

# W25 Aluminium Alloys for Hull Construction and Marine Structure

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### Note:

1. Rev.4 of this UR is to be uniformly implemented by IACS Societies on ships contracted for construction on or after 1 January 2013 and when the application for certification of materials is dated on or after 1 January 2013.

2. The “contracted for construction” date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. For further details regarding the date of “contract for construction”, refer to IACS Procedural Requirement (PR)No. 29.

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**1. SCOPE**

- 1.1 These Requirements apply to wrought aluminium alloys used in the construction of hulls, superstructures and other marine structures. They are not applicable to the use of aluminium alloys at low temperature for cryogenic applications.
- 1.2 These Requirements are applicable to wrought aluminium alloy products within a thickness range of 3 mm and 50 mm inclusive. The application of aluminium alloys products outside this thickness range requires prior agreement of the Classification Society.
- 1.3 The numerical designation (grade) of aluminium alloys and the temper designation are based on those of the Aluminium Association.
- 1.4 Temper conditions (delivery heat treatment) are defined in the European Standard EN 515 or ANSI H35.1.
- 1.5 Consideration may be given to aluminium alloys not specified in these Requirements, and to alternative temper conditions, subject to prior agreement with the Classification Society further to a detailed study of their properties, including corrosion resistance, and of their conditions of use (in particular welding procedures).

**2. APPROVAL**

- 2.1 All materials, including semi finished products, are to be manufactured at works which are approved by the Classification Society for the grades of aluminium alloy supplied.

**3. ALUMINIUM ALLOYS AND THEIR TEMPER CONDITIONS**

- 3.1 Rolled products (sheets, strips and plates)  
The following aluminium alloys are covered by these Requirements:

5083, 5086, 5383, 5059, 5754, 5456

with the hereunder temper conditions:

O<sub>7</sub>, H111, H112, H116, H321

- 3.2 Extruded products (sections, shapes, bars and closed profiles)

The following aluminium alloys are covered by these Requirements:

5083, 5383, 5059, 5086

with the hereunder temper conditions:

O<sub>7</sub>, H111, T<sub>6</sub>, H112,

and:  
6005A, 6061, 6082

with the hereunder temper conditions:

T5 or T6.

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Note: The alloy grades 6005A, 6061 of the 6000 series should not be used in direct contact with sea water unless protected by anodes and/or paint system.

**4. CHEMICAL COMPOSITION**

- 4.1 The Manufacturer is to determine the chemical composition of each cast.
- 4.2 The chemical composition of aluminium alloys is to comply with the requirements given in Table 1.
- 4.3 The Manufacturer's declared analysis will be accepted subject to occasional checks if required by the Surveyor; in particular, product analysis may be required where the final product chemistry is not well represented by the analysis from the cast.
- 4.4 When the aluminium alloys are not cast in the same works in which they are manufactured into semi finished products, the Society Surveyor shall be given a certificate issued by the works in question which indicates the reference numbers and chemical composition of the heats.

**5. MECHANICAL PROPERTIES**

- 5.1 The mechanical properties are to comply with the requirements given in Tables 2 and 3.

Note: It should be recognized that the mechanical properties of the welded joint are lower for strain hardened or heat treated alloys, when compared with those of the base material, in general. For reference, see the UR for Aluminium Consumables.

**6. FREEDOM OF DEFECTS**

- 6.1 The finished material is to have a workmanlike finish and is to be free from internal and surface defects prejudicial to the use of the concerned material for the intended application.
- 6.2 Slight surface imperfections may be removed by smooth grinding or machining as long as the thickness of the material remains within the tolerances given in Section 7.

**7. TOLERANCES**

- 7.1 The underthickness tolerances for rolled products given in Table 4 are minimum requirements.
- 7.2 The underthickness tolerances for extruded products are to be in accordance with the requirements of recognized international or national standards.
- 7.3 Dimensional tolerances other than underthickness tolerances are to comply with a recognized national or international standard.

**8. TESTING AND INSPECTION**

- 8.1 **Tensile test**  
The test specimens and procedures are to be in accordance with UR W2.

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(cont'd)**8.2 Non-destructive examination.**

In general, the non-destructive examination of material is not required for acceptance purposes.

Note: Manufacturers are expected, however, to employ suitable methods of non-destructive examination for the general maintenance of quality standards.

**8.3 Dimensions**

It is the manufacturer's responsibility to check the materials for compliance with the tolerances given in Section 7.

**8.4 Verification of proper fusion of press welds for closed profiles.**

8.4.1 The Manufacturer has to demonstrate by macrosection tests or drift expansion tests of closed profiles performed on each batch of closed profiles that there is no lack of fusion at the press welds.

**8.4.2 Drift expansion tests**

8.4.2.1 Every fifth profile shall be sampled after final heat treatment.

Batches of five profiles or less shall be sampled one profile.

Profiles with lengths exceeding 6 m shall be sampled every profile in the start of the production. The number of tests may be reduced to every fifth profile if the results from the first 3-5 profiles are found acceptable.

8.4.2.2 Each profile sampled will have two samples cut from the front and back end of the production profile.

8.4.2.3 The test specimens are to be cut with the ends perpendicular to the axis of the profile. The edges of the end may be rounded by filing.

8.4.2.4 The length of the specimen is to be in accordance with UR W2.

8.4.2.5 Testing is to be carried out at ambient temperature and is to consist of expanding the end of the profile by means of a hardened conical steel mandrel having an included angle of at least 60°.

8.4.2.6 The sample is considered to be unacceptable if the sample fails with a clean split along the weld line which confirms lack of fusion.

**8.5 Corrosion testing**

8.5.1 Rolled 5xxx-alloys of type 5083, 5383, 5059, 5086 and 5456 in the H111, H112, H116 and H321 tempers intended for use in marine hull construction or in marine applications where frequent direct contact with seawater is expected are to be corrosion tested with respect to exfoliation and intergranular corrosion resistance.

8.5.2 The manufacturers shall establish the relationship between microstructure and resistance to corrosion when the above alloys are approved. A reference photomicrograph taken at 500x, under the conditions specified in ASTM B928, Section 9.4.1, shall be established for each of the alloy-tempers and thickness ranges relevant. The reference photographs shall be taken from samples which have exhibited no evidence of exfoliation corrosion and a pitting rating of PB or better, when subjected to the test described in ASTM G66 (ASSET). The samples shall also have exhibited resistance to intergranular corrosion at a mass loss no greater than

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15mg/cm<sup>2</sup>, when subjected to the test described in ASTM G67 (NAMLT). Upon satisfactory establishment of the relationship between microstructure and resistance to corrosion, the master photomicrographs and the results of the corrosion tests are to be approved by the Classification Society. Production practices shall not be changed after approval of the reference micrographs.

Other test methods may also be accepted at the discretion of the Classification Society.

- 8.5.3 For batch acceptance of 5xxx-alloys in the H116 and H321 tempers, metallographic examination of one sample selected from mid width at one end of a coil or random sheet or plate is to be carried out. The microstructure of the sample is to be compared to the reference photomicrograph of acceptable material in the presence of the Surveyor. A longitudinal section perpendicular to the rolled surface shall be prepared for metallographic examination, under the conditions specified in ASTM B928, Section 9.6.1. If the microstructure shows evidence of continuous grain boundary network of aluminium-magnesium precipitate in excess of the reference photomicrographs of acceptable material, the batch is either to be rejected or tested for exfoliation-corrosion resistance and intergranular corrosion resistance subject to the agreement of the Surveyor. The corrosion tests are to be in accordance with ASTM G66 and G67 or equivalent standards. Acceptance criteria are that the sample shall exhibit no evidence of exfoliation corrosion and a pitting rating of PB or better when test subjected to ASTM G66 ASSET test, and the sample shall exhibit resistance to intergranular corrosion at a mass loss no greater than 15mg/cm<sup>2</sup> when subjected to ASTM G67 NAMLT test. If the results from testing satisfy the acceptance criteria stated in paragraph 8.5.2 the batch is accepted, else it is to be rejected.

As an alternative to metallographic examination, each batch may be tested for exfoliation-corrosion resistance and intergranular corrosion resistance, in accordance with ASTM G66 and G67 under the conditions specified in ASTM B928, or equivalent standards. If this alternative is used, then the results of the test must satisfy the acceptance criteria stated in paragraph 8.5.3.

## 9. TEST MATERIALS

### 9.1 Definition of batches

Each batch is made up of products:

- of the same alloy grade and from the same cast
- of the same product form and similar dimensions (for plates, the same thickness)
- manufactured by the same process
- having been submitted simultaneously to the same temper condition.

### 9.2 The test samples are to be taken

- at one third of the width from a longitudinal edge of rolled products.
- in the range 1/3 to 1/2 of the distance from the edge to the centre of the thickest part of extruded products.

### 9.3 Test samples are to be taken so that the orientation of test specimens is as follows:

#### a) Rolled products

Normally, tests in the transverse direction are required. If the width is insufficient to obtain transverse test specimen, or in the case of strain hardening alloys, tests in the longitudinal direction will be permitted.

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b) Extruded products

The extruded products are tested in longitudinal direction.

- 9.4 After removal of test samples, each test specimen is to be marked in order that its original identity, location and orientation is maintained.

**10. MECHANICAL TEST SPECIMENS**

- 10.1 Type and location of tensile test specimen

The type and location of tensile test specimens are to be in accordance with UR W2.

**11. NUMBER OF TEST SPECIMENS****11.1 Tensile test**

a) Rolled products

One tensile test specimen is to be taken from each batch of the product. If the weight of one batch exceeds 2000 kg, one extra tensile test specimen is to be taken from every 2000 kg of the product or fraction thereof, in each batch.

For single plates or for coils weighting more than 2000 kg each, only one tensile test specimen per plate or coil shall be taken.

b) Extruded products

For the products with a nominal weight of less than 1 kg/m, one tensile test specimen is to be taken from each 1000 kg, or fraction thereof, in each batch. For nominal weights between 1 and 5 kg/m, one tensile test specimen is to be taken from each 2000 kg or fraction hereof, in each batch. If the nominal weight exceeds 5 kg/m, one tensile test specimen is to be taken for each 3000 kg of the product or fraction thereof, in each batch.

**11.2 Verification of proper fusion of press welds**

For closed profiles, verification of proper fusion of press welds is to be performed on each batch as indicated in 8.4 above.

**11.3 Corrosion tests**

For rolled plates of grade 5083, 5383, 5059, 5086 and 5456 delivered in the tempers H116 or H321, one sample is to be tested per batch.

**12. RETEST PROCEDURES**

- 12.1 When the tensile test from the first piece selected in accordance with Section 11 fails to meet the requirements, two further tensile tests may be made from the same piece. If both of these additional tests are satisfactory, this piece and the remaining pieces from the same batch may be accepted.

- 12.2 If one or both the additional tests referred to above are unsatisfactory, the piece is to be rejected, but the remaining material from the same batch may be accepted provided that two of the remaining pieces in the batch selected in the same way, are

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tested with satisfactory results. If unsatisfactory results are obtained from either of these two pieces then the batch of material is to be rejected.

- 12.3 In the event of any material bearing the Classification Society's brand failing to comply with the test requirements, the brand is to be unmistakably defaced by the manufacturer.

**13. BRANDING**

- 13.1 The manufacturer shall mark each product at least one place with the following details:

- a) Manufacturer's mark
- b) Abbreviated designation of aluminium alloy according to Section 3
- c) Abbreviated designation of temper condition according to Section 3
- d) Tempers that are corrosion tested in accordance with section 8.5 are to be marked "M" after the temper condition, e.g. 5083 H321 M.
- e) Number of the manufacturing batch enabling the manufacturing process to be traced back.

- 13.2 The product is also to bear the Classification Society's brand.

- 13.3 When extruded products are bundled together or packed in crates for delivery, the marking specified in para 13.1 should be affixed by a securely fastened tag or label.

**14. DOCUMENTATION**

- 14.1 For each tested batch, the manufacturer must supply to the Classification Society's Surveyor a test certificate, or a shipping statement containing the following details :

- a) Purchaser and order number
- b) Construction project number, when known,
- c) Number, dimensions and weight of the product
- d) Designation of the aluminium alloy (grade) and of its temper condition (delivery heat treatment)
- e) Chemical composition
- f) Manufacturing batch number or identifying mark
- g) Mechanical Test results-
- h) Corrosion Test results (if any).

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Table 1 Chemical composition <sup>1)</sup>

Grade	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Other elements <sup>2)</sup>	
									Each	Total
5083	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
5383	0.25	0.25	0.20	0.7-1.0	4.0-5.2	0.25	0.40	0.15	0.05 <sup>5)</sup>	0.15 <sup>5)</sup>
5059	0.45	0.50	0.25	0.6-1.2	5.0-6.0	0.25	0.40-0.90	0.20	0.05 <sup>6)</sup>	0.15 <sup>6)</sup>
5086	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
5754	0.40	0.40	0.10	0.50 <sup>3)</sup>	2.6-3.6	0.30 <sup>3)</sup>	0.20	0.15	0.05	0.15
5456	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
6005A	0.50-0.9	0.35	0.30	0.50 <sup>4)</sup>	0.40-0.7	0.30 <sup>4)</sup>	0.20	0.10	0.05	0.15
6061	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
6082	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

## Notes:

<sup>1)</sup> Composition in percentage mass by mass maximum unless shown as a range or as a minimum.

<sup>2)</sup> Includes Ni, Ga, V and listed elements for which no specific limit is shown. Regular analysis need not be made.

<sup>3)</sup> Mn + Cr: 0.10-0.60

<sup>4)</sup> Mn + Cr: 0.12-0.50

<sup>5)</sup> Zr: maximum 0.20. The total for other elements does not include Zirconium.

<sup>6)</sup> Zr: 0.05-0.25. The total for other elements does not include Zirconium.



Table 2 Mechanical properties for rolled products,  $3 \text{ mm} \leq t \leq 50 \text{ mm}$ 

Grade	Temper condition <sup>3)</sup>	Thickness, t	Yield Strength $R_{p0.2}$ min. or range $\text{N/mm}^2$	Tensile Strength $R_m$ min. or range $\text{N/mm}^2$	Elongation, % min. <sup>1)</sup>	
					$A_{50 \text{ mm}}$	$A_{5d}$
5083	O	$3 \leq t \leq 50 \text{ mm}$	125	275-350	16	14
	<u>H111</u>	<u><math>3 \leq t \leq 50 \text{ mm}</math></u>	<u>125</u>	<u>275-350</u>	<u>16</u>	<u>14</u>
	H112	$3 \leq t \leq 50 \text{ mm}$	125	275	12	10
	H116	$3 \leq t \leq 50 \text{ mm}$	215	305	10	10
	H321	$3 \leq t \leq 50 \text{ mm}$	215-295	305-385	12	10
5383	O	$3 \leq t \leq 50 \text{ mm}$	145	290	=	17
	<u>H111</u>	<u><math>3 \leq t \leq 50 \text{ mm}</math></u>	<u>145</u>	<u>290</u>	=	<u>17</u>
	H116	$3 \leq t \leq 50 \text{ mm}$	220	305	10	10
	H321	$3 \leq t \leq 50 \text{ mm}$	220	305	10	10
5059	O	$3 \leq t \leq 50 \text{ mm}$	160	330	<u>24</u>	24
	<u>H111</u>	<u><math>3 \leq t \leq 50 \text{ mm}</math></u>	<u>160</u>	<u>330</u>	<u>24</u>	<u>24</u>
	H116	$3 \leq t \leq 20 \text{ mm}$	270	370	10	10
		$20 < t \leq 50 \text{ mm}$	260	360	<del>10</del>	10
	H321	$3 \leq t \leq 20 \text{ mm}$	270	370	10	10
		$20 < t \leq 50 \text{ mm}$	260	360	<del>10</del>	10
5086	O	$3 \leq t \leq 50 \text{ mm}$	95	240-305	16	14
	<u>H111</u>	<u><math>3 \leq t \leq 50 \text{ mm}</math></u>	<u>95</u>	<u>240-305</u>	<u>16</u>	<u>14</u>
	H112	$3 \leq t \leq 12.5 \text{ mm}$	125	250	8	=
		$12.5 < t \leq 50 \text{ mm}$	105	240	=	9
H116	$3 \leq t \leq 50 \text{ mm}$	195	275	10 <sup>2)</sup>	9	
5754	O	$3 \leq t \leq 50 \text{ mm}$	80	190-240	18	17
	<u>H111</u>	<u><math>3 \leq t \leq 50 \text{ mm}</math></u>	<u>80</u>	<u>190-240</u>	<u>18</u>	<u>17</u>
5456	O	$3 \leq t \leq 6.3 \text{ mm}$	130-205	290-365	16	
		$6.3 < t \leq 50 \text{ mm}$	125-205	285-360	16	14
	H116	$3 \leq t \leq 30 \text{ mm}$	230	315	10	10
		$30 < t \leq 40 \text{ mm}$	215	305	=	10
		$40 < t \leq 50 \text{ mm}$	200	285	=	10
	H321	$3 \leq t \leq 12.5 \text{ mm}$	230-315	315-405	12	=
		$12.5 < t \leq 40 \text{ mm}$	215-305	305-385	=	10
$40 < t \leq 50 \text{ mm}$		200-295	285-370	=	10	

Notes:  
<sup>1)</sup> Elongation in 50 mm apply for thicknesses up to and including 12.5 mm and in 5d for thicknesses over 12.5 mm.  
<sup>2)</sup> 8 % for thicknesses up to and including 6.3 mm.  
<sup>3)</sup> The mechanical properties for the O and H111 tempers are the same. However, they are separated to discourage dual certification as these tempers represent different processing.

Table 3 Mechanical properties for extruded products,  $3 \text{ mm} \leq t \leq 50 \text{ mm}$ 

Grade	Temper	Thickness, t	Yield Strength $R_{p0.2}$ min. N/mm <sup>2</sup>	Tensile Strength $R_m$ min. or range N/mm <sup>2</sup>	Elongation, % min. <sup>1)2)</sup>	
					A <sub>50 mm</sub>	A <sub>5d</sub>
5083	O	$3 \leq t \leq 50 \text{ mm}$	110	270-350	14	12
	H111	$3 \leq t \leq 50 \text{ mm}$	165	275	12	10
	H112	$3 \leq t \leq 50 \text{ mm}$	110	270	12	10
5383	O	$3 \leq t \leq 50 \text{ mm}$	145	290	17	17
	H111	$3 \leq t \leq 50 \text{ mm}$	145	290	17	17
	H112	$3 \leq t \leq 50 \text{ mm}$	190	310		13
5059	H112	$3 \leq t \leq 50 \text{ mm}$	200	330		10
5086	O	$3 \leq t \leq 50 \text{ mm}$	95	240-315	14	12
	H111	$3 \leq t \leq 50 \text{ mm}$	145	250	12	10
	H112	$3 \leq t \leq 50 \text{ mm}$	95	240	12	10
6005A	T5	$3 \leq t \leq 50 \text{ mm}$	215	260	9	8
	T6	$3 \leq t \leq 10 \text{ mm}$	215	260	8	6
		$10 < t \leq 50 \text{ mm}$	200	250	8	6
6061	T6	$3 \leq t \leq 50 \text{ mm}$	240	260	10	8
6082	T5	$3 \leq t \leq 50 \text{ mm}$	230	270	8	6
	T6	$3 \leq t \leq 5 \text{ mm}$	250	290	6	
		$5 < t \leq 50 \text{ mm}$	260	310	10	8

Notes:

- 1) The values are applicable for longitudinal and transverse tensile test specimens as well.
- 2) Elongation in 50 mm applies for thicknesses up to and including 12.5 mm and in 5d for thicknesses over 12.5 mm.

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(cont'd)**Table 4 Underthickness tolerances for rolled products**

Nominal thickness (t), mm	Thickness tolerances for nominal width (w), mm		
	$w \leq 1500$	$1500 < w \leq 2000$	$2000 < w \leq 3500$
$3.0 \leq t < 4.0$	0.10	0.15	0.15
$4.0 \leq t < 8.0$	0.20	0.20	0.25
$8.0 \leq t < 12.0$	0.25	0.25	0.25
$12.0 \leq t < 20.0$	0.35	0.40	0.50
$20.0 \leq t < 50.0$	0.45	0.50	0.65

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