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Aluminium and aluminium alloys — Hot-rolled armour plates in weldable aluminium alloy — Technical delivery conditions

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National foreword

This British Standard is the UK implementation of EN 16914:2017.

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Aluminium and aluminium alloys - Hot-rolled armour plates in weldable aluminium alloy - Technical delivery conditions

Aluminium et alliages d'aluminium - Tôles en alliage d'aluminium soudable laminées à chaud pour blindage - Conditions techniques de livraison

Aluminium und Aluminiumlegierungen - Warmgewalzte Panzerplatten aus schweißgeeigneter Aluminiumlegierung - Technische Lieferbedingungen

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European foreword

This document (EN 16914:2017) 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of an identical text or by endorsement, at the latest by September 2017, and conflicting national standards shall be withdrawn at the latest by September 2017.

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1 Scope

This European Standard specifies the technical delivery conditions relating to armour plates in weldable aluminium alloy with a nominal thickness between 10 mm and 70 mm.

For thickness below 10 mm, other specifications may be applied.

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 10204, *Metallic products - Types of inspection documents*

EN ISO 6892-1, *Metallic materials - Tensile testing - Part 1: Method of test at room temperature (ISO 6892-1:2016)*

3 Designation

The aluminium alloys concerned by this document are designated in accordance with the categories listed in Table 1 below:

Table 1 — Categories

Category	Characteristics	Mechanical characteristics	Temper
ARAL1	Aluminium alloy for armour [a]	See 5.2	T651
ARAL2	Aluminium alloy for armour [b]	See 5.2	H13X [c]

[a] ARAL1 aluminium alloy shall have an EN AW-7020 type chemical composition and the mechanical, ballistic and strength characteristics described in the different parts of standard in the relevant standards.

[b] ARAL2 aluminium alloy shall have an EN AW-5083 type chemical composition and the mechanical characteristics described in the different parts of standard in the relevant standards.

[c] According to EN 515 or as agreed between supplier and purchaser.

4 Information to be provided by the purchaser

4.1 Mandatory information (tenders and orders)

The following information shall be provided by the purchaser at the time of the call for tenders and of the order:

a) form and nature of the product:

   1) the designation of the aluminium or aluminium alloy, in accordance with Table 1, specifying the temper for ARAL2;

b) the reference to this European Standard;

c) the nominal dimensions and form of the product:

   1) thickness;

   2) width;

   3) length (in the rolling direction): At each order, the rolling direction shall be specified. Unless otherwise specified, the longest dimension shall be the length;

d) the form and dimension tolerances;

e) quantity required: number of pieces, and the applicable quantity tolerance;

f) all requests for inspection documents;

g) all special requirements agreed upon between the supplier and the customer;

h) the applicable standard for ballistic testing, unless otherwise specified.

4.2 Options

When specified, the options specified in this document are listed below:

a) determination of the chemical composition of the product (see 5.1);

b) the acceptance according to the requirements in this document shall be supervised by an external inspection organization; the name of this organization shall then be explicitly stated at the time of the order;

These options shall be specified at the time of placing the order.

5 Requirements

5.1 Chemical composition

The chemical composition of the alloy shall be within the ranges for chemistry specified in Table 2 or Table 3:

Table 2 — Chemical composition for analysis from melt, in weight-% (ARAL1)

	Si	Fe	Cu	Mn	Mg	Cr	Zn	Zr	Zr + Ti	Al	Other	
											Each	Total
Min.			0,10	0,05	1,0	0,10	4,0	0,08	0,08	remainder		
Max.	0,35	0,40	0,20	0,50	1,4	0,35	5,0	0,20	0,25		0,05	0,15

Table 3 — Chemical composition for analysis from melt, in weight-% (ARAL2)

	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al	Other	
										Each	Total
Min.				0,40	4,0	0,05			remainder		
Max.	0,40	0,40	0,10	1	4,9	0,25	0,25	0,15		0,05	0,15

If agreed between the supplier and the purchaser at the time of the call for tenders and of the order (see 4.2, option 1), the products delivered may be subjected to a determination of chemical composition.

The chemical composition shall be determined according to the methods disclosed in EN 485-1 or a method to be agreed between supplier and purchaser.

5.2 Mechanical characteristics

The tensile tests shall be performed in the longitudinal transverse direction (perpendicular to the rolling direction) and the values shall fit within the ranges indicated in Table 4 or Table 5.

Table 4 — Mechanical characteristics –ARAL1

	At a temperature of + 20 °C		
	Tensile strength R_m MPa	**Yield strength** $R_{p0.2}$ MPa	**Elongation after fracture** *A %*
Min.	360	310	10 %
Max.	440	390	–

Table 5 — Mechanical characteristics – ARAL2

	At a temperature of + 20 °C		
	Tensile strength R_m MPa	**Yield strength** $R_{p0.2}$ MPa	**Elongation after fracture** *A %*
Min.	315	245	9 %
Max.	400	360	–

5.3 Stress corrosion

In the case of ARAL1 plates with a thickness over 20 mm, intended for use in a mechanically-welded structure, a stress corrosion test shall be performed in accordance with Annex A.

In the case of non-welded plates, this test is not required. This information shall be specified at the time of the call for tenders and of the order (see 4.2).

5.4 Absence of defects

The surface quality of the plates shall be in accordance with the requirements in EN 485-1.

5.5 Quality of the edges

The edges and ends of the plates shall be visually checked, and shall be free from delamination that could be detrimental to the welding.

In case of doubt, a non-destructive test (NDT) shall be performed by the supplier; the choice of method is at the supplier's discretion. This absence of lamination shall be checked up to 100 mm from the edges.

5.6 Ballistic performance

Unless otherwise specified, ballistic acceptance test is mandatory for materials confirmed according to this standard. Applicable references are disclosed in bibliography or shall be agreed between the supplier and the purchaser (see 4.1 item h).

6 Geometrical characteristics and tolerances

6.1 Nominal dimension

The nominal dimensions (thickness, width, length) are specified by the purchaser at the time of the call for tenders and of the order.

6.2 Tolerances on nominal dimensions and flatness

6.2.1 Thickness

Unless agreed otherwise at the time of the call for tenders and of the order, and regardless of the widths and lengths of the plates, the thickness tolerances are defined as follows:

$$\pm \left(0,01T + 0,5\right)/2 \qquad (1)$$

where

T is the thickness of the plate.

6.2.2 Width

Unless agreed otherwise at the time of the call for tenders and of the order, the tolerances on width shall be in accordance with the requirements of EN 485-3.

6.2.3 Length

Unless agreed otherwise at the time of the call for tenders and of the order, the tolerances on length shall be in accordance with the requirements of EN 485-3.

6.2.4 Flatness

Unless agreed otherwise at the time of the call for tenders and of the order, the tolerances on flatness shall be in accordance with the requirements of EN 485-3.

7 Inspections

7.1 Quality management

The original manufacturer of plates covered by this specification should set up a quality management system in accordance with standard EN ISO 9001.

Within his quality management system, the manufacturer shall keep an up-to-date procedure for verification of the requirements as specified in Clauses 7 to 9.

7.2 Sampling and testing

Unless agreed otherwise, sampling and testing are defined as follows:

— Lot definition for mechanical testing (see 7.3);

— Lot definition for ballistic testing on ARAL1 (see 7.4);

— Type and number of tests to be performed (see 7.5);

— Compliance of the lot (see 7.6);

— Counter-test (see 7.7).

7.3 Inspection lot definition for mechanical testing

The mass of inspection lot for mechanical testing shall be defined by the purchaser at the time of the call for tenders and of the order.

In the absence of indications at the time of the call for tenders and of the order, the inspection lot for mechanical testing (or acceptance unit) is made up of plates of the same nominal thickness, from the same hot rolling ingot and subjected to the same heat treatment performed as a single batch using the same equipment.

7.4 Inspection lot definition for ballistic testing on ARAL1

An inspection lot for ballistic testing is made up of plates of the same melt, of the same thickness, which have been subjected to the same heat treatment (same thermal cycle) performed with the same heat treatment equipment.

Unless agreed otherwise at the time of the call for tenders and of the order, the mass of inspection lot for ballistic testing is limited to max 15 t.

Inspection lots for ballistic testing from several melts are tolerated provided their composition remains within more restricted limits than those in Table 2. The new ranges relating to major alloy elements (Zn, Mg) shall then be below 80 % of the ranges disclosed in Table 2. In this case, all necessary measures to identify each melt making up the lot shall be taken.

Inspection lot for ballistic testing of plates with different thicknesses are allowed provided:

— that the difference between the maximum thickness and the minimum thickness of these plates is strictly below 30 % of the maximum thickness, and that projectiles used for acceptance testing are identical;

— that the acceptance testing conditions are selected so that all thicknesses are periodically tested.

7.5 Type and number of tests to be performed

The following shall be performed for each inspection lot for mechanical testing (see 7.3):

— one determination of chemical composition of the melt;

— one tensile test with the longitudinal axis of the test piece in the longitudinal-transverse direction respect to the rolling direction;

— dimensional inspection, in accordance with EN 485-3;

— visual inspection of the surface finish, in accordance with EN 485-1.

The following tests shall be performed for each inspection lot for ballistic testing (see 7.4), and for the alloys of the ARAL1 category:

— stress corrosion tests (tests performed on 5 test pieces, see Annex A) in accordance with 5.3;

— one ballistic acceptance test: the supplier shall have a ballistic test report covering the nominal thickness(es) of the plates of the inspection lot, whose results are compliant with the requirements in 5.6. This report shall be available for the purchaser upon request.

7.6 Compliance of the inspection lot

An inspection lot is declared as compliant with this document if:

— the chemical analysis is compliant with the requirements in Table 2 or Table 3;

— all tensile properties are compliant with the requirements in Table 4 or Table 5, taking the requirements stated in 9.2 into account;

— the stress corrosion test is compliant with the requirements in 5.3;

— the surface finish is compliant with the requirements in 5.4;

— the dimensional characteristics are compliant with the requirements in Clause 6;

— the results of the ballistic trials on alloys in the ARAL1 category are compliant with the requirements as agreed between the supplier and the purchaser (see 5.6). For alloys in the ARAL2 category, the inspection lot compliance is recognized without ballistic test results when the ballistic acceptance is not explicitly required on order.

7.7 Counter-tests

EN 485-1 applies to all counter-tests.

In the case of modification through any additional heat treatment, the stress corrosion test shall be performed again.

If the stress corrosion test does not meet the acceptance criteria defined in this standard, the inspection lot shall be rejected.

7.8 Inspection document

A type 3.1 inspection document according to EN 10204 shall be issued by the supplier and forwarded to the purchaser. It shall include the following elements, as a minimum:

— the order number;

— the melt number;

— the inspection lot number for mechanical testing;

— the alloy category (ARAL1 or ARAL2) and the temper designation;

— the dimensions, thicknesses and number of plates making up the inspection lot for mechanical testing;

— the results of the tests specified in 7.5, as well as the sampling location and direction;

— for alloys in the ARAL1 category, the ballistic test report reference;

— for alloys in the ARAL2 category, the ballistic test report reference if this option is selected as part of the order or of the contract.

When acceptance shall be supervised by an external organization (see 4.2, option b), the inspection document is of type 3.2 as per EN 10204. In this case, this document shall include, in addition to the information listed above, the stamp of the external organization, the supervisor's name and signature, and an example of the mark affixed on the plates.

8 Sample and test piece preparation

The sampling intended for determination of chemical composition and tensile testing shall be done by applying according to EN 485-1.

The test pieces shall be taken perpendicular to the main rolling direction (longitudinal transverse). However, if the width of the product is below 300 mm, the tests may be performed in the longitudinal direction. In this case, the mechanical characteristic limits specified in 5.2 apply.

The characteristics of the test pieces for stress corrosion tests are given in Annex A.

The characteristics of the test pieces for ballistic tests are agreed between the purchaser and the supplier at the time of the call for tenders and of the order (see 5.6).

9 Test methods

9.1 Chemical analysis

The elements to be identified, the content of which is to be reported in the inspection document, are those specified in Table 2 and Table 3. The selection of an appropriate method for sampling and testing shall be those defined in EN 485-1. In the case of dispute, the analysis method used shall be agreed on between the purchaser and the producer.

9.2 Tensile test

The tensile test shall be performed at room temperature in accordance with method B in EN ISO 6892-1.

9.3 Stress corrosion test

The elements relating to the stress corrosion test are given in Annex A.

9.4 Ballistic testing

The applicable ballistic testing method shall be agreed between the supplier and the purchaser.

10 Marking, labelling, packaging

Each plate in the lot shall be identified by indelible marking. This marking shall include at least the following information:

— the product category (as defined in Table 1);

— the melt number;

— the plate individual number;

— the producer's name or trade name (if applicable); and, when acceptance shall be supervised by an external organization (see 4.2, option b), the name of the external inspection organization next to the producer's marking.

Annex A
(normative)

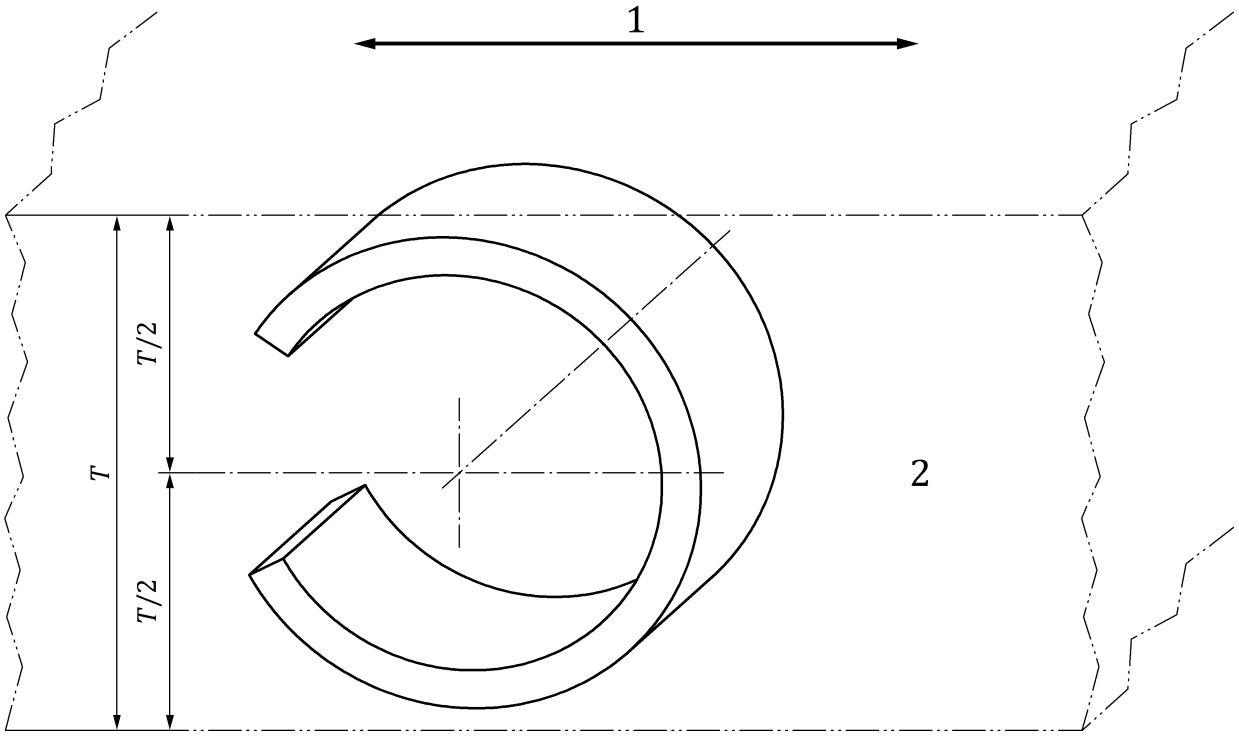
Stress corrosion test

A.1 General

This test is performed on plates with a thickness greater than or equal to 20 mm.

A.2 Sampling of test pieces

Five test pieces are taken in mid-thickness of the plate so that their axis is perpendicular to the rolling direction and parallel to the surface of the plate, as shown in Figure A.1.



Key

1 rolling direction

2 plate

T actual plate thickness

Figure A.1 — Test piece for stress corrosion test

A.3 Forms and dimensions of the test pieces

The test pieces ("C" ring) come in the form of a portion of open tube, put under stress by tightening of a transversal bolt as shown in Figure A.2.

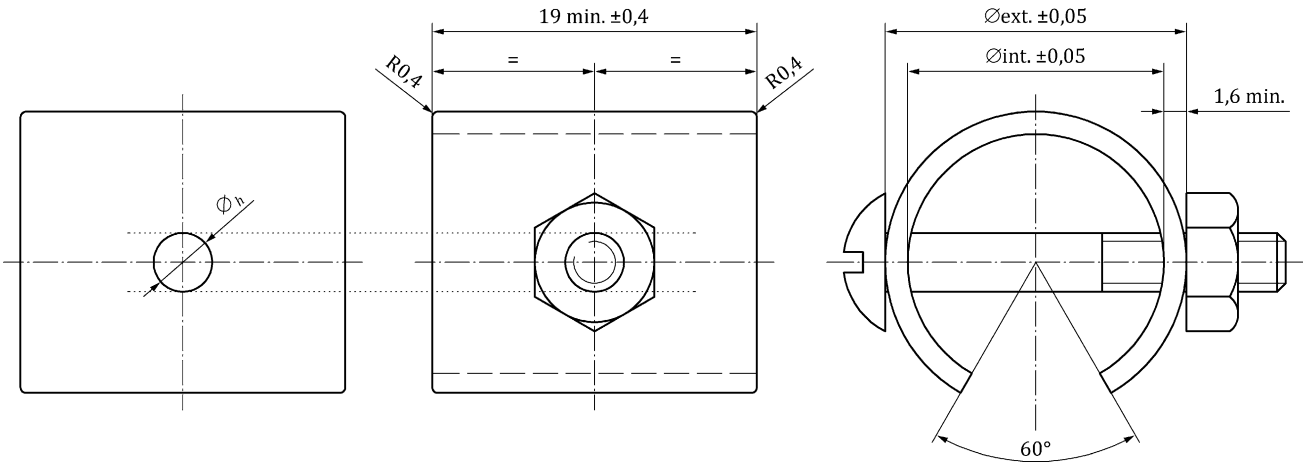


Figure A.2 — Forms and dimensions of the test pieces

For plates with a thickness higher than or equal to 20 mm, and strictly below 35 mm:

D = 0,75" = 19,05 mm ± 0,025 mm

$\varnothing_h$ = 5 mm maximum

t = 0,06" = 1,524 mm ± 0,025 mm

For plates with a thickness higher than or equal to 35 mm:

D = 1,25" = 31,75 mm ± 0,025 mm

$\varnothing_h$ = 6,5 mm maximum

t = 0,1" = 2,54 mm ± 0,025 mm

A.4 Test piece preparation

A.4.1 Machining and surface preparation

A high-quality machined surface is desirable for corrosion tests. Measures should be taken to avoid overheating, plastic deformation, or the development of residual stress on the metallic surface. Standard practice is to perform the machining in steps, so that the final cut leaves the main surface with a perfect roughness with an effective value of 1 µm or better.

Lapping, mechanical polishing, and similar operations causing metal creep are to be avoided.

The surface preparation, including a final degreasing of the sample and the zone subjected to stress, should be completed before any stress is applied on the C-rings.

All possible precautions should be taken to avoid finger marks or any rough handling that can affect the surface finish after preparation.

A.4.2 Calculation formula

The value of the test stress for each alloy is equal to 70 % of the minimum yield strength determined during the tensile test. This test stress is applied to the test piece using a bolt isolated from the test piece by plastic rings in order to avoid any galvanic couple.

The final diameter D_f required for the necessary stress can be calculated using the following formulae:

$$D_f = D \pm \Delta D \quad \text{(A.1)}$$

and

$$\Delta D = \frac{\sigma \pi d^2}{4EtZ} \quad \text{(A.2)}$$

where

D is the outer diameter, in millimetres, of the C-ring before any stress is applied;

D_f is the outer diameter, in millimetres, of the C-ring subjected to the stress, measured at right angles in relation to an axis running through the maximum stress point;

σ is the necessary stress, in meganewtons per square meter, within the proportional limit;

ΔD is the D variation, in millimetres, giving the necessary stress;

d is the average diameter ($D - t$), in millimetres;

t is the wall thickness, in millimetres;

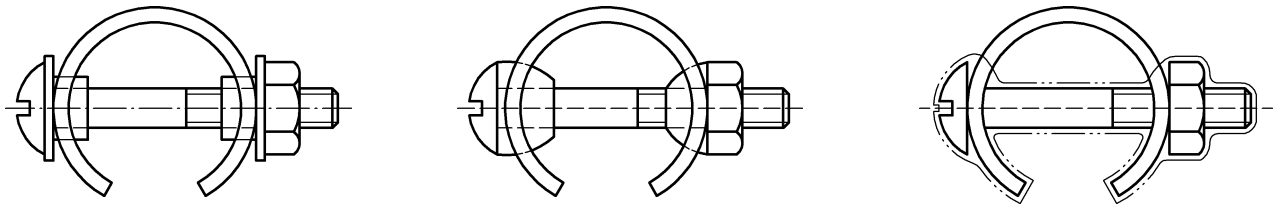
E is the modulus of elasticity, in meganewtons per square metre;

Z is a constant defined from EN ISO 7539-5, Figure A.1. It is equal to 0,945 with $D/t = 12{,}5$.

A.5 Operating procedure

A.5.1 Galvanic effects should be carefully avoided between the C-ring, the stress bolt, the nuts or the wedge and the exposure supports. Protection may be provided by an insulating ring of the type shown in Figure A.3 a) or Figure A.3 b), or by coatings of the type shown in Figure A.3 c). It is also essential to avoid corrosion through fissure, which could generate corrosion products between the ring and the assembly under stress, and then alter the stress in the latter; the coating in Figure A.3 c) is designed for this purpose. It is recommended that the selected coatings or insulating materials do not contaminate the corrosive environment, and are not damaged by it.

A.5.2 The test pieces should be exposed to the testing environment immediately after stressing, or stored so as to avoid contamination or any damage until exposure.



a) Insulating retaining ring **b) Insulating retaining ring** **c) Coating**

Figure A.3 — Protection against crevice corrosion and by galvanic effects

A.6 Testing conditions

The reagent is a 3,5 % ± 0,1 % sodium chloride solution bath.

The test pieces are alternatively kept for 10 min. in the reagent, and then left exposed to air for 50 min.

The test temperature is 27 °C ± 1 °C, and the relative humidity is 45 % ± 10 %.

A.7 Interpretation of the results

Stress cracking is indicated by cracks parallel to the test piece axis, which are located on the non-protected sector. These cracks spread, then meet, and the part itself may eventually break.

The appearance of the first crack is recorded hour by hour, then day by day, as visually inspected, using no additional magnification equipment. As soon as the first crack appears, the test piece is declared to be unsatisfactory. The time required for the first crack to start depends on the level of the stress applied.

The test is “acceptable” when all test pieces are declared to be satisfactory after 10 d of testing.

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