was approved by CEN on 18 January 2016.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (EN 12392:2016) 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of an identical text or by endorsement, at the latest by September 2016, and conflicting national standards shall be withdrawn at the latest by September 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12392:2000.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

Comparing to EN 12392:2000 the following modifications were implemented in EN 12392:2016:

— modification of the scope (extension to cast aluminium and aluminium alloys) (Clause 1);

— new normative references (Clause 2);

— new definitions (Clause 3): melt, casting, forging, tube;

— modification of Clause 4 “Materials” which covers Wrought products and Cast products;

— modification of Clause 5 “Technical conditions for inspection and delivery”: new requirements for Manufacturing methods, Orders or tenders, Test procedures, Inspection documents, Marking, Packaging;

— modification of Clause 6 “Mechanical properties”: different specifications are included at room temperature and low and elevated temperature properties;

— modification of Clause 7 “Tolerances on dimensions and form”: inclusions of Tables 1 to 37;

— deletion of Clause 8 “Elevated temperature properties” (initially in 2000 version);

— new Annex A (Informative) “Materials and application range”;

— new Annex B (Informative) “Tensile properties at low and high temperature;

— new Annex ZA (Informative) “Relationship with EU Directive 2014/68”;

— new references into Bibliography.

According to the CEN-CENELEC Internal Regulations, the national standards organizations 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 the material requirements and testing procedures applicable to wrought and cast aluminium and aluminium alloys intended for use in the production of pressure equipment.

This European Standard covers:

— the products forms, grades and tempers of wrought and cast aluminium and aluminium alloys which may be used for such applications together with data for wrought and cast alloys over their permissible working temperature ranges;

— the permissible alloys/ tempers covered by this are those given in Table A.1 and in B.1 for wrought alloys and in Table A.2 and in B.2 for castings;

— the technical conditions for inspection and delivery, mechanical property limits and tolerances on form and dimensions by reference to the appropriate European standards for the relevant wrought and cast aluminium and aluminium alloys, and

— additional requirements which are specific to pressure equipment applications.

It applies to hot-rolled plate, cold-rolled sheet/ strip/ circles, extruded or extruded and cold drawn rod/bar, tube, extruded open / hollow profiles, forgings and castings, by this standard are those given in Table A.1 for wrought alloys and in Table A.2 for castings.

It is the sole objective of this standard to cover materials only for pressure purposes and it excludes any elements of fabrication or fabrication methods for pressure equipment; such information can be found in the relevant standards listed in the “Bibliography” section.

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 485-3, *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 586-1, *Aluminium and aluminium alloys - Forgings - Part 1: Technical conditions for inspection and delivery*

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 941, *Aluminium and aluminium alloys - Circle and circle stock for the production of general applications - Specifications*

EN 1371-1, *Founding - Liquid penetrant testing- Part 1: Sand, gravity die and low pressure die castings*

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 1779, *Non-destructive testing - Leak testing - Criteria for method and technique selection*

EN 2101, *Aerospace series - Chromic acid anodizing of aluminium and wrought aluminium alloys*

EN 4050-1, *Aerospace series - Test method for metallic materials - Ultrasonic inspection of bars, plates, forging stock and forgings - Part 1: General requirements*

EN 4050-2, *Aerospace series - Test method for metallic materials - Ultrasonic inspection of bars, plates, forging stock and forgings - Part 2: Performance of test*

EN 4050-3, *Aerospace series - Test method for metallic materials - Ultrasonic inspection of bars, plates, forging stock and forgings - Part 3: Reference blocks*

EN 4050-4, *Aerospace series - Test method for metallic materials - Ultrasonic inspection of bars, plates, forging stock and forgings - Part 4: Acceptance criteria*

EN 10204:2004, *Metallic products - Types of inspection documents*

EN 12020-1, *Aluminium and aluminium alloys - Extruded precision profiles in alloys EN AW-6060 and EN AW-6063 - Part 1: Technical conditions for inspection and delivery*

EN 12020-2, *Aluminium and aluminium alloys - Extruded precision profiles in alloys EN AW-6060 and EN AW-6063 - Part 2: Tolerances on dimensions and form*

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

EN 12681, *Founding - Radiographic examination*

EN 13957, *Aluminium and aluminium alloys - Extruded round, coiled tube for general applications - Specification*

EN 13958, *Aluminium and aluminium alloys - Cold drawn, round, coiled tube for general applications - Specification*

EN 14361, *Aluminium and aluminium alloys - Chemical analysis - Sampling from metal melts*

EN 14726, *Aluminium and aluminium alloys - Chemical analysis - Guideline for spark optical emission spectrometric analysis*

EN ISO 3452-1, *Non-destructive testing - Penetrant testing - Part 1: General principles (ISO 3452-1)*

EN ISO 6506-1, *Metallic materials - Brinell hardness test - Part 1: Test method (ISO 6506-1)*

EN ISO 6892-1, *Metallic materials - Tensile testing - Part 1: Method of test at room temperature (ISO 6892-1)*

EN ISO 8062, *Castings – System of dimensional tolerances and machining allowances (ISO 8062)*

EN ISO 8492, *Metallic materials - Tube - Flattening test (ISO 8492)*

EN ISO 8493, *Metallic materials - Tube - Drift-expanding test (ISO 8493)*

EN ISO 8495, *Metallic materials - Tube - Ring-expanding test (ISO 8495)*

EN ISO 8496, *Metallic materials - Tube - Ring tensile test (ISO 8496)*

ASTM B548, *Standard Test Method for Ultrasonic Inspection of Aluminium-Alloy Plate for Pressure Vessels*

ASTM B594, *Standard Practice for Ultrasonic Inspection of Aluminium-Alloy Wrought Products*

ASTM E112, *Standard Test Methods for Determining Average Grain Size*

ASTM E215, *Standard Practice for Standardizing Equipment for Electromagnetic Testing of Seamless Aluminum-Alloy Tube*

3 Terms and definitions

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

3.1
heat-treatment batch or lot
quantity of products of the same alloy or purity grade of alloy, form, thickness or cross-section and produced in the same way and heat-treated in one furnace load; or such products solution-treated and subsequently precipitation treated in one furnace load

Note 1 to entry: More than one solution-treatment batch can be included in one ageing furnace load.

Note 2 to entry: For heat treatment in a continuous furnace (vertical or horizontal), the products continuously heat-treated during a specified time (e.g. 8 h) can be considered as one heat treatment lot.

Note 3 to entry: For forgings, a heat-treatment lot may consist of a group of forgings of similar size and shape.

3.2
inspection lot
consignment, or a part thereof, submitted for inspection, comprising products of the same grade or alloy, form, thickness or cross-section, and processed in the same manner

Note 1 to entry: For forgings, an inspection lot may consist of a group of forgings of similar size and shape.

3.3
melt
quantity of molten metal that has simultaneously undergone the same preparatory treatment in the furnace before the casting operation

3.4
cast
quantity of products cast simultaneously from the same melt

3.5
casting
product at or near finished shape, formed by solidification of the metal in a mould or a die

Note 1 to entry: Pressure die-cast products are excluded from the scope of the present standard.

Note 2 to entry: The mould of concern can be a single use mould (sand) or a permanent mould (e.g. cast iron or steel).

Note 3 to entry: As pressure die casting is not of concern in the present Standard, only permanent moulds and no dies are applicable for cast products.

3.6
forging
wrought product formed by hammering or pressing, typically when hot, such as open die forging, drop or closed die forging or seamless rolled ring forging

3.7
tube
hollow, wrought product with a uniform cross-section, with only one enclosed void and with a uniform wall thickness, supplied in straight lengths or in coiled form

Note 1 to entry: Cross-sections are in the shape of circles, ovals, squares, rectangles, equilateral triangles or regular polygons and can have rounded corners, provided the inner and outer cross-sections are concentric and have the same form and orientation.

3.8
operating temperature range
temperature range at which the material is exposed during its use

4 Materials

4.1 General

The materials covered by this standard are to be used in a wide range of pressure equipment operating over diverse range of both pressure and temperature. The range of applications extends from relatively low pressure automotive equipment such as heat exchangers to heavy duty applications including unfired pressure vessels and piping used in pressure equipment. As a result, it will be necessary for the standard to detail an extensive range of aluminium product forms, alloys and tempers as follows:

— sheet, strip, plate and circles (EN 485, EN 941);

— cold drawn rod/bar and tube (EN 754);

— extruded rod/bar, tube and profiles (EN 755);

— precision profiles (EN 12020);

— extruded coiled tube (EN 13957);

— cold drawn coiled tube (EN 13958);

— forgings (EN 586);

— castings (EN 1706).

Materials (alloys and tempers), which may be used in compliance with the present standard are listed in Tables 1, A.1 and A.2, together with their welding characteristics, main field of application and operating temperature ranges.

NOTE For heat exchangers, for use in equipment not subject to the requirements of the EU directive listed in Annex ZA, other materials can be used after written agreement between supplier and purchaser.

If the pressure equipment is operating above room temperature for times exceeding 100 h, then the long time behaviour of the material according to Tables B.1 to B.4 shall be considered.

4.2 Wrought products

Applicable alloys and the chemical compositions for wrought alloys are given in Table 2. The chemical compositions of aluminium and aluminium alloys are specified in percentage by mass. Limits for impurities are expressed as maxima that also will apply to alloying elements unless expressed as a range. Aluminium is specified as a minimum for unalloyed aluminium, and as a remainder for aluminium alloys.

4.3 Cast products

Applicable alloys and the chemical compositions for cast alloys are given in Table 3. The chemical compositions of aluminium and aluminium alloys are specified in percentage by mass. Limits for impurities are expressed as maxima which also will apply to alloying elements unless expressed as a range.

5 Technical conditions for inspection and delivery

5.1 Manufacturing methods

5.1.1 General

The provisions of EN 485-1 (sheets, strips and plates), EN 941 (circles), EN 755-1 (extruded rods/bars, tubes and profiles), EN 754-1 (cold drawn rods/bars, and tubes), EN 12020-1, EN 13957, EN 13958, EN 586-1 (forgings incl. seamless rolled rings), EN 1559-1 (Founding) and EN 1559-4 (Founding) apply with the amendments and additions specified in 5.2 to 5.5 below.

Unless otherwise agreed between supplier and purchaser, the manufacturing methods used shall be left to the discretion of the supplier. In addition, there shall be no obligation on the supplier to use the same processes or process route for subsequent or similar orders.

5.1.2 Specific requirements regarding porthole extruded and/or drawn products

Regarding porthole extruded and/or drawn products, limitations for safe application of porthole extruded and/or drawn products are provided at Tables 4 and 5:

— Table 4 applies to porthole extruded tube (EN 755-8), porthole extruded and drawn tube (EN 754-8), porthole extruded hollow profiles (EN 755-9) and porthole extruded precision profiles (EN 12020) and may be used up to and including an outside diameter of 600 mm (DN 600) and a thickness (t) of maximum 20 mm

— Table 5 applies to porthole extruded coiled tube (EN 13957) and porthole extruded and drawn coiled tube EN 13958 and may be used up to and including an outside diameter 50 mm (DN 50) and a thickness (t) of maximum 5 mm.

The stated values for allowable maximum pressure (PS) and volume (V) in Tables 4 and 5 are limitations superseding those disclosed in (PED) 97/23/EC .

The purchaser and or equipment manufacturer (when different) is responsible for the design of the final equipment.

As a result, the purchaser and/ or equipment manufacturer (if different) shall, when placing an order with the supplier (material manufacturer), provide the following information to ensure that the correct Hazard Category and adequate quality assurance is applied to the particular combination of criteria:

— the type of pressure equipment being considered (vessel or piping acc. to 97/23/EC Art. 1 and intended use);

— the state of the fluid in the equipment (gas or liquid);

— the hazard group of the fluid (acc. to PED 97/23/EC Art. 9);

— design maximum pressure (PS);

— confirmation that the completed equipment assembly will be pressure tested.

The supplier (material manufacturer) shall not be liable for any issues arising from inaccurate information provided by the purchaser/equipment manufacturer.

NOTE 1 Some further comment is necessary on the methods of extrusion used for tube and hollow profiles. In particular seamless extrusion produces a product that does not contain any seams or weld lines in the product cross-section. On the other hand extruded products manufactured using a porthole or bridge die will contain at least one longitudinal weld or seam. The presence of such welds or seams can be a major concern on products that are to be used for e.g. pressure vessels since the weld/seam could lead to premature failure of the vessel under pressure.

NOTE 2 In addition despite rigorous process control during the extrusion process, there is no definitive non-destructive test method that can provide total assurance of the integrity of the welds in the product cross-section. In view of the safety implications of using porthole products, it is necessary to provide guidelines in this standard as to the permitted product areas where porthole products may or may not be used.

NOTE 3 It needs to be highlighted that, beside the limits for nominal size DN and thickness t, Tables 4 and 5 provide additional limitations regarding pressure PS, volume V and testing procedures. The equipment supplier can decide to use porthole extrusion for products exceeding the stated limits/hazard categories, but this can only be done after written agreement between supplier and purchaser, and provided that adequate quality assurance/testing procedures are agreed.

5.1.3 Quality control

The manufacturer/supplier shall be responsible for the performance of all inspection and tests required by the relevant European standard and/or the particular specification prior to shipment of the product. If the purchaser wishes to carry out an inspection prior to shipment, this shall be agreed with the supplier and the request shall be stated on the original order.

5.2 Orders or tenders

The order or tender documents shall define the product required and contain the following minimum information:

a) the type and form of the product. In the case of tube whether extruded, cold drawn or coiled, it is also essential to state the method of extrusion to be used i.e. seamless or porthole (see also point i) below);

b) reference to this particular Standard EN 12392;

c) the dimensions and shape of the particular product required;

1) plate: thickness, width and length;

2) sheet: thickness, width and length;

3) strip: thickness width and coil dimensions;

4) circles: thickness and diameter;

5) round tube: method of production, outside (OD) or inside (ID) diameter, wall thickness (WT), and length;

NOTE 1 Two of the OD/ID/WT dimensions may be given tolerances but not all three.

6) coiled round tube: outside (OD) or inside (ID) diameter, wall thickness (WT), coil dimensions and tube length if required in straight lengths;

NOTE 2 Two of the OD/ID/WT dimensions may be given tolerances but not all three.

7) round bar: diameter and length;

8) square and hexagonal bar: width across flats and length;

9) rectangular bar: width, thickness and length;

10) extruded profiles and hollow sections: drawing of cross section and length;

11) forgings (open-die forgings, closed-die forgings and seamless rolled rings): reference to drawing or finished size;

12) castings: reference to a drawing.

d) the product tolerances on dimensions and form together with particular reference to the relevant European standard for the specific product concerned;

e) quantity required: whether it is weight, number of pieces, total length and the quantity tolerance on the total amount of the order;

f) product certification requirement with particular reference to EN 10204:2004;

g) identification marking requirements;

h) surface finish requirements particularly details of any surface treatments to be carried out;

i) the order shall clearly show if the ordered product is to be produced by the porthole extrusion method. In case of porthole extrusion, additional information as expressed in 5.1.2 shall be provided;

j) any other special requirements agreed between supplier and purchaser (e.g. grain size). Reference to design standard, test methods, test frequency, reference to drawings, part numbers or any other special requirements;

This applies to particular requirements such as flattening test, leak test, ultrasonic test, etc., which shall be expressly stated together with the criteria to which the material shall be verified.

k) any additional inspection to be carried out prior to delivery;

l) surface protection oil requirements;

m) packaging methods to be used.

5.3 Test procedures

5.3.1 General

This subclause covers only chemical composition and tensile / hardness testing which are common to all the products. The remaining test procedures and methods are given in the sections dealing with the individual products.

Regarding the standards to be used for testing, the EN or EN ISO standards shall be used whenever possible. However, other standards such as ASTM may be used when EN or EN ISO are either not available or not considered as appropriate.

Unless otherwise specified by the contracting parties and stated on the order, the following minimum test frequencies shall apply.

5.3.2 Chemical analysis of the melt

The samples for chemical analysis shall be taken at the time of casting or melting in accordance with EN 14361 and EN 14726. At least one specimen shall be taken from each melt. The methods of analysis used should be at the discretion of the supplier or by agreement between the supplier and purchaser.

For castings, chemical analysis shall be carried out on samples taken from the same melt as the castings; the samples shall be cooled quickly enough to minimize any segregation effects. The frequency of sampling will depend on the particular process of concern and shall therefore be agreed between the supplier and purchaser. The frequency, for example, may vary from one sample per charge to one sample per piece or per shift.

5.3.3 Tensile and hardness testing

The methods used shall be in compliance with EN ISO 6892-1 for tensile testing and EN ISO 6506-1 for Brinell hardness testing. Other methods of hardness testing e.g. Webster method may be used subject to agreement between supplier and purchaser. This agreement shall also include the frequency of testing and the minimum acceptable value for that particular method.

Tensile testing shall be carried out as specified in EN 485-1, EN 754-1, EN 755-1, EN 586 1, EN 1559-1, or EN 1559-4, as applicable, noting the following:

a) frequency of test:

   1) for sheet, strip and plate at least one test-piece shall be taken from each cast represented in each inspection lot, or heat-treatment lot where applicable, of 10 000 kg or part thereof. For single plate or coil weighing more than 10 000 kg each, only one test-piece per plate or coil shall be taken;

   2) for extruded or extruded and cold drawn products;

      i) for profiles and hollow sections having a nominal mass of up to and including 1 kg/m, a minimum of one test piece shall be taken from each cast represented in each inspection or heat treatment lot of 1000 kg or part thereof.

      ii) for profiles and hollow sections having a nominal mass of over 1 kg/m and up to 5 kg/m, a minimum of one test piece shall be taken from each cast represented in each inspection or heat treatment lot of 2000 kg or part thereof.

3) for extruded and cold drawn tube (in straight lengths or coiled);

   i) for tube produced by the porthole extrusion method, a minimum of one tensile test shall be taken for every 1000 kg or part thereof for each inspection or heat treatment lot.

   ii) for tube produced by the seamless extrusion method to be used for heavy duty applications, unfired pressure vessels, or piping used in pressure equipment, a minimum of two tensile tests shall be taken for each 1000 kg or part thereof for each cast represented in every inspection or heat treatment lot.

4) for forgings including seamless rolled rings;

   i) for forgings weighing up to 2 kg at least one test piece shall be taken from each inspection lot or heat treatment lot of 1000 kg or part thereof;

   ii) for forgings weighing over 2 kg and up to and including 10 kg, a minimum of one test piece shall be taken from each inspection or heat treatment lot of 2000 kg or part thereof;

   iii) for forgings weighing over 10 kg, a minimum of one test piece shall be taken from each inspection or heat treatment lot of 3000 kg or part thereof.

5) for castings;

   Depending on agreement between supplier and purchaser, this can be:

   i) one test piece for each part;

   ii) one test piece for each melting charge in case of temper designation “F”;

   iii) one test piece for each melting charge and heat treatment lot.

   It is essential that the supplier and purchaser shall agree on the position, orientation, dimensions and cooling rate of the tensile test pieces. Depending on this agreement, the test pieces may be cast:

   — separately from the castings but from the same melt and in a special mould (made from the same material as the castings themselves);

   — at the same time as the castings i.e. the test piece is attached to the casting itself.

   i) If test pieces are taken from castings, then their geometry, location, test frequency and relevant values shall be agreed between supplier and purchaser before starting the production. Test pieces should be taken from areas with a wall thickness between 5 and 25 mm.

   ii) For round test pieces the minimum diameter shall be 4,0 mm. Refer to the footnotes in Tables 36 and 37 for yield strength, tensile strength values and for elongation values.

   In both cases, the cooling rate of the test samples shall be adjusted to achieve a microstructure compatible with the castings particularly in critical areas which may be subject to subsequent heat treatment.

   The minimum tensile values required shall be in accordance with this Standard and these values shall be used in conjunction with the design standard for the particular casting in

question. Mechanical properties at specified positions in the part may be adjusted by the foundry to higher values as the minimal values given in Table 36 and 37. These positions shall be agreed between supplier and purchaser before the start of the production.

b) yield strength measurement:

1) Rp0,2 shall be measured for all alloys, and

2) for aluminium grades EN AW-1080A, EN AW-1070A and EN AW-1050A, in temper O, H111 or H112, Rp1,0 (proof stress at 1 % permanent elongation) shall also be measured. Results shall meet the requirements specified in Table 6.

5.3.4 Specific test procedures by product form

5.3.4.1 Sheet, strip, plate and circle

5.3.4.1.1 Bend test

When specified and agreed between supplier and purchaser, a bend test shall be carried out in accordance with EN 485-1.

5.3.4.1.2 Internal quality for rolled plate

When specified by the purchaser in the order, plate 12,5 mm in thickness and greater shall be ultrasonically tested in accordance with a method and to criteria agreed upon between supplier and purchaser; EN 4050-1 to 4 may be used as a guideline.

As an alternative and when specified and agreed between supplier and purchaser, ultrasonic testing shall be carried out in accordance with ASTM B594 or ASTM B548. Acceptance criteria have to be agreed between supplier and purchaser.

5.3.4.2 Extruded and cold drawn rod/bar, tube and coiled tube and profile (seamless and porthole products)

5.3.4.2.1 Weld integrity test for porthole extruded and porthole extruded/drawn products

Mandatory tests shall be carried out at both the extrusion stage and at inspecting a lot of the final product, according to 5.1.2. The weld integrity can be performed either by expansion/flaring test according to 5.3.4.2.6 and/or by ring tensile test according to 5.3.4.2.7.

The frequency of testing shall be specified between supplier and purchaser according to the relevant hazard category, following the recommendations of Tables 4 and 5.

5.3.4.2.2 Eddy current test

When specified, tubes shall be tested by Eddy current testing in accordance with ASTM E215.

Each tube in the inspection lot shall be tested all along the length (as noted in the relevant standards, it is not possible to check a proportion of the tube at the tube ends).

5.3.4.2.3 Ultrasonic testing

When specified, tubes shall be tested by Ultrasonic testing in accordance with EN 4050 series or ASTM B594.

Each tube in the inspection lot shall be tested along the complete tube length according to criteria to be agreed between supplier and purchaser.

5.3.4.2.4 Grain size measurement

When specified, grain size measurement test shall be carried out in accordance with ASTM E112.

The frequency of testing and the maximum grain size value shall be agreed between supplier and purchaser.

5.3.4.2.5 Flattening test

When specified, tubes with a wall thickness not exceeding 10 % of the outside diameter shall be tested by the flattening test in accordance with test method in EN ISO 8492 and Table 7 in this standard.

The test shall be carried out on one full section ring from one end of 10 % of the tubes in the inspection lot.

5.3.4.2.6 Expanding/Flaring test

When specified, tubes or tubular profiles (e.g. star profiles) shall be tested by the Drift expanding test in accordance with EN ISO 8493 and Table 8 of this Standard EN 12392, or the Ring expanding test in accordance with EN ISO 8495.

For porthole products the Ring tensile test in accordance with EN ISO 8496 can be specified as an integrity test for the extrusion seams according to 5.1.2 and 5.3.4.3.1. In such cases additional requirements to those of EN ISO 8493, Table 8 or EN ISO 8495 can be agreed between supplier and purchaser (e.g. higher expansion rates; appearance of the crack surface).

For porthole products the frequency of testing shall be dependent on the relevant hazard category, following the recommendations in Tables 4 and 5.

For seamless products the frequency of testing shall be agreed between supplier and purchaser.

5.3.4.2.7 Ring tensile test

When specified, tubes with an outside diameter greater than 146mm shall be tested by a Ring tensile test in accordance with EN ISO 8496.

For porthole products, a Ring tensile test can be specified as integrity test for the extrusion seams according to 5.1.2 and 5.3.4.3.1. In such cases additional requirements to those of EN ISO 8496 can be agreed between supplier and purchaser (e.g. positions of the extrusion seams; appearance of the crack surface).

For porthole tubes, the frequency of testing shall be specified in dependence of the relevant hazard category, following the recommendations in Table 4 and Table 5.

For seamless tubes the frequency of testing shall to be agreed between supplier and purchaser.

5.3.4.2.8 Charpy pendulum impact test

When specified, Charpy pendulum impact test shall be carried out in accordance with EN ISO 148-1.

The frequency of testing shall be agreed between supplier and purchaser.

5.3.4.2.9 Leak test

When specified, seamless or porthole tubes with an outside diameter of 38 mm or less shall be tested for leaks by one of the following methods at the option of the supplier:

— Method 1: Pneumatically at no less than 0,40 MPa air pressure while immersed in water or other suitable liquid. Any evidence of leakage shall be cause for rejection;

— Method 2: Pneumatically at no less than 0,60 MPa air pressure with a gauge that will indicate loss of pressure. There shall not be any loss of pressure during a test period of at least 15 s duration, and

— Method 3: Eddy current testing according to 5.3.4.2.2 or ultrasonic inspection according to 5.3.4.2.3 can be used.

Specification of test equipment and test conditions shall be subject to agreement between supplier and purchaser.

Each tube in the inspection lot shall be tested.

5.3.4.3 Forgings

5.3.4.3.1 Ultrasonic testing

When specified, ultrasonic testing shall be carried out according to ASTM B594 or EN 4050 series, according to criteria agreed upon between supplier and purchaser.

5.3.4.3.2 Surface inspection of forgings

When specified by the purchaser or on the order, all hand or die forgings shall be visually inspected on all their surface, using one of the following methods:

— pickling;

— pickling and chromic anodizing followed by a cold water rinse according to EN 2101;

— liquid penetrant inspection according to EN ISO 3452-1.

The test method to be used shall be indicated on the order. The surface of the forging shall be free from defects prejudicial to its use such as cracks, cold shuts, etc. However, reference standards for such defects shall be agreed between supplier and purchaser.

5.3.4.4 Castings

5.3.4.4.1 Visual inspection

Unless otherwise agreed, any surface inspection shall be carried out visually with the unaided eye or at a magnification of x6 maximum. The types and acceptance levels of surface defects shall be defined and agreed between the supplier and purchaser. In certain conditions, surface roughness measurements and/ or limit samples may be appropriate e.g. EN 1370.

5.3.4.4.2 Dye penetrant testing

When specified, dye penetrant testing shall be carried out in accordance with EN 1371-1 or EN ISO 3452-1.

5.3.4.4.3 Radiographic testing

When it is specified, radiographic testing shall be carried out in accordance with EN 12681.

5.3.4.4.4 Ultrasonic testing

When specified, ultrasonic testing shall be carried out according to a method agreed between supplier and purchaser.

5.3.4.4.5 Leak testing

When specified, leak testing shall be carried out in accordance with EN 1779 or any other method agreed between supplier and purchaser.

5.3.5 Other tests

Other tests such as pressure test and impact strength test for thick walled products shall be defined by written agreement between supplier and purchaser.

5.4 Inspection documents

Unless otherwise agreed between supplier and purchaser and stated on the order, an inspection test certificate of type 3.1 shall be provided, as described in EN 10204:2004 and shall be specified on the original order. Additional and independent inspection and certification shall be agreed between supplier and purchaser, in accordance with EN 10204:2004.

Results from specific tests agreed between supplier and purchaser shall be included in the inspection documents.

5.5 Marking

Marking of products shall be undertaken when requested by the purchaser and agreed upon by the supplier and shall be included in the order documents. The marking shall allow complete traceability back to all manufacturing data and records.

When specified, products shall be marked a supplier symbol, the alloy and temper designations, an identification number traceable to the cast number, or when applicable to the charge number or heat-treatment lot number. Any other information can be included subject to agreement between the supplier and purchaser.

When marking is specified and unless otherwise stipulated, the marking shall be permanently legible and applied by means of punches, painting, ink or cast on. The method of marking shall not adversely affect the final use of the product (eg punching may not be appropriate for thin sheet or thin wall tube). Where paint or ink is used for marking, paints or inks that are insoluble in water shall be employed. Roll-stamping or ink marking along the entire product length is acceptable.

Where tubes, bars or profiles are delivered in bundles, it is permissible, instead of individual marking of the products, for the bundles to be marked as lots through the attachment of a tag.

5.6 Packaging

Unless otherwise stated in the European standard specific to the given product or specified in the order documents concerned, the supplier shall take all reasonable precautions to ensure that the products shall be delivered in a condition suitable for use and consistent with the method of transportation selected by the supplier and/ or purchaser.

6 Mechanical properties

6.1 Mechanical properties at room temperature

6.1.1 General

For wrought and cast products all hardness values quoted are for information only unless otherwise agreed between supplier and purchaser.

It is important to recognize that welding of products delivered in all strain hardened tempers (e.g. H**) or heat treated tempers (T** and T***) will result in a significant change (most often a reduction) in mechanical properties as a result of any welding operation.

6.1.2 Sheet, strip, plate and circle

Mechanical property limits for sheet, strip, plate and circle are given in Table 9 to Table 34.

6.1.3 Extruded rod/bar, tube, coiled tube and profile

Mechanical property limits for extruded rod/bar, tube, coiled tube and profile are given in EN 755-2.

6.1.4 Cold drawn rod/bar, tube and coiled tube

Mechanical property limits for cold drawn rod/bar and tube and coiled tube are given in EN 754-2.

6.1.5 Forgings

Mechanical property limits for forgings are given in Table 35.

6.1.6 Castings

Mechanical property limits for castings are given in Tables 36 and 37.

6.2 Low and elevated temperature properties

Low and elevated temperature properties for wrought and cast alloys are given in Tables B.1 to B.4.

The low temperature values are shown for a temperature range of −273 °C to 20 °C.

In Tables B.1 and B.2 regarding wrought products, the property values for elevated temperatures show 1,0 % or 0,2 % proof stress values for temperatures between 20 °C and 150 °C for 1 h at temperature, as well as average 10 000 h and 100 000 h creep rupture strength values (R_{km10}^4 and R_{km10}^5) for temperatures between 75 °C and 200 °C.

In Tables B.3 and B.4 regarding cast products, the property values for elevated temperatures show ultimate tensile strength and 0,2 % proof stress values for temperatures between 20 °C and 200 °C for 1 h at temperature.

All the values in Tables B.1 to B.4 are given for informational purposes only and are not guaranteed nor can they be used as a basis for acceptance or rejection.

The compiled values are based upon a critical review of authoritative published data available at the time of drafting this standard.

The values shown in the tables are considered typical for a product thickness range of 6 mm to 12,5 mm for wrought products and 7 mm to 25 mm for cast products respectively.

Nominal design strength values may be established from this data after application of the appropriate safety coefficients relevant to the pressure equipment standards of the equipment under consideration.

The elevated temperature proof stress (Rp0,2 and/or Rp1,0) values given in Tables B.1 to B.4 are appropriate to materials having the minimum proof stress values at ambient temperature shown for instance in column 4 of Tables B.1 or B.2, or column 6 of Tables B.3 or B.4. If the minimum values of the proof stress specified in the applicable standard (as per 6.1) is less or higher than that given in Tables B.1 to B.4. for the same alloy and temper type, the elevated temperature property values for temperature up to 150 °C shall be reduced or increased proportionately.

EXAMPLE Extruded bar in alloy EN AW-5083, temper O.

In EN 755-2 minimum $R_{p0,2}$ is specified as 110 MPa for extruded bar.

Table B.2 quotes a minimum $R_{p0,2}$ value of 125 MPa at ambient temperature and of 119 MPa at 100 °C.

$R_{p0,2}$ value to be used at 100 °C for extruded bar shall be:

$$119 \times \frac{110}{125} = 105 \text{ MPa}$$

Values for intermediate temperatures not shown in the table shall be obtained by interpolation between the two nearest temperatures quoted, the result being rounded to the nearest full unit.

The strength values given for ambient temperature apply to pressure equipment operated in the temperature range - 273 °C to + 20 °C as shown in Tables B.1 to B.4.

7 Tolerances on dimensions and form

7.1 Sheet, strip, plate and circle

Tolerances on dimensions and form for sheet, strip, plate and circle are specified in the following European Standards: EN 485-3, EN 485-4, EN 941.

7.2 Extruded rod/bar, tube, coiled tube and profile

Tolerances on dimensions and form for extruded rod/bar, tube and profile are specified in the following European Standards: EN 755-3, EN 755-4, EN 755-5, EN 755-6, EN 755-7, EN 755-8, EN 755-9, EN 13957, EN 12020-2.

7.3 Cold drawn rod/bar, tube and coiled tube

Tolerances on dimensions and form for cold drawn rod/bar and tube are specified in the following European Standards: EN 754-3, EN 754-4, EN 754-5, EN 754-6, EN 754-7, EN 754-8, EN 13958.

7.4 Forgings

Tolerances on dimensions and form for forgings are specified in the European Standard EN 586-3.

7.5 Castings

Tolerances on dimensions and form for castings are specified in the European Standard EN ISO 8062.

Table 1 — List of alloys – tempers – product forms - wrought products

	Temper	Product forms						
Alloy designation	**designation**	**Sheet, strip, plate and circle**	**Extruded rod/bar**	**Extruded profile**	**Extruded tube**	**Cold drawn rod/bar**	**Cold drawn tube**	**Forgings**
EN AW-1050A [Al 99,5]	O/H111	X	X	-	X	X	X	-
	H112	X	X	X	X	-	-	X
	H12	-	-	-	-	X	X	-
	H14	-	-	-	-	X	X	-
EN AW-1070A [Al 99,7]	O/H111	X	X	-	-	-	-	-
	H112	X	X	-	-	-	-	-
EN AW-1080A [Al 99,8(A)]	O/H111	X	-	-	-	-	-	-
	H112	X	-	-	-	-	-	-
EN AW-2014A [Al Cu4SiMg]	T6	X	X	X	X	X	X	-
EN AW-2017A [Al Cu4MgSi(A)]	T3	-	-	-	-	X	X	-
	T4	X	X	X	X	-	-	-
EN AW-2024 [Al Cu4Mg1]	T3	X	X	X	X	X	X	-
	T4	X	-	-	-	-	-	-
EN AW-3003 [Al Mn1Cu]	O/H111	X	X	-	X	X	X	-
	H112	X	X	X	X	-	-	X
	H12	X	-	-	-	X	X	-
	H14	X	-	-	-	X	X	-
	H18	X	-	-	-	X	X	-
EN AW-3103 [Al Mn1]	O/H111	X	X	-	X	X	X	-
	H112	X	X	X	X	-	-	-
	H12	X	-	-	-	X	X	-
	H14	X	-	-	-	X	X	-
	H18	X	-	-	-	X	X	-
EN AW-3105 [Al Mn0,5Mg0,5]	O/H111	X	-	-	-	-	-	-
	H112	X	-	-	-	-	-	-
	H12	X	-	-	-	-	-	-
	H14	X	-	-	-	-	-	-
	H18	X	-	-	-	-	-	-
EN AW-5005 [Al Mg1(B)]	O/H111	X	X	-	X	X	X	-
	H12	-	X	X	X	-	-	-
EN AW-5005A [Al Mg1(C)]	O/H111	X	X	-	X	X	X	-
	H12	-	X	X	X	-	-	-
EN AW-5042 [EN AW-Al Mg3,5Mn]	O	X	-	-	-	-	-	-
EN AW-5049 [Al Mg2Mn0,8]	O/H111	X	-	-	X	-	X	-
	H112	X	-	-	-	-	-	-
	H12	-	-	-	-	X	X	-
	H14	-	-	-	-	X	X	-
EN AW-5050 [Al Mg1,5(C)]	O/H111	X	-	-	-	-	-	-
	H112	X	-	-	-	-	-	-

	Temper	Product forms						
Alloy designation	**designation**	**Sheet, strip, plate and circle**	**Extruded rod/bar**	**Extruded profile**	**Extruded tube**	**Cold drawn rod/bar**	**Cold drawn tube**	**Forgings**
EN AW-5052 [Al Mg2,5]	O/H111	X	X	-	X	X	X	-
	H112	X	X	X	X	-	-	-
EN AW-5059 [EN AW-Al Mg5,5MnZnZr]	O/H111	X	-	-	-	-	-	-
	H112	X	-	-	-	-	-	-
EN AW-5083 [Al Mg4,5Mn0,7]	O/H111	X	X	-	X	X	X	-
	H112	X	X	X	X	-	-	X
EN AW-5086 [Al Mg4]	O/H111	X	X	-	X	X	X	-
	H112	X	X	X	X	-	-	-
EN AW-5088 [EN AW-Al Mg5Mn0,4]	O/H111	X	-	-	-	-	-	-
	H112	X	-	-	-	-	-	-
EN AW-5154A [Al Mg3,5(A)]	O/H111	X	X	-	X	X	X	-
	H112	X	X	X	X	-	-	-
EN AW-5251 [Al Mg2Mn0,3]	O/H111	X	X	-	X	X	X	-
	H112	-	X	X	X	-	-	-
EN AW-5383 [EN AW-Al Mg4,5Mn0,9]	O/H111	X	-	-	-	-	-	-
	H112	X	-	-	-	-	-	-
EN AW-5454 [Al Mg3Mn]	O/H111	X	X	-	X	-	-	-
	H112	X	X	X	X	-	-	-
EN AW-5456 [EN AW-Al Mg5Mn1]	O/H111	X	-	-	-	-	-	-
EN AW-5754 [Al Mg3]	O/H111	X	X	-	X	X	X	-
	H112	X	X	X	X	-	-	-

Alloy designation	Temper designation	Product forms						
		Sheet, strip,plate and circle	Extruded rod/bar	Extruded profile	Extruded tube	Cold drawn rod/bar	Cold drawn tube	Forgings
EN AW-6005A	T4	-	X	X	X	-	-	–
	T6	-	X	X	X	-	-	–
EN AW-6060 [Al MgSi]	T4	-	X	X	X	X	X	-
	T6	-	X	X	X	X	X	-
	T8	-	-	-	-	X	X	-
EN AW-6061 [Al Mg1SiCu]	T4	X	X	X	X	X	X	-
	T6	X	X	X	X	X	X	X
EN AW-6063 [Al Mg0,7Si]	T4	-	X	X	X	X	X	-
	T6	-	X	X	X	X	X	-
	T8	-	-	-	-	X	X	-
EN AW-6063A [Al Mg0,7Si(A)]	T4	-	X	X	X	X	X	-
	T6	-	X	X	X	X	X	-
	T8	-	-	-	-	X	X	-
EN AW-6082 [Al Si1MgMn]	T4	X	X	X	X	X	X	-
	T6	X	X	X	X	X	X	X
	T8	-	-	-	-	X	X	-
EN AW-6106 [Al MgSiMn]	T4	-	X	X	X	-	-	-
	T5	-	-	X	-	-	-	-
	T6	-	X	X	X	-	-	-
	T8	-	-	-	-	X	X	-
EN AW-6351 [Al SiMg0,5Mn]	T4	-	X	X	X	-	-	-
	T6	-	X	X	X	-	-	-

Legend

X available product form

NOTES

In the column “Temper designation”, T4 shall also indicate T451, T4511, T4510 etc. Similar extensions are intended for T3, T6 and T8.

For extruded and extruded/drawn products, refer to EN 754–2 and EN 755–2 for relevant tempers

Tempers T42 and T62 are laboratory tempers to demonstrate that O or T4 temper will meet the specified values of T4 and T6 tempers after the appropriate heat treatment. This requirement shall be agreed between supplier and purchaser.

Table 2 — Wrought products - Chemical composition limits

Materials to be used for welded components shall be produced from rolling or extrusion ingots with a hydrogen level no greater than 0,2 ml per 100 g aluminium, measured on liquid metal during casting or through a method to be agreed between supplier and purchaser.

They shall have a lead content not exceeding 0,0150 % or 150 ppm (or 150µg/g). For particularly safety-sensitive applications (e.g. high volumes at high pressure), it is recommended that lower values be agreed upon between supplier and purchaser.

Alloy designation		Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V	Remarks	Others [a]		Aluminium
Numerical	Chemical symbols													Each	Total [b]	min.
EN AW-1050A	EN AW-Al 99,5	0,25	0,40	0,05	0,05	0,05	-	-	0,07	0,05	-	-	-	0,03	-	99,50 [c]
EN AW-1070A	EN AW-Al 99,7	0,20	0,25	0,03	0,03	0,03	-	-	0,07	0,03	-	-	-	0,03	-	99,70 [c]
EN AW-1080A	EN AW-Al 99,8(A)	0,15	0,15	0,03	0,02	0,02	-	-	0,06	0,02	0,03	-	d	0,02	-	99,80 [c]
EN AW-2014A	EN AW-Al Cu4SiMg(A)	0,50–0,9	0,50	3,9–5,0	0,40–1,2	0,20–0,8	0,10	0,10	0,25	0,15	-	-	0,20 Zr+Ti	0,05	0,15	Remainder
EN AW-2017A	EN AW-Al Cu4MgSi(A)	0,20–0,8	0,7	3,5–4,5	0,40–1,0	0,40–1,0	0,10	-	0,25	-	-	-	0,25 Zr+Ti	0,05	0,15	Remainder
EN AW-2024	EN AW-Al Cu4Mg1	0,50	0,50	3,8–4,9	0,30–0,9	1,2–1,8	0,10	-	0,25	0,15	-	-	e	0,05	0,15	Remainder
EN AW-3003	EN AW-Al Mn1Cu	0,6	0,7	0,05–0,20	1,0–1,5	-	-	-	0,10	-	-	-	-	0,05	0,15	Remainder
EN AW-3103	EN AW-Al Mn1	0,50	0,7	0,10	0,9–1,5	0,30	0,10	-	0,20	-	-	-	0,10 Zr+Ti[d]	0,05	0,15	Remainder
EN AW-3105	EN AW-Al Mn0,5Mg0,5	0,6	0,7	0,30	0,30–0,8	0,20–0,8	0,20	-	0,40	0,10	-	-	-	0,05	0,15	Remainder
EN AW-5005	EN AW-Al Mg1(B)	0,30	0,7	0,20	0,20	0,50–1,1	0,10	-	0,25	-	-	-	-	0,05	0,15	Remainder
EN AW-5005A	EN AW-Al Mg1(C)	0,30	0,45	0,05	0,15	0,7–1,1	0,10	-	0,20	-	-	-	-	0,05	0,15	Remainder
EN AW-5042	EN AW-Al Mg3,5Mn	0,20	0,35	0,15	0,20–0,50	3,0–4,0	0,10	-	0,25	0,10	-	-	-	0,05	0,15	Remainder
EN AW-5050	EN AW-Al Mg1,5(C)	0,40	0,7	0,20	0,10	1,1–1,8	0,10	-	0,25	-	-	-	-	0,05	0,15	Remainder
EN AW-5052	EN AW-Al Mg2,5	0,25	0,40	0,10	0,10	2,2–2,8	0,15–0,35	-	0,10	-	-	-	-	0,05	0,15	Remainder
EN AW-5049	EN AW-Al Mg2Mn0,8	0,40	0,50	0,10	0,50–1,1	1,6–2,5	0,30	-	0,20	0,10	-	-	-	0,05	0,15	Remainder
EN AW-5059	EN AW-Al Mg5,5MnZnZr	0,45	0,50	0,25	0,6–1,2	5,0–6,0	0,25	-	0,40–0,9	0,20	-	-	0,05–0,25Zr	0,05	0,15	Remainder
EN AW-5083	EN AW-Al Mg4,5Mn0,7	0,40	0,40	0,10	0,40–1,0	4,0–4,9	0,05–0,25	-	0,25	0,15	-	-	-	0,05	0,15	Remainder

Alloy designation		Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V	Remarks	Others [a]		Aluminium
Numerical	Chemical symbols													Each	Total [b]	min.
EN AW-5086	EN AW-Al Mg4	0,40	0,50	0,10	0,20–0,7	3,5–4,5	0,05–0,25	-	0,25	0,15	-	-	-	0,05	0,15	Remainder
EN AW-5088	EN AW-Al Mg5Mn0,4	0,20	0,10–0,35	0,25	0,20–0,50	4,7–5,5	0,15	-	0,20–0,40	-	-	-	0,15Zr	0,05	0,15	Remainder
EN AW-5154A	EN AW-Al Mg3,5(A)	0,50	0,50	0,10	0,50	3,1–3,9	0,25	-	0,20	0,20	-	-	0,10–0,50 Mn+Cr [d]	0,05	0,15	Remainder
EN AW-5251	EN AW-Al Mg2Mn0,3	0,40	0,50	0,15	0,10–0,50	1,7–2,4	0,15	-	0,15	0,15	-	-	-	0,05	0,15	Remainder
EN AW-5383	EN AW-Al Mg4,5Mn0,9	0,25	0,25	0,20	0,7–1,0	4,0–5,2	0,25	-	0,40	0,15	-	-	0,20 Zr	0,05	0,15	Remainder
EN AW-5454	EN AW-Al Mg3Mn	0,25	0,40	0,10	0,50–1,0	2,4–3,0	0,05–0,20	-	0,25	0,20	-	-	-	0,05	0,15	Remainder
EN AW-5456	EN AW-Al Mg5Mn1	0,25	0,40	0,10	0,50–1,0	4,7–5,5	0,05–0,20	-	0,25	0,20	-	-	-	0,05	0,15	Remainder
EN AW-5754	EN AW-Al Mg3	0,40	0,40	0,10	0,50	2,6–3,6	0,30	-	0,20	0,15	-	-	0,10–0,6 Mn+Cr [d]	0,05	0,15	Remainder
EN AW-6005A	EN AW-Al SiMg(A)	0,50–0,9	0,35	0,30	0,50	0,40–0,7	0,30	-	0,20	0,10	-	-	0,12–0,50 Mn+Cr	0,05	0,15	Remainder
EN AW-6060	EN AW-Al MgSi	0,30–0,6	0,10–0,30	0,10	0,10	0,35–0,6	0,05	-	0,15	0,10	-	-	-	0,05	0,15	Remainder
EN AW-6061	EN AW-Al Mg1SiCu	0,40–0,8	0,7	0,15–0,40	0,15	0,8–1,2	0,04–0,35	-	0,25	0,15	-	-	-	0,05	0,15	Remainder
EN AW-6063	EN AW-Al Mg0,7Si	0,20–0,6	0,35	0,10	0,10	0,45–0,9	0,10	-	0,10	0,10	-	-	-	0,05	0,15	Remainder
EN AW-6063A	EN AW-Al Mg0,7Si(A)	0,30–0,6	0,15–0,35	0,10	0,15	0,6–0,9	0,05	-	0,15	0,10	-	-	-	0,05	0,15	Remainder
EN AW-6082	EN AW-Al Si1MgMn	0,7–1,3	0,50	0,10	0,40–1,0	0,6–1,2	0,25	-	0,20	0,10	-	-	-	0,05	0,15	Remainder
EN AW-6106	EN AW-Al MgSiMn	0,30–0,6	0,35	0,25	0,05–0,20	0,40–0,8	0,20	-	0,10	-	-	-	-	0,05	0,10	Remainder
EN AW-6351	EN AW-Al SiMg0,5Mn	0,7–1,3	0,50	0,10	0,40–0,8	0,40–0,8	-	-	0,20	0,20	-	-	-	0,05	0,15	Remainder

[a] "Others" includes listed elements for which no specific limit is shown as well as unlisted metallic elements. The supplier may analyse samples for trace elements not specified in the registration or specification. However, such analysis is not required and may not cover all metallic "Other" elements. Should any analysis by the supplier or the purchaser establish that an "Others" element exceeds the limit of "Each" or that the aggregate of several "Others" elements exceeds the limit of "Total", the material shall be considered non-conforming.

[b] The sum of those "Others" metallic elements 0,010 % or more each, expressed to the second decimal place before determining the sum.

[c] The aluminium content for unalloyed aluminium not made by a refining process is the difference between 100,00 % and the sum of all other metallic elements present in amounts of 0,010 % or more each, expressed to the second decimal place before determining the sum.

[d] 0,0003 max. Be for welding electrode, welding rod and filler wire only.

[e] Zr + Ti limit of 0,20 maximum may be used for extruded and forged products if mutually agreed by supplier or manufacturer and purchaser.

[f] Zr + Ti limit of 0,25 maximum may be used for extruded and forged products if mutually agreed by supplier or manufacturer and purchaser.

Table 3 — Cast products - Chemical composition limits

Alloy designation		Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Pb	Sn	Ti [c]	Other each [a,b]	Other total [a,b]	Aluminium
Numerical	Chemical symbols														
EN AC-21000	EN AC-Al Cu4MgTi	0,20	0,35	4,2 to 5,0	0,10	0,15 to 0,35	-	0,05	0,10	0,05	0,05	0,15 to 0,30	0,03	0,10	Remainder
EN AC-21100	EN AC-Al Cu4 Ti	0,18	0,19	4,2 to 5,2	0,55	-	-	-	0,07	-	-	0,15 to 0,30	0,03	0,10	Remainder
EN AC-41000	EN AC-Al Si2MgTi	1,6 to 2,4	0,60	0,10	0,30 to 0,50	0,45 to 0,65	-	0,05	0,10	0,05	0,05	0,05 to 0,20	0,05	0,15	Remainder
EN AC-42100	EN AC-Al Si7Mg0,3	6,5 to 7,5	0,19	0,05	0,10	0,25 to 0,45	-	-	0,07	-	-	0,25 [d]	0,03	0,10	Remainder
EN AC-42200	EN AC-Al Si7Mg0,6	6,5 to 7,5	0,19	0,05	0,10	0,45 to 0,70	-	-	0,07	-	-	0,25 [d]	0,03	0,10	Remainder
EN AC-43000	EN AC-Al Si10Mg(a)	9,0 to 11,0	0,55	0,05	0,45	0,20 to 0,45	-	0,05	0,10	0,05	0,05	0,15	0,05	0,15	Remainder
EN AC-43300	EN AC-Al Si9Mg	9,0 to 10,0	0,19	0,05	0,10	0,25 to 0,45	-	-	0,07	-	-	0,15	0,03	0,10	Remainder
EN AC 44000	EN AC-AlSi11	10,0 to 11,8	0,19	0,05	0,10	0,45	-	-	0,07	-	-	0,15	0,03	0,10	Remainder
EN AC 44200	EN AC-AlSi12(a)	10,5 to 13,5	0,55	0,05	0,035	-	-	-	0,10	-	-	0,15	0,05	0,15	Remainder
EN AC 45500	EN AC-AlSi7Cu0.5Mg	6,5 to 7,5	0,19	0,2 to 0,7	0,10	0,20 to 0,45	-	-	0,07	-	-	0,20 [d]	0,03	0,10	Remainder
EN AC-51300	EN AC-AlMg5 [e]	0,55	0,55	0,10	0,45	4,5 to 6,5	-	-	0,10	-	-	0,20	0,05	0,15	Remainder

a In Al-Si alloys, "Others" does not include modifying or refining elements such as Na, Sr, Sb and P.
b "Others" includes all the elements which are not listed in this Table or without specific values.
c Refining agents such as Ti, B or master alloys containing nucleating particles such as TiB2 shall not be considered as impurities. Nevertheless, the minimum and maximum content of refining elements shall be agreed between supplier and purchaser.
d Minimum Ti limits are not necessary if the grain refining is not necessary or achieved by an alternative method.
e For alloys with Mg ≥ 3 %, the alloy may contain 0,01 % Be max.

Table 4 — Applicable limitations for porthole products according to EN 754, EN 755 and EN 12020 (see 5.1.2 and 5.3.4.2)

Type of equipment and fluids				Applicable limitations [f]				Applicable testing procedures [j] in dependence of hazard category			
Equipment type	Fluid state [c]	Fluid hazard group [d]	Table no. [e]	Max. DN [h] [mm]	Max. t [mm]	Max. PS [g] [bar]	Max. V [i] [litres]	I	II	III	IV
Vessel [a]	Gas	Group 1	Table 1	600	20	20	200	P1	P2	P3	N/A
		Group 2	Table 2	600	20	20	200	P1	P2	P3	N/A
	Liquid	Group 1	Table 3	600	20	200	500	P1	P2	N/A	N/A
		Group 2	Table 4	600	20	200	500	P1	N/A	N/A	N/A
Steam Generator	N/A	N/A	Table 5	-	-	-	-	-	-	-	-
Piping [b]	Gas	Group 1	Table 6	600	20	20	-	P1	P2	P3	N/A
		Group 2	Table 7	600	20	20	-	P1	P2	P3	N/A
	Liquid	Group 1	Table 8	600	20	200	-	P1	P2	N/A	N/A
		Group 2	Table 9	600	20	200	-	P1	N/A	N/A	N/A

[a] Vessels means housings designed and built to contain fluids under pressure including its direct attachments up to the coupling point connecting it to other equipment. A vessel may be composed of more than one chamber.

[b] Piping means components intended for the transport of fluids, when connected together for integration into a pressure system. Piping includes in particular a pipe or system of pipes, tubing, fittings, expansion joints, hoses, or other pressure-bearing components as appropriate. Heat exchangers consisting of pipes for the purpose of cooling or heating air shall be considered as piping.

[c] Fluids means gases, liquids and vapours in pure phase as well as mixtures thereof. A fluid may contain a suspension of solids. If the fluid has a vapour pressure at the maximum allowable temperature of the equipment of greater than 0.5 bar above normal atmospheric pressure it is treated as a gas, otherwise as a liquid.

[d] Refer to Directives 97/23/EC, Article 9 and 2014/68, Article 13.

[e] Tables/diagrams according to Directive 97/23/EC Art. 3, Annex II.

[f] Limitations applicable to porthole products, in addition to the limitations disclosed in to 97/23/EC for seamless products.

[g] Maximum allowable pressure PS means the maximum pressure for which the equipment is designed, as specified by the manufacturer. It is defined at a location specified by the manufacturer. This shall be the location of connection of protective and/or limiting devices or the top of equipment or if not appropriate any point specified.

[h] Nominal size (DN) means a numerical designation of size which is common to all components in a piping system other than components indicated by outside diameters or by thread size. It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions. The nominal size is designated by DN followed by a number.

[i] Volume (V) means the internal volume of a chamber, including the volume of nozzles to the first connection or weld and excluding the volume of permanent internal parts.

[j] Adequate (destructive) testing procedure of extrusion seam to be agreed between supplier and purchaser with the following frequency;

- P1: Front and back end of every extrusion string
- P2: Front and back end of every 6m extrusion string
- P3: Front and back end of every 3m extrusion string
- N/A: Not applicable/recommended, but can be used after written agreement between supplier and purchaser and provided, that adequate quality assurance/testing procedures are agreed and stated in the ordering document.

Footnotes [a] through [d] copied from PED 97/23EC

Table 5 — Applicable limitations for porthole extruded products according to EN 13957 and EN 13958 (see 5.1.2 and 5.3.4.2)

Type of equipment and fluids				Applicable limitations [f]				Applicable testing procedures [j] in dependence of hazard category			
Equipment type	Fluid state [c]	Fluid hazard group [d]	Table no. [e]	Max. DN [h] [mm]	Max. t [mm]	Max. PS [g] [bar]	Max. V [i] [litres]	I	II	III	IV
Vessel [a]	Gas	Group 1	Table 1	50	5	100	-	S	TBA	N/A	N/A
		Group 2	Table 2	50	5	100	-	S	TBA	N/A	N/A
	Liquid	Group 1	Table 3	50	5	500	-	S	TBA	N/A	N/A
		Group 2	Table 4	50	5	500	-	S	N/A	N/A	N/A
Steam Generator	N/A	N/A	Table 5	-	-	-	-	-	-	-	-
Piping [b]	Gas	Group 1	Table 6	50	5	100	-	S	TBA	N/A	N/A
		Group 2	Table 7	50	5	100	-	S	TBA	N/A	N/A
	Liquid	Group 1	Table 8	50	5	500	-	S	TBA	N/A	N/A
		Group 2	Table 9	50	5	500	-	S	N/A	N/A	N/A

[a] Vessels means housings designed and built to contain fluids under pressure including its direct attachments up to the coupling point connecting it to other equipment. A vessel may be composed of more than one chamber

[b] Piping means components intended for the transport of fluids, when connected together for integration into a pressure system. Piping includes in particular a pipe or system of pipes, tubing, fittings, expansion joints, hoses, or other pressure-bearing components as appropriate. Heat exchangers consisting of pipes for the purpose of cooling or heating air shall be considered as piping

[c] Fluids means gases, liquids and vapours in pure phase as well as mixtures thereof. A fluid may contain a suspension of solids. If the fluid has a vapour pressure at the maximum allowable temperature of the equipment of greater than 0,5 bar above normal atmospheric pressure it is treated as a gas, otherwise as a liquid

[d] Refer to Directives 97/23/EC, Article 9 and 2014/68, Article 13

[e] Tables/diagrams according to PED 97/23/EC Art. 3, Annex II

[f] Limitations applicable to porthole products, in addition to the limitations disclosed in to PED 97/23/EC for seamless products

[g] Maximum allowable pressure PS means the maximum pressure for which the equipment is designed, as specified by the manufacturer. It is defined at a location specified by the manufacturer. This shall be the location of connection of protective and/or limiting devices or the top of equipment or if not appropriate any point specified.

[h] Nominal size (DN) means a numerical designation of size which is common to all components in a piping system other than components indicated by outside diameters or by thread size. It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions. The nominal size is designated by DN followed by a number.

[i] Volume (V) means the internal volume of a chamber, including the volume of nozzles to the first connection or weld and excluding the volume of permanent internal parts.

[j] Adequate (destructive) testing procedure of extrusion seam to be agreed between supplier and purchaser with the following frequency;

- TBA: To be agreed for tubes supplied in coils or lengths produces from coil
- S: Standard testing without specific restrictions
- N/A: Not applicable/recommended, but can be used after written agreement between supplier and purchaser and provided, that adequate quality assurance/testing procedures are agreed and stated in the ordering document.

Table 6 — Mechanical properties for unalloyed aluminium in tempers O, H111 or H112

Product form	**Alloy designation**	**Size range**[a]	$R_{p1,0}$ MPa
		mm	min.
Sheet, strip, plate and circle	EN AW-1080A [Al 99,8(A)]	$0,2 < t \leq 12,5$	22
	EN AW-1070A [Al 99,7]	$0,2 < t \leq 12,5$	25
	EN AW-1050A [Al 99,5]	$0,2 < t \leq 50$	30
Extruded rod/bar	EN AW-1050A [Al 99,5]	All	30
Extruded tube	EN AW-1050A [Al 99,5]	All	30
Cold drawn rod/bar	EN AW-1050A [Al 99,5]	$D \leq 80$ or $S \leq 60$	30
Cold drawn tube	EN AW-1050A [Al 99,5]	$t \leq 20$	30

a *D*: Diameter of round bar.
S: Width across flat for square and hexagonal bar, thickness of rectangular bar.
t: Thickness of sheet, strip and plate, wall thickness of tube

Table 7 — Flattening test - Specified H values

(dimensions in mm)

Alloy designation	Temper designation	Wall thickness *t*		Specified minimum *H* values
		Over	up to and including	
EN AW-1050A [Al 99,5] EN AW-1070A [Al 99,7] EN AW-1080A [Al 99,8(A)]	O/H111/H112	0,32	12,5	2 *t*
EN AW-2014A [Al Cu4SiMg]	T6	0,45	12,5	10 *t*
EN AW-2017A [Al Cu4MgSi(A)]	T4	0,45	12,5	8 *t*
EN AW-2024 [Al Cu4Mg1]	T3 T4	0,45	12,5	8 *t*
EN AW-3003 [Al Mn1Cu]	O/H111/H112	0,63	12,5	2 *t*
EN AW-3103 [Al Mn1] EN AW-3105 [Al Mn0,5Mg0,5]	H12	0,63	12,5	3 *t*
EN AW-5005 [Al Mg1(B)] EN AW-5005A [Al Mg1(C)] EN AW-5042 [EN AW-Al Mg3,5Mn] EN AW-5049 [Al Mg2Mn0,8] EN AW-5050 [Al Mg1,5(C)] EN AW-5052 [Al Mg2,5] EN AW-5083 [Al Mg4,5Mn0,7] EN AW-5086 [Al Mg4] EN AW-5154A [Al Mg3,5(A)] EN AW-5454 [Al Mg3Mn] EN AW-5754 [Al Mg3]	O/H111/H112	0,25	11,5	3 *t*
EN AW-6060 [Al MgSi] EN AW-6063 [Al Mg0,7Si]	T4	0,63	12,5	4 *t*
EN AW-6063A [Al Mg0,7Si(A)] EN AW-6106 [Al MgSiMn]	T6 T8	0,63	12,5	8 *t*
EN AW-6061 [Al Mg1SiCu]	T4	0,36	12,5	6 *t*
EN AW-6351 [Al SiMg0,5Mn] EN AW-6082 [Al SiMgMn]	T6 T8	0,36	12,5	8 *t*
-Legend *H* Distance between plates *t* Wall thickness				
In the column “Temper designation”, T4 T4 shall also indicate T451, T4511, T4510 etc. Similar extensions are intended for T3, T6 and T8.				
NOTE For extruded and extruded/drawn products, refer to EN 754–2 and EN 755–2 for relevant tempers.				

Table 8 — Flaring test - Specified C values

Specified outside diameter *D*	Class A		Class B	
	***C* values**	**Expansion**	***C* values**	**Expansion**
mm	mm	%	mm	%
3,2	4,50	40	4,32	35
4,0	5,60	40	5,40	35
6,0	8,40	40	8,10	35
8,0	10,40	30	10,00	25
10,0	13,00	30	12,50	25
12,0	15,60	30	15,00	25
14,0	18,20	30	17,50	25
16,0	20,00	25	19,20	20
18,0	22,50	25	21,60	20
20,0	25,00	25	24,00	20
25,0	30,00	20	28,75	20
32,0	38,40	20	36,80	15
40,0	48,00	20	46,00	15
50,0	57,50	15	55,00	10
63,0	72,45	15	69,30	10
70,0	80,50	15	77,00	10
80,0	92,00	15	88,00	10
90,0	103,50	15	99,00	10
100,0	115,00	15	110,00	10
For a non listed tube of diameter D_1, use the diameter D from the table which immediately precedes the diameter D_1 to determine X from : X = (C-D)/D. Use X to establish the applicable C_1 value from: C_1 = D1(1 + X) where C_1 is the expanded diameter of the non listed tube. D: outside diameter before flaring.C: maximum outside diameter after flaring.Class A: applies to O and Hxxx and T4 type (naturally aged) tempers. Class B: applies to T6 type (artificially aged) tempers				
In the column “Temper designation”, T4 shall also indicate T451, T4511, T4510 etc. Similar extensions are intended for T3, T6 and T8				
NOTE For extruded and extruded/drawn products, refer to EN 754–2 and EN 755–2 for relevant tempers.				

Table 9 — Aluminium EN AW-1050A [Al 99,5] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$[a] MPa		Elongation min. %		Bend radius[a]		Hardness HBW[b]
	over	up to	min.	max.	min.	max.	$A_{50\,mm}$	A	180°	90°	
O	0,2	0,5	65	95	20	55	26		0 t	0 t	20
	0,5	1,5	65	95	20	55	28		0 t	0 t	20
	1,5	3,0	65	95	20	55	30		0 t	0 t	20
	3,0	6,0	65	95	20	55	35		0,5 t	0,5 t	20
	6,0	12,5	65	95	20	55	35		1,0 t	1,0 t	20
	12,5	25	65	95	20	55		35			20
H111	0,2	0,5	65	95	20	55	26		0 t	0 t	20
	0,5	1,5	65	95	20	55	28		0 t	0 t	20
	1,5	3,0	65	95	20	55	30		0 t	0 t	20
	3,0	6,0	65	95	20	55	35		0,5 t	0,5 t	20
	6,0	12,5	65	95	20	55	35		1,0 t	1,0 t	20
	12,5	25	65	95	20	55		35			20
H112	≥ 3,0	12,5	75		30		20				23
	12,5	50,0	75		25			20			22

a $Rp_{1.0}$ values also apply (see Table 6)

b For information only

Table 10 — Aluminium EN AW-1070A [Al 99,7] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2a}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[b]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O	0,2	0,5	60	90	15	50	30		0 t	0 t	18
	0,5	1,5	60	90	15	50	32		0 t	0 t	18
	1,5	3,0	60	90	15	50	34		0 t	0 t	18
	3,0	6,0	60	90	15	50	40		0,5 t	0,5 t	18
	6,0	12,5	60	90	15	50	40		0,5 t	0,5 t	18
	12,5	25,0	60	90	15	50		40			18
H111	0,2	0,5	60	90	15	50	30		0 t	0 t	18
	0,5	1,5	60	90	15	50	32		0 t	0 t	18
	1,5	3,0	60	90	15	50	34		0 t	0 t	18
	3,0	6,0	60	90	15	50	40		0,5 t	0,5 t	18
	6,0	12,5	60	90	15	50	40		0,5 t	0,5 t	18
	12,5	25,0	60	90	15	50		40			18
H112	2.5	6,0	70		20		21				
	≥ 6,0	12,5	70		20		21				

a $Rp_{1.0}$ values also apply (see Table 6)
b For information only

Table 11 — Aluminium EN AW-1080A [Al 99,8(A)] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[b]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O	0,2	0,5	60	90	15	50	30		0 t	0 t	18
	0,5	1,5	60	90	15	50	32		0 t	0 t	18
	1,5	3,0	60	90	15	50	34		0 t	0 t	18
	3,0	6,0	60	90	15	50	40		0,5 t	0,5 t	18
	6,0	12,5	60	90	15	50	40		0,5 t	0,5 t	18
H111	0,2	0,5	60	90	15	50	30		0 t	0 t	18
	0,5	1,5	60	90	15	50	32		0 t	0 t	18
	1,5	3,0	60	90	15	50	34		0 t	0 t	18
	3,0	6,0	60	90	15	50	40		0,5 t	0,5 t	18
	6,0	12,5	60	90	15	50	40		0,5 t	0,5 t	18
H112	≥ 3,0	6,0	70		18		21				
	6,0	12,5	70		18		21				
	12,5	25,0	70		18			21			

a $Rp_{1.0}$ values also apply (see Table 6).

b For information only.

Table 12 — Alloy EN AW-2014A [Al Cu4SiMg(A)] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[a]
	over	up to	min.	max.	min.	max.	$A_{50\,mm}$	A	180°	90°	
T651	≥ 0,2	0,5	440		380					5,0 t [b]	150
	0,5	1,5	440		380		6			5,0 t [b]	150
	1,5	3,0	440		380		7			6,0 t [b]	150
	3,0	6,0	440		380		8			6,0 t [b]	150
	6,0	12,5	460		410		8				
	12,5	25,0	460		410			6			
	25,0	40,0	450		400			5			
	40,0	60,0	430		390			5			
	60,0	90,0	430		390			4			
	90,0	115,0	420		370			4			
	115,0	140,0	410		350			4			

Whenever a new application of this alloy is contemplated, and if this application involves special properties such as corrosion resistance, toughness, fatigue strength, it is strongly recommended that the user consult the producer in order to make a precise and appropriate selection of the material.

a For information only

b Appreciably smaller cold bend radii can be achieved immediately after quenching

Table 13 — Alloy EN AW-2017A [Al Cu4MgSi(A)] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[a]
	over	up to	min.	max.	min.	max.	$A_{50\,mm}$	A	180°	90°	
T451	≥ 0,4	1,5	390		245		14		3,0 t [b]	3,0 t [b]	110
	1,5	6,0	390		245		15		5,0 t [b]	5,0 t [b]	110
	6,0	12,5	390		260		13			8,0 t [b]	111
	12,5	40,0	390		250			12			110
	40,0	60,0	385		245			12			108
	60,0	80,0	370		240			7			
	80,0	120,0	360		240			6			105
	120,0	150,0	350		240			4			101
	150,0	180,0	330		220			2			
	180,0	200,0	300		200			2			

Whenever a new application of this alloy is contemplated, and if this application involves special properties such as corrosion resistance, toughness, fatigue strength, it is strongly recommended that the user consult the producer in order to make a precise and appropriate selection of the material.

a For information only

b Appreciably smaller cold bend radii can be achieved immediately after quenching

Table 14 — Alloy EN AW-2024 [Al Cu4Mg1] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[a]
	over	up to	min.	max.	min.	max.	$A_{50\,mm}$	A	180°	90°	
T351	≥ 0,4	1,5	435		290		12		4,0 t [b]	4,0 t [b]	123
	1,5	3,0	435		290		14		4,0 t [b]	4,0 t [b]	123
	3,0	6,0	440		290		14		5,0 t [b]	5,0 t [b]	124
	6,0	12,5	440		290		13			8,0 t [b]	124
	12,5	40,0	430		290			11			122
	40,0	80,0	420		290			8			120
	80,0	100,0	400		285			7			115
	100,0	120,0	380		270			5			110
	120,0	150,0	360		250			5			104

Whenever a new application of this alloy is contemplated, and if this application involves special properties such as corrosion resistance, toughness, fatigue strength, it is strongly recommended that the user consult the producer in order to make a precise and appropriate selection of the material.

[a] For information only

[b] Appreciably smaller cold bend radii can be achieved immediately after quenching

Table 15 — Alloy EN AW-3003 [Al Mn1Cu] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[a]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O	0,125	0,2	100	135	35		18		-	-	-
	0,2	0,5	100	135	35		18		0 t	0 t	28
	0,5	1,5	100	135	35		18		0 t	0 t	28
	1,5	3,0	100	135	35		23		0 t	0 t	28
	3,0	6,0	100	135	35		23		1,0 t	1,0 t	28
	6,0	12,5	100	135	35		23			1,5 t	28
	12,5	50,0	100	135	35			23			28
H111	0,125	0,2	100	135	35		18		-	-	-
	0,2	0,5	100	135	35		15		0 t	0 t	28
	0,5	1,5	100	135	35		17		0 t	0 t	28
	1,5	3,0	100	135	35		20		0 t	0 t	28
	3,0	6,0	100	135	35		23		1,0 t	1,0 t	28
	6,0	12,5	100	135	35		24			1,5 t	28
	12,5	50,0	100	135	35			23			28
H112	≥ 6,0	12,5	115		70		10				35
	12,5	80,0	100		40			18			29
H12	0,2	0,5	120	160	90		3		1,5 t	0 t	38
	0,5	1,5	120	160	90		4		1,5 t	0,5 t	38
	1,5	3,0	120	160	90		5		1,5 t	1,0 t	38
	3,0	6,0	120	160	90		6			1,0 t	38
	6,0	12,5	120	160	90		7			2,0 t	38
	12,5	40,0	120	160	90			8			38
H14	0,2	0,5	145	185	125		2		2,0 t	0,5 t	46
	0,5	1,5	145	185	125		2		2,0 t	1,0 t	46
	1,5	3,0	145	185	125		3		2,0 t	1,0 t	46
	3,0	6,0	145	185	125		4			2,0 t	46
	6,0	12,5	145	185	125		5			2,5 t	46
	12,5	25,0	145	185	125			5			46
H18	0,2	0,5	190		170		1			1,5t	60
	0,5	1,5	190		170		2			2,5t	60
	1,5	3,0	190		170		2			3,0t	60

NOTE Including brazing sheet for heat exchanger, one or both sides clad e.g. EN AW-4004 or EN AW-4104 for heat exchangers applications See EN 573–3 for chemical composition of EN AW-4004 or EN AW-4104. Other cladding materials can be used following agreement between supplier and purchaser.
[a] For information only

Table 16 — Alloy EN AW-3103 [Al Mn1] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[a]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O	0,2	0,5	90	130	35		18		0 t	0 t	27
	0,5	0,8	90	130	35		19		0 t	0 t	27
	0,8	1,5	90	130	35		23		0 t	0 t	27
	1,5	3,0	90	130	35		23		0 t	0 t	27
	3,0	6,0	90	130	35		24		1,0 t	1,0 t	27
H111	0,2	0,5	90	130	35		17		0 t	0 t	27
	0,5	1,5	90	130	35		19		0 t	0 t	27
	1,5	3,0	90	130	35		21		0 t	0 t	27
	3,0	6,0	90	130	35		24		1,0 t	1,0 t	27
	6,0	12,5	90	130	35		28			1,5 t	27
	12,5	50,0	90	130	35			25			27
H112	≥ 6,0	12,5	110		70		10				34
	12,5	80,0	95		40			18			28
H12	0,2	0,5	115	155	85		3		1,5 t	0 t	36
	0,5	1,5	115	155	85		4		1,5 t	0,5 t	36
	1,5	3,0	115	155	85		5		1,5 t	1,0 t	36
	3,0	6,0	115	155	85		6			1,0 t	36
	6,0	12,5	115	155	85		7			2,0 t	36
	12,5	40,0	115	155	85			8			36
H14	0,2	0,5	140	180	120		2		2,0 t	0,5 t	45
	0,5	1,5	140	180	120		2		2,0 t	1,0 t	45
	1,5	3,0	140	180	120		3		2,0 t	1,0 t	45
	3,0	6,0	140	180	120		4			2,0 t	45
	6,0	12,5	140	180	120		5			2,5 t	45
	12,5	25,0	140	180	120			5			45
H18	0,2	0,5	185		165		1			1,5 t	58
	0,5	1,5	185		165		2			2,5 t	58
	1,5	3,0	185		165		2			3,0 t	58

[a] For information only

Table 17 — Alloy EN AW-3105 [Al Mn0,5Mg0,5] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[a]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O	0,2	0,5	100	155	40		14		0 t		29
	0,5	1,5	100	155	40		15		0 t		29
	1,5	3,0	100	155	40		17		0,5 t		29
H111	0,2	0,5	100	155	40		14		0 t		29
	0,5	1,5	100	155	40		15		0 t		29
	1,5	3,0	100	155	40		17		0,5 t		29
H12	0,2	0,5	130	180	105		3		1,5 t		41
	0,5	1,5	130	180	105		4		1,5 t		41
	1,5	3,0	130	180	105		4		1,5 t		41
H14	0,2	0,5	150	200	130		2		2,5 t		48
	0,5	1,5	150	200	130		2		2,5 t		48
	1,5	3,0	150	200	130		2		2,5 t		48
H18	0,2	0,5	195		180		1				62
	0,5	1,5	195		180		1				62
	1,5	3,0	195		180		1				62

[a] For information only

Table 18 — Alloy EN AW-5005 [Al Mg1(B)], alloy EN AW-5005A [Al Mg1(C)] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[a]
	over	up to	min.	max.	min.	max.	$A_{50\,mm}$	A	180°	90°	
O	0,2	0,5	100	145	35		15		0 t	0 t	29
	0,5	1,5	100	145	35		19		0 t	0 t	29
	1,5	3,0	100	145	35		20		0,5 t	0 t	29
	3,0	6,0	100	145	35		22		1,0 t	1,0 t	29
	6,0	12,5	100	145	35		24			1,5 t	29
	12,5	50,0	100	145	35			20			29
H111	0,2	0,5	100	145	35		15		0 t	0 t	29
	0,5	1,5	100	145	35		19		0 t	0 t	29
	1,5	3,0	100	145	35		20		0,5 t	0 t	29
	3,0	6,0	100	145	35		22		1,0 t	1,0 t	29
	6,0	12,5	100	145	35		24			1,5 t	29
	12,5	50,0	100	145	35			20			29

[a] For information only

Table 19 — Alloy EN AW-5042 [Al Mg3,5Mn] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW [a]
	over	up to	min.	max.	min.	max.	$A_{50\,mm}$	A	180°	90°	
O	1,0	3,0	240	350	115		18				
	3,0	6,0	240	350	115			18			

[a] For information only

Table 20 — Alloy EN AW-5049 [Al Mg2Mn0,8] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[a]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O	0,2	0,5	190	240	80		12		0,5 t	0 t	52
	0,5	1,5	190	240	80		14		0,5 t	0,5 t	52
	1,5	3,0	190	240	80		16		1,0 t	1,0 t	52
	3,0	6,0	190	240	80		18		1,0 t	1,0 t	52
	6,0	12,5	190	240	80		18			2,0 t	52
	12,5	25,0	190	240	80			18			52
H111	0,2	0,5	190	240	80		12		0,5 t	0 t	52
	0,5	1,5	190	240	80		14		0,5 t	0,5 t	52
	1,5	3,0	190	240	80		16		1,0 t	1,0 t	52
	3,0	6,0	190	240	80		18		1,0 t	1,0 t	52
	6,0	12,5	190	240	80		18			2,0 t	52
	12,5	25,0	190	240	80			18			52
H112	≥ 6,0	12,5	210		100		12				62
	12,5	25,0	200		90			10			58
	25,0	40,0	190		80			12			52
	40,0	50,0	190		80			14			52

a For information only

Table 21 — Alloy EN AW-5050 [Al Mg1,5(C)] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[a]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O	0,2	0,5	130	170	45		16		0 t	0 t	36
	0,5	1,5	130	170	45		17		0 t	0 t	36
	1,5	3,0	130	170	45		19		0,5 t	0 t	36
	3,0	6,0	130	170	45		21			1,0 t	36
	6,0	12,5	130	170	45		20			2,0 t	36
	12,5	50,0	130	170	45			20			36
H111	0,2	0,5	130	170	45		16		0 t	0 t	36
	0,5	1,5	130	170	45		17		0 t	0 t	36
	1,5	3,0	130	170	45		19		0,5 t	0 t	36
	3,0	6,0	130	170	45		21			1,0 t	36
	6,0	12,5	130	170	45		20			2,0 t	36
	12,5	50,0	130	170	45			20			36
H112	≥ 6,0	12,5	140		55		12				39
	12,5	40,0	140		55			10			39
	40,0	80,0	140		55			10			39

[a] For information only

Table 22 — Alloy EN AW-5052 [Al Mg2,5] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[a]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O	0,2	0,5	170	215	65		12		0 t	0 t	47
	0,5	1,5	170	215	65		14		0 t	0 t	47
	1,5	3,0	170	215	65		16		0,5 t	0,5 t	47
	3,0	6,0	170	215	65		18			1,0 t	47
	6,0	12,5	165	215	65		19			2,0 t	46
	12,5	80,0	165	215	65			18			46
H111	0,2	0,5	170	215	65		12		0 t	0 t	47
	0,5	1,5	170	215	65		14		0 t	0 t	47
	1,5	3,0	170	215	65		16		0,5 t	0,5 t	47
	3,0	6,0	170	215	65		18			1,0 t	47
	6,0	12,5	165	215	65		19			2,0 t	46
	12,5	80,0	165	215	65			18			46
H112	≥ 6,0	12,5	190		80		7				55
	12,5	40,0	170		70			10			47
	40,0	80,0	170		70			14			47

[a] For information only

Table 23 — Alloy EN AW-5059 [Al Mg5,5MnZnZr] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[b]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O	≥ 3,0	6,0	330	-	160	-	24		1,5 t		
	6,0	12,5	330	-	160	-	24		4,0 t		
	12,5	20,0	330	-	160	-		24			
	20,0	40,0	310	-	160	-		20			
	40,0	180,0	300	-	145	-		17			
H111	≥ 3,0	6,0	330	-	160	-	24		1,5 t		
	6,0	12,5	330	-	160	-	24		4,0 t		
	12,5	20,0	330	-	160	-	-	24			
	20,0	40,0	310	-	160	-	-	20			
	40,0	180,0	300	-	145		-	17			
H112	≥ 3,0	6,0	330	-	160	-	22		2,0 t	-	-
	6,0	11,0	330	-	160	-	20		4,0 t	-	-
	11,0	40,0	330	-	160	-	-	20	-	-	-

[a] For information only

[b] No data available

Table 24 — Alloy EN AW-5083 [Al Mg4,5Mn0,7] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[a]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O[b]	0,2	0,5	275	350	125		11		1,0 t	0,5 t	75
	0,5	1,5	275	350	125		12		1,0 t	1,0 t	75
	1,5	3,0	275	350	125		14		1,5 t	1,0 t	75
	3,0	6,3	275	350	125		17			1,5 t	75
	6,3	12,5	275	345	125		17			2,5 t	75
	12,5	50,0	275	345	125			17			75
	50,0	80,0	270		130			14			73
	80,0	120,0	270		130			14			70
	120,0	200,0	270		130			14			69
H111 [b]	0,2	0,5	275	350	125		11		1,0 t	0,5 t	75
	0,5	1,5	275	350	125		12		1,0 t	1,0 t	75
	1,5	3,0	275	350	125		14		1,5 t	1,0 t	75
	3,0	6,3	275	350	125		17			1,5 t	75
	6,3	12,5	275	345	125		17			2,5 t	75
	12,5	50,0	275	345	125			17			75
	50,0	80,0	270		130			14			73
	80,0	120,0	270		130			14			70
	120,0	200,0	270		130			14			69
H112	≥ 6,0	12,5	275		125		14				75
	12,5	50,0	275		125			14			75

[a] For information only

[b] When specified, necking ratio to be agreed between supplier and purchaser

Table 25 — Alloy EN AW-5086 [Al Mg4] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW [a]
	over	up to	min.	max.	min.	max.	$A_{50\,mm}$	A	180°	90°	
O	0,2	0,5	240	310	100		11		1,0 t	0,5 t	65
	0,5	1,5	240	310	100		12		1,0 t	1,0 t	65
	1,5	3,0	240	310	100		13		1,0 t	1,0 t	65
	3,0	6,0	240	310	100		15		1,5 t	1,5 t	65
	6,0	12,5	240	310	100		17			2,5 t	65
	12,5	150,0	240	310	100			16			65
H111	0,2	0,5	240	310	100		11		1,0 t	0,5 t	65
	0,5	1,5	240	310	100		12		1,0 t	1,0 t	65
	1,5	3,0	240	310	100		13		1,0 t	1,0 t	65
	3,0	6,0	240	310	100		15		1,5 t	1,5 t	65
	6,0	12,5	240	310	100		17			2,5 t	65
	12,5	150,0	240	310	100			16			65
H112	≥ 6,0	12,5	250		105		8				69
	12,5	40,0	240		105			9			65
	40,0	80,0	240		100			12			65

[a] For information only

Table 26 — Alloy EN AW-5088 [AlMg5Mn0,4] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW [b]
	over	up to	min.	max.	min.	max.	$A_{50\,mm}$	A	180°	90°	
O	3,0	6,0	280		135			26	1,5 t	1,0 t	
	6,0	12,5	280		135			26	1,5 t	1,0 t	
H111	3,0	6,0	280		135			26	1,5 t	1,0 t	
	6,0	12,5	280		135			26	1,5 t	1,0 t	

[a] For information only

[b] No data available

Table 27 — Alloy EN AW-5154A [Al Mg3,5(A)] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW [a]
	over	up to	min.	max.	min.	max.	$A_{50\,mm}$	A	180°	90°	
O	0,2	0,5	215	275	85		12		0,5 t	0,5 t	58
	0,5	1,5	215	275	85		13		0,5 t	0,5 t	58
	1,5	3,0	215	275	85		15		1,0 t	1,0 t	58
	3,0	6,0	215	275	85		17			1,5 t	58
	6,0	12,5	215	275	85		18			2,5 t	58
	12,5	50,0	215	275	85			16			58
H111	0,2	0,5	215	275	85		12		0,5 t	0,5 t	58
	0,5	1,5	215	275	85		13		0,5 t	0,5 t	58
	1,5	3,0	215	275	85		15		1,0 t	1,0 t	58
	3,0	6,0	215	275	85		17			1,5 t	58
	6,0	12,5	215	275	85		18			2,5 t	58
	12,5	50,0	215	275	85			16			58
H112	≥ 6,0	12,5	220		125		8				63
	12,5	40,0	215		90			9			59
	40,0	80,0	215		90			13			59

a For information only

Table 28 — Alloy EN AW-5251 [Al Mg2Mn0,3] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW [a]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O	0,2	0,5	160	200	60		13		0 t	0 t	44
	0,5	1,5	160	200	60		14		0 t	0 t	44
	1,5	3,0	160	200	60		16		0,5 t	0,5 t	44
	3,0	6,0	160	200	60		18			1,0 t	44
	6,0	12,5	160	200	60		18			2,0 t	44
	12,5	50,0	160	200	60			18			44
H111	0,2	0,5	160	200	60		13		0 t	0 t	44
	0,5	1,5	160	200	60		14		0 t	0 t	44
	1,5	3,0	160	200	60		16		0,5 t	0,5 t	44
	3,0	6,0	160	200	60		18			1,0 t	44
	6,0	12,5	160	200	60		18			2,0 t	44
	12,5	50,0	160	200	60			18			44

[a] For information only

Table 29 — Alloy EN AW-5383 [Al Mg4,5Mn0,9] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW [a]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O	0,2	0,5	290	360	145		11		1,0 t	0,5 t	85
	0,5	1,5	290	360	145		12		1,0 t	1,0 t	85
	1,5	3,0	290	360	145		13		1,5 t	1,0 t	85
	3,0	6,0	290	360	145		15			1,5 t	85
	6,0	12,5	290	360	145		16			2,5 t	85
	12,5	50,0	290	360	145			15			85
	50,0	80,0	285	355	135			14			80
	80,0	120,0	275		130			12			76
	120,0	150,0	270		125			12			75
H111	0,2	0,5	290	360	145		11		1,0 t	0,5 t	85
	0,5	1,5	290	360	145		12		1,0 t	1,0 t	85
	1,5	3,0	290	360	145		13		1,5 t	1,0 t	85
	3,0	6,0	290	360	145		15			1,5 t	85
	6,0	12,5	290	360	145		16			2,5 t	85
	12,5	50,0	290	360	145			15			85
	50,0	80,0	285	355	135			14			80
	80,0	120,0	275		130			12			76
	120,0	150,0	270		125			12			75
H112	≥ 6,0	12,5	290		145		12				85
	12,5	40,0	290		145			10			85
	40,0	80,0	285		135			10			80

[a] For information only

Table 30 — Alloy EN AW-5454 [Al Mg3Mn] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW [a]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O	0,2	0,5	220	275	105		12		0,5 t	0,5 t	58
	0,5	1,5	220	275	105		13		0,5 t	0,5 t	58
	1,5	3,0	220	275	105		15		1,0 t	1,0 t	58
	3,0	6,0	220	275	105		18			1,5 t	58
	6,0	20,0	220	275	105			18		2,5 t	58
	20,0	80,0	215	275	85			16			58
H111	0,2	0,5	220	275	105		12		0,5 t	0,5 t	58
	0,5	1,5	220	275	105		13		0,5 t	0,5 t	58
	1,5	3,0	220	275	105		15		1,0 t	1,0 t	58
	3,0	6,0	220	275	105		18			1,5 t	58
	6,0	20,0	220	275	105			18		2,5 t	58
	20,0	80,0	215	275	85			16			58
H112	≥ 6,0	12,5	220		125		8				63
	12,5	40,0	215		90			9			59
	40,0	120,0	215		90			13			59

[a] For information only

Table 31 — Alloy EN AW-5456 [Al Mg5Mn1] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW [a]
	over	up to	min.	max.	min.	max.	$A_{50\ mm}$	A	180°	90°	
O	1,20	6,30	290	365	130	205	16			2,5 t	80
	6,30	12,50	285	360	125	205	16				80
	12,50	80,00	285	360	125	205		14			80
	80,00	120,00	285		120			12			75
	120,00	160,00	270		115			12			73
	160,00	200,00	265		105			10			70
H111	1,20	6,30	290	365	130	205	16			2,5 t	80
	6,30	12,50	285	360	125	205	16				80
	12,50	80,00	285	360	125	205		14			80
	80,00	120,00	285		120			12			75
	120,00	160,00	270		115			12			73
	160,00	200,00	265		105			10			70

[a] For information only

Table 32 — Alloy EN AW-5754 [Al Mg3] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW [a]
	over	up to	min.	max.	min.	max.	$A_{50\,mm}$	A	180°	90°	
O	0,2	0,5	190	240	80		12		0,5 t	0 t	52
	0,5	1,5	190	240	80		14		0,5 t	0,5 t	52
	1,5	3,0	190	240	80		16		1,0 t	1,0 t	52
	3,0	6,0	190	240	80		18		1,0 t	1,0 t	52
	6,0	12,5	190	240	80		18			2,0 t	52
	12,5	100,0	190	240	80			18			52
H111	0,2	0,5	190	240	80		12		0,5 t	0 t	52
	0,5	1,5	190	240	80		14		0,5 t	0,5 t	52
	1,5	3,0	190	240	80		16		1,0 t	1,0 t	52
	3,0	6,0	190	240	80		18		1,0 t	1,0 t	52
	6,0	12,5	190	240	80		18			2,0 t	52
	12,5	100,0	190	240	80			18			52
H112	≥ 6,0	12,5	190		100		12				62
	12,5	25,0	190		90			10			58
	25,0	40,0	190		80			14			52
	40,0	80,0	190		80			14			52

[a] For information only

Table 33 — Alloy EN AW-6061 [Al Mg1SiCu] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW [a]
	over	up to	min.	max.	min.	max.	$A_{50\,mm}$	A	180°	90°	
O[c]	≥ 0,4	1,5		150		85	14		1,0 t	0,5 t	40
	1,5	3,0		150		85	16		1,0 t	1,0 t	40
	3,0	6,0		150		85	19			1,0 t	40
	6,0	12,5		150		85	16			2,0 t	40
	12,5	25,0		150				16			40
T651	≥ 0,4	1,5	290		240		6			2,5 t[b]	88
	1,5	3,0	290		240		7			3,5 t[b]	88
	3,0	6,0	290		240		10			4,0 t[b]	88
	6,0	12,5	290		240		9			5,0 t[b]	88
	12,5	40,0	290		240			8			88
	40,0	80,0	290		240			6			88
	80,0	100,0	290		240			5			88
	100,0	150,0	275		240			5			84
	150,0	250,0	265		230			4			81
	250,0	350,0	260		220			4			80
	350,0	400,0	260		220			2			80
T62	≥ 0,4	1,5	290		240		6			2,5 t[b]	88
	1,5	3,0	290		240		7			3,5 t[b]	88
	3,0	6,0	290		240		10			4,0 t[b]	88
	6,0	12,5	290		240		9			5,0 t[b]	88
	12,5	40,0	290		240			8			88
	40,0	80,0	290		240			6			88
	80,0	100,0	290		240			5			88
	100,0	150,0	275		240			5			84
	150,0	250,0	265		230			4			81
	250,0	350,0	260		220			4			80
	350,0	400,0	260		220			2			80

a For information only

b Appreciably smaller cold bend radii can be achieved immediately after quenching

c Temper O applies to products supplied in soft temper then heat treated to final temper by the purchaser

Table 34 — Alloy EN AW-6082 [Al Si1MgMn] - Sheet, strip, plate and circle

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW [a]
	over	up to	min.	max.	min.	max.	$A_{50\,mm}$	A	180°	90°	
O	≥ 0,4	1,5		150		85	14		1,0 t	0,5 t	40
	1,5	3,0		150		85	16		1,0 t	1,0 t	40
	3,0	6,0		150		85	18			1,5 t	40
	6,0	12,5		150		85	17			2,5 t	40
	12,5	25,0		155				16			40
T651	≥ 0,4	1,5	310		260		6			2,5 t [b]	94
	1,5	3,0	310		260		7			3,5 t [b]	94
	3,0	6,0	310		260		10			4,5 t [b]	94
	6,0	12,5	300		255		9			6,0 t [b]	91
	12,5	60,0	295		240			8			89
	60,0	100,0	295		240			7			89
	100,0	150,0	275		240			6			84
	150,0	175,0	275		230			4			83
	175,0	350,0	260		220			2			
T62	≥ 0,4	1,5	310		260		6			2,5 t [b]	94
	1,5	3,0	310		260		7			3,5 t [b]	94
	3,0	6,0	310		260		10			4,5 t [b]	94
	6,0	12,5	300		255		9			6,0 t [b]	91
	12,5	60,0	295		240			8			89
	60,0	100,0	295		240			7			89
	100,0	150,0	275		240			6			84
	150,0	175,0	275		230			4			83
	175,0	350,0	260		220			2			

a For information only

b Appreciably smaller cold bend radii can be achieved immediately after quenching

c Temper O applies to products supplied in soft temper then heat treated to final temper by the purchaser

Table 35 — Mechanical properties at room temperature – forgings

Alloy Designation	Temper	Section size	Test direction	Tensile Strength	Yield Strength	Elongation
		t [mm]		Rm [MPa]	R0.2 [MPa]	A [%]
EN AW-1050A	H112	t ≤ 100	L, T	70	20	23
EN AW-3003	H112	t ≤ 100	L	95	35	18
EN AW-5083	H112	t ≤ 150	L	270	120	14
			T	260	110	14
		150 < t ≤ 250	L, T	260	110	14
EN AW-5754	H112	t ≤ 150	L, T	180	80	15
EN AW-6061	T6	t ≤ 100	L	260	240	7
			T	260	240	5
EN AW-6082	T6	t ≤ 100	L	310	260	6
			T	290	250	5

Note about the definitions:
Section size t: Diameter of the largest sphere which can be inscribed within the forging.
Test direction
L = longitudinal direction. Specimen axis parallel to the forging flow lines.
T = transverse direction. Specimen axis not parallel to the forging flow lines.

Table 36 — Mechanical properties at room temperature - castings - sand castings

Table to be used for typical mechanical properties taken from separately cast test bars at room temperature (normative information) [1)]

Item	Alloy designation		Temper designation	Tensile strength Rm [MPa]	Yield strength Rp0.2 [MPa]	Elongation A [%]	Brinell hardness HBW
	Numerical	Chemical symbols					
1	EN AC-21000	EN AC-Al Cu4MgTi	T4	(300) – 400	(200) – 350	(3) – 10	(90) – 120
2	EN AC-21100	EN AC-Al Cu4 Ti	T6	(300) – 450	(200) – 400	(3) – 4	(95) – 125
3	EN AC-21100	EN AC-Al Cu4 Ti	T64	(280) – 360	(180) – 240	(5) – 12	(85) – 100
4	EN AC-41000	EN AC-Al Si2MgTi	T6	(240) – 280	(180) – 220	(3) – 10	(85) – 95
5	EN AC-42100	EN AC-Al Si7Mg0,3	T6	(230) – 320	(190) – 260	(2) – 8	(75) – 100
6	EN AC-42100	EN AC-Al Si7Mg0,3	T64	(200) – 280	(120) – 200	(4) – 12	(60) – 90
7	EN AC-43000	EN AC-Al Si10Mg(a)	T6	(220) – 300	(180) – 240	(2) – 6	(75) – 90
8	EN AC-43000	EN AC-Al Si10Mg(a)	T64	(160) – 260	(100) – 200	(3) – 8	(50) – 85
9	EN AC-43300	EN AC-Al Si9Mg	T6	(230) – 300	(190) – 230	(2) – 6	(75) – 100
10	EN AC-44000	EN AC-Al Si11	F	(150) – 200	(70) – 110	(6) – 10	(50) – 60
11	EN AC-	EN AC-Al Si 12(a)	F	(150) – 190	(70) – 95	(5) – 8	(50) – 60

[1)] Normative minimum values are the values in brackets.

	44200						
12	EN AC-45500	EN AC-Al Si7Cu0,5Mg	T6	(250) - 320	(190) - 260	(1) - 6	(85) - 95
13	EN AC-51300	EN AC-AlMg5	F	(160)	(90)	(12) – 14	(55)
Items 1–13: All values are valid for separately cast or cast-on test bars. Items 1–12: The values for Rm and Rp0.2 obtained in the castings may be not less than 70 % of the minimum values specified in some locations Items 1–12: The values of the elongation obtained from castings may be up to 50 % less in some locations. Item 13: No reduction of values obtained in the casting are allowed.							

Table 37 — Mechanical properties at room temperature - castings - permanent mould castings

Table to be used for typical mechanical properties taken from separately cast test bars at room temperature (normative information) [1)]

Item	Alloy designation		Temper designation	Tensile strength Rm [MPa]	Yield strength Rp0.2 [MPa]	Elongation A [%]	Brinell hardness HBW
	Numerical	Chemical symbols					
1	EN AC-21000	EN AC-Al Cu4MgTi	T4	(320) – 420	(200) – 300	(8) – 18	(90) – 110
2	EN AC-21100	EN AC-Al Cu4 Ti	T6	(330) – 450	(220) – 400	(7) – 16	(95) – 145
3	EN AC-21100	EN AC-Al Cu4 Ti	T64	(320) – 300	(180) – 250	(8) – 20	(90) – 120
4	EN AC-41000	EN AC-Al Si2MgTi	T6	(260) – 300	(180) – 230	(5) – 10	(85) – 95
5	EN AC-42100	EN AC-Al Si7Mg0,3	T6	(290) – 340	(210) – 280	(4) – 9	(90) – 125
6	EN AC-42100	EN AC-Al Si7Mg0,3	T64	(250) – 270	(180) – 200	(8) – 12	(80) – 95
7	EN AC-42200	EN AC-Al Si7Mg0,6	T6	(320) - 360	(240) - 290	(3) - 6	100
8	EN AC-42200	EN AC-Al Si7Mg0,6	T64	(290) - 310	(180) - 220	(6) - 8	90
9	EN AC-43000	EN AC-Al Si10Mg(a)	T6	(260) – 320	(220) – 310	(1) – 4	(90) – 110
10	EN AC-43000	EN AC-Al Si10Mg(a)	T64	(240) – 260	(200) – 240	(2) – 6	(80) – 95
11	EN AC-43300	EN AC-Al Si9Mg	T6	(290) – 360	(210) – 310	(4) – 7	(90) – 120
12	EN AC-43300	EN AC-Al Si9Mg	T64	(250) – 290	(180) – 210	(6) – 10	(80) – 90
13	EN AC-44000	EN AC-Al Si11	F	(170) – 240	(80) – 130	(7) – 16	(45) – 75
14	EN AC-44200	EN AC-Al Si 12(a)	F	(170) – 210	(80) – 120	(6) – 10	(55) – 70
15	EN AC-45500	EN AC-Al Si7Cu0,5Mg	T6	(320) - 340	(240) - 280	(4) - 8	(100) - 110
16	EN AC-51300	EN AC-AlMg5	F	(180)	(100)	(4)	(60) - 70

Items 1–16: All values are valid for separately cast or cast-on test bars.
Items 1–15: The values for Rm and Rp0.2 obtained in the castings may be not less than 70 % of the minimum values specified in some locations.
Items 1–15: The values of the elongation obtained from castings may be up to 50 % less in some locations.
Item16: No reduction of values obtained in the casting is allowed.

Annex A
(informative)

Materials and application ranges

Table A.1 — Wrought products

Alloy designation	Temper designation	Weldability TIG, MIG or plasma		Main applications [a)]			Maximum working temperature °C[c]	Remarks
		Weldable (Y/N) [b]	Property affected (Y/N) [b]	Pressure vessels	Piping	Hydraulic equipment		
EN AW-1050A [Al 99,5]	O/H111 H112 H12 H14	Y	Y	X	X	X	200	d
EN AW-1070A [Al 99,7]	O/H111 H112	Y	Y	X	X	X	200	d
EN AW-1080A [Al 99,8(A)]	O/H111 H112	Y	Y	X	X	X	200	d
EN AW-2014A [Al Cu4SiMg]	T6	N		-	X	X	150	e
EN AW-2017A [Al Cu4MgSi(A)]	T4	N	-	-	X	X	150[j]	e
EN AW-2024 [Al Cu4Mg1]	T3 T4	N	-	-	X	X	120[j]	e
EN AW-3003 [Al Mn1Cu]	O/H111 H112 H12 H14 H18	Y Y Y Y Y	N N Y Y Y	X X X - -	X X X X X	X X X - -	250	d
EN AW-3103 [Al Mn1]	O H112 H12 H14 H18	Y Y Y Y Y	N N Y Y Y	X X X - -	X X X X X	X X X - -	250	d

EN AW-3105 [Al Mn0,5Mg0,5]	O/H111 H112 H12 H14 H18	Y Y Y Y Y	N N Y Y Y	X X X - -	X X X X X	X X X - -	200	d
EN AW-5005 [Al Mg1(B)] EN AW-5005A [Al Mg1(C)]	O/H111 H112	Y Y	N N	X X	X X	X X	200	d
EN AW-5042 [Al Mg3,5Mn]	O	Y	N	X	X	-	100	d
EN AW-5049 [Al Mg2Mn0,8]	O/H111 H112 H12 H14	Y Y N N	Y Y N N	X X X X	X X X X	X X X X	200	d
EN AW-5050 [Al Mg1,5(C)]	O/H111 H112	Y Y	N N	X X	X X	X X	200	d
EN AW-5052 [Al Mg2,5]	O/H111 H112	Y Y	N N	X X	X X	X X	200	d
EN AW-5059 [Al Mg5,5MnZnZr]	O/H111 H112	Y Y	N N	X X	X X	X X	75	d f
EN AW-5083 [Al Mg4,5Mn0,7]	O/H111 H112	Y Y	N N	X X	X X	X X	75	d f
EN AW-5086 [Al Mg4]	O/H111 H112	Y Y	N N	X X	X X	X X	75	d f
EN AW-5088 [Al Mg5Mn0,4]	O/H111	Y	Y	X	X	X	75	
EN AW-5154A [Al Mg3,5(A)]	O/H111 H112	Y Y	N N	X X	X X	X X	100	d
EN AW-5251 [Al Mg2Mn0,3]	O/H111 H112	Y Y	N N	X X	X X	X X	200	d
EN AW-5383 [Al Mg4,5Mn0,9]	O/H111 H112	Y Y	N N	X X	X X	X X	75	d f
EN AW-5454 [Al Mg3Mn]	O/H111 H112	Y Y	Y Y	X X	X X	X X	200	d
EN AW-5456 [Al Mg5Mn1]	O/H111	Y	N	X	X	X	75	d f
EN AW-5754 [Al Mg3]	O/H111 H112	Y Y	N N	X X	X X	X X	100	d

EN AW-6005A	T4 T6	Y Y	Y Y	X X	X X	X X	80[i] 160	g e
EN AW-6060 [Al MgSi]	T4 T6 T8	Y Y Y	Y Y Y	X X X	X X X	X X X	80[i] 160	g e
EN AW-6061 [Al Mg1SiCu]	T4/T42 T6/T62	Y Y	Y Y	X X	X X	X X	80[i] 160	g e
EN AW-6063 [Al Mg0,7Si] EN AW-6063A [Al Mg0,7Si(A)]	T4 T6 T8	Y Y Y	Y Y Y	X X -	X X X	X X X	80[i] 160	g e
EN AW-6082 [Al Si1MgMn]	T4/T42 T6/T62 T8	Y Y Y	Y Y Y	X X X	X X X	X X X	80[i] 160	g e
EN AW-6106 [Al MgSiMn]	T4 T5 T6 T8	Y Y Y Y	Y Y Y Y	X X X X	X X X X	X X X X	160	g e
EN AW-6351 [Al SiMg0,5Mn]	T4 T6	Y Y	Y Y	X X	X X	X X	80[i] 160	g e

[a] X: permissible material for this application

[b] Y = yes, *N* = No.

[c] The minimum working temperature is unlimited (- 273 °C).

[d] For welded pieces in H1x tempers, O temper mechanical properties shall be used.

[e] In the column “Temper designation”, T4 shall also indicate T451, T4511, T4510 etc. Similar extensions are intended for T3, T6 and T8.

[f] Higher temperatures may also be used if test or service experience have demonstrated that these alloys are suitable at such temperatures for specific duty.

[g] Reduced mechanical properties on welded components shall be derived from tensile testing of welded specimens (prEN in preparation).

[h] Tempers T42 and T62 are laboratory tempers to demonstrate that O or T4 temper will meet the specified values of T4 and T6 tempers after the appropriate heat treatment. This requirement shall be agreed between supplier and purchaser.

[i] in case of exposition at elevated temperatures, materials supplied in this temper will have their strength properties increase whereas the elongation will oppositely decrease.

Table A.2 — Materials and application ranges - cast products

The information contained in the table herebelow included in this European Standard for the guidance of designers and users of casting alloys aims at broadly ranking the alloys in the property listed. Information is valid for sand and permanent mould castings. Rankings vary with the production method and with the heat treatment condition of the casting and rankings are only applicable in the column concerned. Some numerical values are also included for guidance.

Alloy designation		**Other properties** [a,b]								
		Machinability		**Resistance to corrosion**	**Decorative anodizing**	**Ability to be welded**	**Ability to be polished**	**Linear thermal expansion**	**Electrical conductivity** [c]	**Thermal conductivity** [c]
Numerical	**Chemical Symbols**	**As cast**	**After heat treatment**					**[·10⁶ K⁻¹] (273k - 373 K)**	**[MS/m]**	**[W/mK]**
EN AC-21000	EN AC-Al Cu4MgTi	-	A	D	C	D	B	23	16 to 23	120 to 150
EN AC-21100	EN AC-Al Cu4 Ti	-	A	D	C	D	B	23	16 to 23	120 to 150
EN AC-41000	EN AC-Al Si2MgTi	C	B	B	B	B	B	23	19 to 25	140 to 160
EN AC-42100	EN AC-Al Si7Mg0,3	-	B	B	D	B	C	22	20 to 27	160 to 180
EN AC-42200	EN AC-Al Si7Mg0,6	-	B	B	D	B	C	22	20 to 27	160 to 180
EN AC-43000	EN AC-Al Si10Mg(a)	B/C	B	B	E	A	D	21	18 to 25	140 to 170
EN AC-43300	EN AC-Al Si9Mg	B/C	B	B	E	A	D	21	20 to 26	150 to 180
EN AC-44000	EN AC-Al Si11	C[d]	-	B	E	A	D	21	18 to24	140 to 170
EN AC-44200	EN AC-Al Si12(a)	C	-	B	E	A	D	20	17 to24	140 to 170
EN AC-45500	EN AC-Al Si7Cu0,5Mg	B	B	B/C	D	B	C	22	16 to 22	150 to 165
EN AC-51300	EN AC-Al Mg5	A	-	A	A	A	A	24	15 to 21	110 to 130

Legend

A Excellent

B Good

C Fair

D Poor

E Not recommended

F Unsuitable

[a] Rankings are only applicable in the column concerned.

[b] Valid for sand and permanent mould casting.

[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.

Annex B
(informative)

Tensile properties at low and high temperatures

NOTE These values disclosed in Tables B.1 to B.4 are based on a critical review and interpolation of authoritative published data available at the time of drafting.

B.1 Wrought products

Table B.1 — Elevated temperature property values (unalloyed aluminium)

Aluminium designation	**Temper**	**Properties at ambient temperature (see 6.1)**		**-273 °C to 20 °C**	**50 °C**	**75 °C**			**100 °C**			**125 °C**			**150 °C**			**175 °C**		**200 °C**	
		R_m MPa	$R_{p0,2}$ MPa	$R_{p1,0}$ MPa	$R_{p1,0}$ MPa	$R_{p1,0}$ MPa	R_{km10^4} MPa	R_{km10^5} MPa	$R_{p1,0}$ MPa	R_{km10^4} MPa	R_{km10^5} MPa	$R_{p1,0}$ MPa	R_{km10^4} MPa	R_{km10^5} MPa	$R_{p1,0}$ MPa	R_{km10^4} MPa	R_{km10^5} MPa	R_{km10^4} MPa	R_{km10^5} MPa	R_{km10^4} MPa	R_{km10^5} MPa
EN AW-1050A	O/H111	65	20	30	29	28	34	30	26	29	25	25	23	20	24	19	15	15	12	12	9,5
	H112	75	30	30*	29*	28*	34	30	26*	29	25	25*	23	20	24*	19	15	15	12	12	9,5
EN AW-1070A	O/H111	60	15	25	24	23	-	-	21	-	-	20	-	-	19	-	-	-	-	-	-
	H112	70	15	25	24	23	-	-	21	-	-	20	-	-	19	-	-	-	-	-	-
EN AW-1080A	O/H111	60	15	22	21	20	-	-	19	-	-	18	-	–	17	-	-	-	-	-	-
	H112	70	15	22	21	20	-	-	19	-	-	18	-		17	-	-	-	-	-	-

Table B.2 — Elevated temperature property values (aluminium alloys)

Alloy designation	**Temper**	**Properties at ambient temperature (see 6.1)**		**-273 °C to 20 °C**	**50 °C**	**75 °C**			**100 °C**			**125 °C**			**150 °C**			**175 °C**		**200 °C**	
		R_m Mpa	$R_{p0,2}$ MPa	$R_{p0,2}$ MPa	$R_{p0,2}$ MPa	$R_{p0,2}$ MPa	R_{km10^4} MPa	R_{km10^5} MPa	$R_{p0,2}$ MPa	R_{km10^4} MPa	R_{km10^5} MPa	$R_{p0,2}$ MPa	R_{km10^4} MPa	R_{km10^5} MPa	$R_{p0,2}$ MPa	R_{km10^4} MPa	R_{km10^5} MPa	R_{km10^4} MPa	R_{km10^5} MPa	R_{km10^4} MPa	R_{km10^5} MPa
EN AW-2014A	T6 / T651	450	395	395	395	390	-	-	-	-	-	-	-	-	-	-	(124)	-	-	-	(42)
EN AW-2017A	T4 / T451	390	260	260	260	257	-	-	-	-	-	-	-	-	-	-	(90)	-	-	-	(39)
EN AW-2024	T3 / T351	440	290	290	290	283	-	-	-	-	-	-	270	-	-	186	100	115	-	73	44
EN AW-3003	O/H111 H112 H12	95 115 120	35 70 90	35 70 90	35 70 90	33 67 86	86 86 112**	79** 79** 108**	32 63 81	74 74 100**	66** 66** 92**	31 58 75	62 62 86**	52 52 78**	29 53 68	49 49 68**	39** 39** 58**	38 38 48**	29** 29** 41**	29 29 36**	23** 23** 31**
EN AW-3103	O/H111 H112 H12	90 110 115	35 70 85	35 70 85	35 70 85	33 67 82	86 86 112**	79** 79** 108**	32 63 77	74 74 100**	66** 66** 92**	31 58 72	62 62 86**	52 52 78**	29 53 65	49 49 68**	39** 39** 58**	38 38 48**	29** 29** 41**	29 29 36**	23** 23** 31**
EN AW-3105	O/H111 H12	100 130	40 105	40 105	40 105	38 101	- -	- -	36 95	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
EN AW-5005	O/H111	100	35	35	35	34	[75]	[69]	33	[64]	[53]	-	[55]	[45]	-	[43]	[35]	[33]	[26]	[26]	[21]
EN AW-5005A	O/H111 H112	100 100	40 40	40 40	40 40	39 39	[79] [79]	[72] [72]	38 38	[68] [69]	[56] [56]	- -	[58] [58]	[48] [48]	- -	[45] [45]	[37] [37]	[34] [34]	[27] [27]	[28] [28]	[22] [22]
EN AW-5042	O/H111	240	115	115	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Alloy	Temper	Properties at ambient temperature (see 6.1)		-273 °C to 20 °C	50 °C	75 °C			100 °C			125 °C			150 °C			175 °C		200 °C	
EN AW-5049	O/H111 H112	190 210	80 140	80 140	80 140	78 137	150 150	128** 128**	76 133	120 120	95** 95**	- -	9090	66** 66**	- -	64 64	46** 46**	46 46	33** 33**	34 34	24** 24**
EN AW-5050	O/H111 H112	130 140	45 55	45 55	45 55	44 54	[99] [99]	[89] [89]	43 52	[84] [84]	[69] [69]	- -	[70] [70]	[56] [56]	- -	[53] [53]	[43] [43]	[40] [40]	[30] [30]	[31] [31]	[22] [22]
EN AW-5052	O/H111 H112	165 190	65 110	65 110	65 110	64 108	[133] [133]	[114] [114]	62 105	[110] [110]	[88] [88]	- -	[84] [84]	[65] [65]	- -	[62] [62]	[47] [47]	[45] [45]	[30] [30]	[32] [32]	[20] [20]
EN AW-5059	O/H111 H112	330 330	160 160	160 160	160 160	160 160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EN AW-5083	O/H111 H112	270 275	125 125	125 125	125 125	122 122	[171] [171]	[141] [141]	119 119	[136] [136]	[105] [105]	- -	[102] [102]	[73] [73]	- -	[71] [71]	[43] [43]	[46] [46]	[24] [24]	[27] [27]	[15] [15]
EN AW-5086	O/H111 H112	240 250	100 125	100 125	100 125	98 122	[170] [170]	[140] [140]	95 119	[134] [134]	[105] [105]	- -	[101] [101]	[72] [72]	- -	[70] [70]	[43] [43]	[46] [46]	[26] [26]	[28] [28]	[17] [17]
EN AW-5088	O/H111 H112	240 250	100 125	100 125	100 125	98 122	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

Alloy designation	**Temper**	**Properties at ambient temperature (see 6.1)**		**-273 °C to 20 °C**	**50 °C**	**75 °C**			**100 °C**			**125 °C**			**150 °C**			**175 °C**		**200 °C**	
		R_m Mpa	$R_{p0,2}$ MPa	$R_{p0,2}$ MPa	$R_{p0,2}$ MPa	$R_{p0,2}$ MPa	R_{km10^4} MPa	R_{km10^5} MPa	$R_{p0,2}$ MPa	R_{km10^4} MPa	R_{km10^5} MPa	$R_{p0,2}$ MPa	R_{km10^4} MPa	R_{km10^5} MPa	$R_{p0,2}$ MPa	R_{km10^4} MPa	R_{km10^5} MPa	R_{km10^4} MPa	R_{km10^5} MPa	R_{km10^4} MPa	R_{km10^5} MPa
EN AW-5154A	O/H111 H112	215 220	85 125	85 125	85 125	83 122	[161-] [161]	[131] [131]	81 119	[129] [129]	[101] [101]	- -	[97] [97]	[70] [70]	- -	[68] [68]	[44] [44]	[45] [45]	[28] [28]	[30] [30]	[18] [18]
EN AW-5251	O/H111 H12/H32	160 190	60 150	60 150	60 150	59 147	130 -	112** -	57 143	107 -	88** -	- -	85 -	64** -	- -	63 -	41** -	41 -	27** -	28 -	19** -
EN AW-5383	O/H111 H112	270 275	125 125	125 125	125 125	122 122	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
EN AW-5454	O/H111 H112	215 220	85 125	85 125	85 125	83 122	160 160	127 127	81 119	125 125	95 95	- -	94 94	68 68	- -	69 69	47 47	49 49	32 32	35 35	23 23
EN AW-5456	O/H111	285	125	125	125	122	[171]	[141]	122	[136]	[105]	120	[102]	[73]	120	[71]	[43]	[46]	[24]	[27]	[15]
EN AW-5754	O/H111 H112	190 210	80 140	80 140	80 140	78 137	128 128	110** 110**	76 133	105 105	85** 85**	- -	82 82	61** 61**	- -	60 60	39**39**	39 39	23** 23**	24 24	16** 16**
EN AW-6005A	T4 T6	180 255	90 215	90 215	90 215	- 205	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
EN AW-6060	T4 T6	120 190	60 150	60 150	60 150	- 146	- [206]	- [193]		- [176]	- [160]		- [144]	- [121]		- [105]	- [75]	- [64]	- [46]	- [42]	- [33]

Alloy	Temper	Properties at ambient temperature (see 6.1)		-273 °C to 20 °C	50 °C	75 °C			100 °C			125 °C			150 °C			175 °C		200 °C	
EN AW-6061	T4	180	110	110	110	-	-	-		-	-		-	-		-	-	-	-	-	-
	T6	260	240	240	240	233	254	236**		229	204**		198	163**		156	115**	110	76**	76	52**
EN AW-6063	T4	150	90	90	90	-	-	-		-	-		-	-		-	-	-	-	-	-
	T6	230	190	190	190	184	206**	193**		176**	160**		144**	121**		105**	75**	64**	46**	42**	32**
EN AW-6063A	T4	150	90	90	90	-	-	-		-	-		-	-		-	-	-	-	-	-
	T6	230	190	190	190	184	206**	193**		176**	160**		144**	121**		105**	75**	64**	46**	42**	32**
EN AW-6082	T4	205	110	110	110	-	-	-		-	-		-	-		-	-	-	-	-	-
	T6	295	250	250	250	242	241	215		197	168		153	119		110	80	76	53	53	36
EN AW-6106	T5	250	200	200	200	195	-	-		-	125		-	-		-	85	-	-	-	22
EN AW-6351	T4	205	110	110	110	-	-	-		-	-		-	-		-	-	-	-	-	-
	T6	295	250	250	250	242	[241]	[215]		[197]	[168]		[153]	[119]		[110]	[80]	[76]	[55]	[53]	[36]

Legend

() Limited data available

** extended extrapolation

[ ] Interpolated between similar alloys

B.2 Cast products

Minimum tensile and Brinell hardness values for elevated temperature of cast products determined on separately cast test samples are given in Table B.3 for sand castings and in Table B.4 for permanent mould castings.

Table B.3 — Cast products - sand cast products

Item	Alloy designation		Temper designation	- 273°C to 20°C				150 °C		200 °C	
				Tensile strength Rm [Mpa] min.	Yield strength $Rp_{0.2}$ [Mpa] min.	Elongation A [%] min.	Brinell hardness HBW min.	Tensile strength Rm [Mpa] min. [a]	Yield strength $Rp_{0.2}$ [Mpa] min. [a]	Tensile strength Rm [Mpa] min. [a]	Yield strength $Rp_{0.2}$ [Mpa] min.a
	Numerical	Chemical symbols									
1	EN AC-21000	EN AC-Al Cu4MgTi	T4	300	200	5	90	300	200	240	160
2	EN AC-21100	EN AC-Al Cu4 Ti	T6	300	200	3	95	-	-	-	-
3	EN AC-21100	EN AC-Al Cu4 Ti	T64	280	180	5	85	-	-	-	-
4	EN AC-41000	EN AC-Al Si2MgTi	T6	240	180	3	85	-	-	-	-
5	EN AC-42100	EN AC-Al Si7Mg0,3	T6	230	190	2	75	140	120	70	60
6	EN AC-42100	EN AC-Al Si7Mg0,3	T64	200	120	4	60	-	-	-	-
7	EN AC-43000	EN AC-Al Si10Mg(a)	T6	220	180	1	75	-	-	-	-
8	EN AC-43000	EN AC-Al Si10Mg(a)	T64	160	100	3	50	-	-	-	-
9	EN AC-43300	EN AC-Al Si9Mg	T6	230	190	2	75	-	-	-	-
10	EN AC-44000	EN AC-Al Si11	F	150	70	6	50	-	-	-	-
11	EN AC-44200	EN AC-Al Si12(a)	F	150	70	5	50	-	-	-	
12	EN AC-45500	EN AC-Al Si7Cu0,5Mg	T6	250	190	1	85	-	-	-	
13	EN AC-51300	EN AC-AlMg5	F	160	90	12	55	-	70 [b]	-	

Items 1 - 12: Values for temperatures of −273°C to 20°C are minimum normative values Items 1 - 12: The values obtained in the castings may be not less than 70 % of the minimum values specified Items 1 - 12: The values obtained from castings may be up to 50 % less than the minimum values specified Item 13: Values for temperatures of −273°C to 20°C are minimum normative values
[a] Values at elevated temperatures (150°C and 200°C) are informative only [b] Valid for 130°C

Table B.4 — Cast products - permanent mould cast products

Item	Alloy designation		Temper designation	- 273°C to 20°C				150 °C		200 °C	
	Numerical	Chemical symbols		Tensile strength Rm [Mpa] min.	Yield strength $Rp_{0.2}$ [Mpa] min.	Elongation A [%] min.	Brinell hardness HBW min.	Tensile strength Rm [Mpa] min. [a]	Yield strength $Rp_{0.2}$ [Mpa] min. [a]	Tensile strength Rm [Mpa] min. [a]	Yield strength $Rp_{0.2}$ [Mpa] min. [a]
1	EN AC-21000	EN AC-Al Cu4MgTi	T4	320	200	8	90	320	200	240	160
2	EN AC-21100	EN AC-Al Cu4 Ti	T6	330	220	7	95	-	-	-	-
3	EN AC-21100	EN AC-Al Cu4 Ti	T64	320	180	8	90	-	-	-	-
4	EN AC-41000	EN AC-Al Si2MgTi	T6	260	180	5	85	-	-	-	-
5	EN AC-42100	EN AC-Al Si7Mg0,3	T6	290	210	4	90	210	120	70	50
6	EN AC-42100	EN AC-Al Si7Mg0,3	T64	250	180	8	80	-	-	-	-
7	EN AC-42200	EN AC-Al Si7Mg0,6	T6	320	240	3	100	210	180	70	50
8	EN AC-42200	EN AC-Al Si7Mg0,6	T64	290	210	6	100	-	-	-	-
9	EN AC-43000	EN AC-Al Si10Mg(a)	T6	260	220	1	90	-	-	-	-
10	EN AC-43000	EN AC-Al Si10Mg(a)	T64	240	200	2	80	-	-	-	-
11	EN AC-43300	EN AC-Al Si9Mg	T6	290	210	4	90	-	-	-	-
12	EN AC-43300	EN AC-Al Si9Mg	T64	250	180	6	80	-	-	-	-
13	EN AC-44000	EN AC-Al Si11	F	170	80	7	45	-	-	-	-
14	EN AC-44200	EN AC-Al Si12(a)	F	170	80	6	55	-	-	-	-
15	EN AC-45500	EN AC-Al Si7Cu0,5Mg	T6	320	240	4	100	270	220	220	190
16	EN AC-51300	EN AC-AlMg5	F	180	100	4	60	-	70 [b]	-	-

Items 1 – 15: Values for temperatures of −273°C to 20°C are minimum normative values.Items 1 – 15: The values obtained in the castings may be not less than 70 % of the minimum values specified Items 1 – 15: The values obtained from castings may be up to 50 % less than the minimum values specified Item 16: Values for temperatures of −273°C to 20°C are minimum normative values
[a] Values at elevated temperatures (150°C and 200°C) are informative only [b] Valid for 130°C

Annex ZA
(informative)

Relationship between this European Standard and the Essential safety requirements of Directive 2014/68/EU aimed to be covered

This European Standard has been prepared under a Commission's standardization request M/071 (Pressure equipment to provide one voluntary means of conforming to Essential Safety requirements of Directive 2014/68/EU of the European Parliament and of the Council of 15 May 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of pressure equipment.

Once this standard is cited in the Official Journal of the European Union under that Directive 2014/68/EU, compliance with the normative clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Safety requirements of that Directive 2014/68/EU, and associated EFTA regulations..

Table ZA.1 — Correspondence between this European standard and Directive 2014/68/EU

Essential Safety Requirements of Directive 2014/68/EU	Clause(s)/sub-clause(s) of this EN	Remarks/notes
Article 1	5.1.2	Type of pressure equipment being considered
Annex I - 4.1.a Annex I - 4.2	5.3.3	Mechanical properties Location of test samples
Article 1	5.3.4.2.1	Type of pressure equipment being considered
Annex I - 4.3	5.4	Inspection documents
Annex I - 4.1.a	6.1	Mechanical properties

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European Standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the product(s) falling within the scope of this standard.

Bibliography

[1] EN 1370, *Founding - Examination of surface condition*

[2] EN 1706, *Aluminium and aluminium alloys - Castings - Chemical composition and mechanical properties*

[3] EN 12516-4, *Industrial valves - Shell design strength - Part 4: Calculation method for valve shells manufactured in metallic materials other than steel*

[4] EN 13445-5, *Unfired pressure vessels - Part 5: Inspection and testing*

[5] EN 13445-8, *Unfired pressure vessels - Part 8: Additional requirements for pressure vessels of aluminium and aluminium alloys*

[6] EN 13480-5, *Metallic industrial piping - Part 5: Inspection and testing*

[7] EN 13480-8, *Metallic industrial piping - Part 8: Additional requirements for aluminium and aluminium alloy piping*

[8] ASTM B210/B210M, *Standard Specification for Aluminium and Aluminium-Alloy Drawn Seamless Tubes*

[9] ASTM B234/B234M, *Standard specification for aluminium and aluminium alloy drawn seamless tubes for condenser and heat exchangers*

[10] ASTM B241/B241M, *Standard specification for aluminium and aluminium seamless pipe and seamless extruded tube*

[11] ASTM B345/B345M, *Standard Specification for Aluminium and Aluminium-Alloy Seamless Pipe and Seamless Extruded Tube for Gas and Oil Transmission and Distribution Piping Systems*

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