SLOVENSKI STANDARD
oSIST prEN 12392:2014

01-september-2014

Aluminij in aluminijeve zlitine - Gnetne in ulite zlitine - Posebne zahteve za aluminijeve izdelke za izdelavo naprav, ki delajo pod tlakom

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

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

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

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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

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

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Foreword

This document (prEN 12392:2014) has been prepared by Technical Committee CEN/TC 132 “Aluminium and aluminium alloys”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

This document will supersede 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.

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, according to the definition given in European Pressure Equipment Directive 97/23 EC.

The 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.

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 shape and dimensions 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 583-1, *Non-destructive testing — Ultrasonic examination — Part 1: General principles*

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

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

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

EN 754-2:2013, *Aluminium and aluminium alloy - Cold drawn rod/bar and tube - Part 2: Mechanical properties*

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

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

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

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

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

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

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

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

EN 755-2:2013, *Aluminium and aluminium alloy - Extruded rod/bar, tube and profiles - Part 2: Mechanical properties*

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

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

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

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

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

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

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

EN 941, *Aluminium and aluminium alloy - Circle and circle stock for general applications – Specifications*

EN 1370, *Founding – Surface roughness inspection by visual tactile comparators*

EN 1371-1, *Founding – Liquid penetrant inspection – 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 1706, *Aluminium and aluminium alloys — Castings — Chemical composition and mechanical properties*

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

EN 2101, *Aerospace series - Chromic anodisation 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, 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*

EN ISO 6506–1, *Metallic materials – Brinell hardness test – Part 1: Method*

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

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

EN ISO 8495, *Metallic materials – Tube – Ring expanding test*

EN ISO 8496, *Metallic materials – Tube – Ring tensile test*

ISO 6892-1, *Metallic materials - Tensile testing - Part 1: method of test at room temperature*

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

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 for Aerospace Applications*

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

ASTM E215, *Standard practice for standardizing equipment for electromagnetic examination of seamless aluminium tube*

prEN 2002-8:1998, *Aerospace series - Test methods for metallic materials - Part 8: Micrographic determination of grain size*

prEN 2002-20:1996, *Aerospace series - Test methods for metallic materials - Part 20: Eddy current testing of circular cross-section tubes*

3 Terms and definitions

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

Note 3 to entry: As pressure die casting is not of concern in the present Standard, no die but only permanent moulds 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. 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. As a result, it will be necessary for the Standard to detail an extensive range of aluminium alloy 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), and

— 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 time 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 which 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, 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 Comment on the methods of porthole extruded and/or drawn products

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.

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. These guidelines are based on the Hazard Categories (Category I, II, III and IV) defined in the PED Directive 97/23/EC Annex II and are given below.

The guidelines themselves are divided into two tables;

— 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, and

— 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) are only recommendations.

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) must, 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 PED 97/23 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 Art. 9);

— design maximum pressure (PS), and

— 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.

It has to be underlined, that, beside the normative limits for nominal size DN and thickness t, Tables 4 and 5 provide additional guidelines which are recommendations and not normative requirements. 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 purchaser and supplier 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 must be agreed with the supplier and the request must 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, and

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, and

5) round tube: method of production, outside or inside diameter 1), wall thickness 1), and length;

NOTE 1 Two of these dimensions can be given tolerances but not all three.

6) coiled round tube: outside or inside diameter 1), wall thickness 1), coil dimensions and tube length if required in straight lengths;

NOTE 2 Two of these dimensions can 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, and

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 section 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;

NOTE 3 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, and

m) packaging methods to be used.

5.3 Test procedures

5.3.1 General

This section of the Standard 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.

NOTE 1 For castings, chemical analysis shall be carried out on samples taken from the same melt as the castings; the samples must be cooled quickly enough to minimise any segregation effects.

NOTE 2 For castings, 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 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 and EN 586 1, EN 1559-1, and 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) tube produced by the porthole extrusion method;

         I) a minimum of one tensile test shall be taken for every 1000 kg or part thereof for each inspection or heat treatment lot.

      ii) tube produced by the seamless extrusion method to be used for heavy duty applications or unfired pressure vessels.

         I) 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, and

      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, and