



SLOVENSKI STANDARD
SIST EN 485-2:2004

01-november-2004

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Aluminium and aluminium alloys - Sheet, strip and plate - Part 2: Mechanical properties

Aluminium und Aluminiumlegierungen - Bänder, Bleche und Platten - Teil 2:
Mechanische Eigenschaften

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Aluminium et alliages d'aluminium - Tôles, bandes et tôles épaisses - Partie 2:
Caractéristiques mécaniques

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Ta slovenski standard je istoveten z: EN 485-2:2004

ICS:

77.150.10 Alumijski izdelki Aluminium products

SIST EN 485-2:2004 **en**

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English version

Aluminium and aluminium alloys - Sheet, strip and plate - Part 2: Mechanical properties

Aluminium et alliages d'aluminium - Tôles, bandes et tôles
épaisses - Partie 2: Caractéristiques mécaniques

Aluminium und Aluminiumlegierungen - Bänder, Bleche
und Platten - Teil 2: Mechanische Eigenschaften

This European Standard was approved by CEN on 24 March 2004.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This document (EN 485-2:2004) 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of an identical text or by endorsement, at the latest by January 2005, and conflicting national standards shall be withdrawn at the latest by January 2005.

Within its programme of work, Technical Committee CEN/TC 132 entrusted CEN/TC 132/WG 7 "Sheet, strip and plate" to prepare the following standard:

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

This standard is part of a set of four standards. The other standards deal with:

- *Part 1: Technical conditions for inspection and delivery*
- *Part 3: Tolerances on dimensions and form for hot-rolled products*
- *Part 4: Tolerances on shape and dimensions for cold-rolled products*

This document supersedes EN 485-2:1994. [standards.iteh.ai](https://standards.iteh.ai/catalog/standards/sist/478108f9-1b07-4780-b802-9417f54b10bc/sist-en-485-2-2004)

Besides very slight editorial adjustments in the text and update of normative references, the following technical changes have been made:

- Clause 1: NOTE added.
- Clause 2: ASTM G34-86 changed into ASTM G34-97
ASTM G66-86 changed into ASTM G66-95
- Clause 5: Note added
- Tables 2 to 39: Due to the introduction of new alloys, the tables have been renumbered when necessary.
- New alloys: EN AW-2014A, 4015, 5005A, 5449, 5383, 6016.
- Modified values or extended ranges:
 - EN AW-1070A: O/H111 (over 12,5 mm up to 25,0 mm) added.

EN AW-1050A:	O/H111 (over 12,5 mm up to 80,0 mm) extended. H14 (over 0,5 mm up to 1,5 mm) $A_{50 \text{ mm}}$ modified. H24 (over 0,5 mm up to 1,5 mm) $A_{50 \text{ mm}}$ modified.
EN AW-1200:	O/H111 (over 12,5 mm up to 80,0 mm) extended.
EN AW-2014:	T6, T651 (over 100,0 mm up to 160,0 mm) extended.
EN AW-2017A:	T4, T451 modified, T452 added.
EN AW-3103:	H16 (over 4,0 mm up to 8,0 mm) added.
EN AW-5049:	H112 (6,0 up to 25,0) modified.
EN AW-5052:	F modified, H112 (6,0 mm up to 12,5 mm) modified.
EN AW-5454:	F modified and extended.
EN AW-5754:	F (over 100,0 mm up to 150,0 mm) added, H112 modified.
EN AW-5083:	F modified, O/H111 (over 120,0 mm up to 300,0 mm) extended, H112 (over 80,0 mm up to 120,0 mm) added.
EN AW-5086:	H112 (6,0 mm up to 12,5 mm) modified.
EN AW-6061:	T6, T651, T62 (over 150,0 mm up to 400,0 mm) extended.
EN AW-6082:	T6, T651, T62 (over 175,0 mm up to 350,0 mm) added.
EN AW-7020:	T6, T651, T62 (over 175,0 mm up to 250,0 mm) added.
EN AW-7075:	T6, T651, T62 (over 150,0 mm up to 300,0 mm) added, T652 added.

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

1 Scope

This part of EN 485 specifies the mechanical properties of wrought aluminium and aluminium alloy sheet, strip and plate for general engineering applications.

It applies to flat rolled products.

It does not apply to semi-finished rolled products in coiled form to be subjected to further rolling (reroll stock) or to special products such as corrugated, embossed, painted, etc. sheets and strips or to special applications such as aerospace, can stock, finstock, etc. which are dealt with in separate European Standards.

The systems for designating these materials are described in EN 573-1 and EN 573-2. Their chemical composition limits are specified in EN 573-3.

Mechanical property limits are specified for all Class A alloys, as defined in EN 573-4.

Temper designations are defined in EN 515.

NOTE Some of the products listed in the present standard can be subject to patent or patent applications, and their listing herein does not in any way imply the granting of a licence under such patent right.

CEN/TC 132 affirms it is its policy that in the case when a patentee refuses to grant licences on standardised standard products under reasonable and not discriminatory conditions then this product shall be removed from the corresponding standard.

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2 Normative references

The following referenced documents are indispensable for the application of this document. 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 2004-1, *Aerospace series — Test methods for aluminium and aluminium alloy products — Part 1: Determination of electrical conductivity of wrought aluminium alloys.*

EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of test at ambient temperature.*

EN ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method (ISO 6506-1:1999).*

EN ISO 7438, *Metallic materials — Bend test (ISO 7438:1985).*

ISO 9591, *Corrosion of aluminium alloys — Determination of resistance to stress-corrosion cracking.*

ASTM G34-97, *Exfoliation Corrosion Susceptibility in 2xxx and 7xxx Series Aluminum Alloys (EXCO test).*

ASTM G66-95, *Visual Assessment of Exfoliation Corrosion Susceptibility of 5xxx Series Aluminium Alloys (ASSET test).*

3 Tensile test

The selection, preparation and number of specimens and test-pieces is specified in EN 485-1.

The test shall be carried out in accordance with EN 10002-1, particular attention being paid to the following:

- normally the test-pieces shall be taken with their length transverse (or long transverse) to the principal direction of rolling. If the width of the product is less than 300 mm, then test in the longitudinal direction is permitted. In both cases the mechanical property limits specified in Tables 2 to 39 shall apply;
- machined test-pieces of rectangular or circular cross-section (as applicable) shall be used;
- for specified thicknesses up to and including 12,5 mm the test-piece shall have a rectangular (or square) cross-section. Its reduced section shall be 12,5 mm wide and its thickness equal to the full thickness of the product;
- for specified thicknesses from 10,0 mm up to and including 12,5 mm a round test-piece or a rectangular test-piece may be used;
- for specified thicknesses exceeding 12,5 mm the test-piece shall have a circular cross section with a recommended diameter of 10 mm for its reduced section;
- recommended shapes for rectangular and round test-pieces are shown in Figures 1 and 2;
- during a test to determine proof stress, the rate of stress application shall not exceed 12 MPa/s. After removal of the extensometer the rate of straining may be increased but it shall not exceed 50 % of the length of the reduced section per minute;
- elongation for rectangular (or square) test-pieces shall be measured using an original gauge length of 50 mm;
- elongation for round test-pieces shall be measured using an original gauge length equal to 5 D where D is the diameter of the reduced section;
- for determination of compliance, proof stress and tensile strength values shall be rounded to the nearest 1 MPa and elongation values to the nearest 1 % using the rounding rules set out in annex A.

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4 Bend test

Sheet, strip and plate shall be capable of being bent cold through an angle of 90° or 180°, as applicable, around a pin having a radius equal to k times the thickness t of the sheet, strip or plate (e.g. 2,5 t) without cracking. Recommended values of the minimum bend radii for different alloys, tempers and thicknesses are given in Tables 2 to 39. Compliance with these values and/or conduct of the test is only required when so specified on the order.

The test shall be carried out in accordance with EN ISO 7438, particular attention being paid to the following:

- bend test shall be carried out on a specimen taken adjacent to the tensile test specimen;
- test-piece shall be taken in the transverse direction, the bend axis being parallel to the rolling direction. For material less than 150 mm wide, the test-piece may be taken in the rolling direction;
- width of the test piece shall be at least 20 mm and preferably 40 mm to 50 mm. For material less than 20 mm wide, the width of the test-piece shall be the full width of the material;
- edges of the test-piece may be machined when practical. They may be rounded to a radius of approximately 2 mm.

5 Hardness test

Hardness test can be a convenient means for checking the homogeneity of a lot ; it can also be used for a quick semi-quantitative check of the thermal treatment to which the material has been submitted or, as a first approach, for material identification purpose. However its accuracy is generally less than can be expected from a tensile test which it cannot replace.

NOTE Hardness can be measured at different locations, e.g. on the surface of the product or on the tensile specimen. For some materials, results can be different.

The values in Tables 2 to 39 are typical Brinell hardness (HBW) values for a test carried out according to EN ISO 6506-1 with a 2,5 mm diameter steel ball. They are given for information only.

If the Brinell hardness test is not possible (because of thin gauge or soft temper) then Vickers hardness test, according to EN ISO 6507-1, can be used. In that case the values will be approximately 10 % above the stated Brinell values.

Table 1, given for convenience, shows for several HBW values the minimum gauge down to which the hardness measurement remains valid, according to the rules stated in EN ISO 6506-1, using a 2,5 mm diameter steel ball and a load of 612,9 N.

Table 1 — Minimum material gauge and Brinell hardness values

Brinell hardness (HBW)	30	40	50	60	70	80	90	100
minimum gauge (mm)	2,1	1,6	1,3	1,1	0,91	0,80	0,71	0,64
Brinell hardness (HBW)	110	120	130	140	150	160	170	180
minimum gauge (mm)	0,58	0,53	0,49	0,45	0,42	0,40	0,37	0,35

6 Electrical conductivity

Electrical conductivity measurements are required for lot acceptance purposes, in the case of alloy EN AW-7075 in the tempers T73, T7351, T76 and T7651, in order to assess the resistance to stress-corrosion cracking or the exfoliation-corrosion resistance of the material as applicable.

The specimen for electrical conductivity testing shall be taken adjacent to the tensile test specimen.

The measurement shall be carried out by the eddy-current method as specified in EN 2004-1. The reference blocks to be used shall be agreed between producer and purchaser. The results shall be rounded to the nearest 0,1 MS/m, using the rounding rules set out in annex A.

The acceptance criteria are specified in Table 38.

7 Stress-corrosion resistance

7.1 Plate made of alloy EN AW-7075 in the T73 and T7351 tempers and over 25 mm in thickness, shall be capable of exhibiting no evidence of stress-corrosion cracking when subjected to ISO 9591 accelerated stress-corrosion cracking test.

For the purpose of this standard the following provisions shall apply:

- a minimum of three adjacent replicate test pieces shall be taken from each specimen and submitted to the test;
- exposure shall be carried out by alternate immersion in a 3,5 % by mass sodium chloride solution in water;
- test-pieces shall be stressed in the short transverse direction with a stress level of 75 % of the specified proof stress;
- no stress-corrosion related rupture shall be observed after a minimum exposure time of 20 days.

The method of stressing (bending, uniaxial loading, C-ring, etc.), the shape and dimensions of the test-pieces and the frequency of the test are left to the discretion of the producer, who shall maintain records of all lots so tested and make them available for examination at the producer's facility for not less than five years.

7.2 For lot acceptance-purposes resistance to stress-corrosion cracking for each lot of material shall be established by testing the previously selected tensile test specimens to the criteria shown in Table 38.

8 Exfoliation corrosion resistance (5xxx series alloys)

8.1 Products made of alloys EN AW-5086, EN AW-5083 and EN AW-5383 in the H116 temper shall be capable of exhibiting no evidence of exfoliation corrosion when subjected to ASTM G66-95 accelerated exfoliation corrosion susceptibility test.

The test shall be carried out on full thickness test-pieces for material less than 2,5 mm in thickness. For material 2,5 mm or more in thickness, 10 % of the thickness shall be removed by machining, from one as-rolled surface, and both the machined and as-rolled surfaces submitted to the test and evaluated.

8.2 For lot-acceptance purposes, the acceptability of each lot of material mentioned in 8.1 shall be determined by the producer, by metallographic examination of one specimen per lot selected from midsection at one end of a random sheet, plate or coil, using the following procedure:

- a section perpendicular to the rolling surface and parallel to the rolling direction shall be polished (preferably electrolytic polish) and then microetched for 3 min, using a solution of 40 ml 85 % phosphoric acid in 60 ml distilled water, at (35 ± 5) °C;
- metallographic examination shall be carried out at 500 times magnification;
- revealed microstructure shall be predominantly free of a continuous grain boundary network of aluminium-magnesium precipitate (Al_3Mg_2).

Acceptability shall be determined by comparison to producer-established reference photomicrographs of acceptable material. If the microstructure shows evidence of Al_3Mg_2 precipitates in excess of the relevant reference, the lot is either rejected or subjected to the ASTM G66-95 test.

Reference photomicrographs shall be established on acceptable material (according to ASTM G66-95), for each thickness range specified in Table 29 (EN AW-5083) or Table 30 (EN AW-5383) or Table 31 (EN AW-5086) as applicable. Production practices shall not be changed after establishment of these references.

Significant changes in production practices that alter the microstructures of the alloy shall require the establishment of new reference photomicrographs as described above.

The producer shall maintain at the producing facility all records relating to the establishment of reference photomicrographs and production practices.

9 Exfoliation corrosion resistance (7xxx series alloys)

9.1 Products made of alloy EN AW-7075 in the tempers T76 and T7651 shall be capable of exhibiting no evidence of exfoliation corrosion in excess of grade EB, as defined in ASTM G34-97, when subjected to the test in 9.3.

9.2 For lot acceptance-purposes, resistance to exfoliation corrosion for each lot of material shall be established by testing the previously selected tensile test specimens to the criteria shown in Table 38.

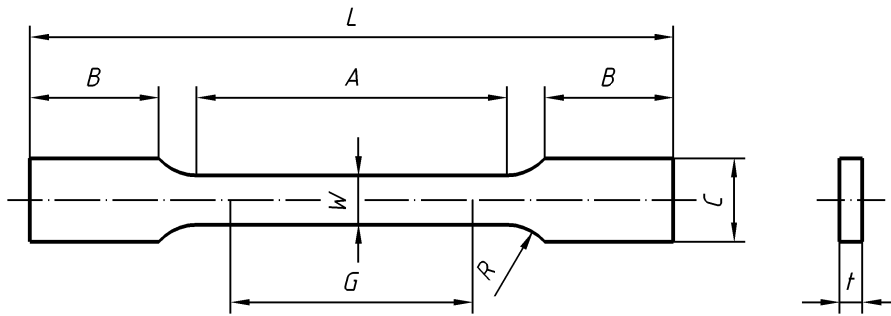
9.3 When carried out, for monitoring purposes, the test shall be in accordance with ASTM G34-97 (EXCO test), and the following additional requirements shall apply:

- specimens for test shall be selected at random from material considered acceptable in accordance with the lot acceptance criteria shown in Table 38, for each thickness range listed in that table;
- test-pieces shall be a minimum of (50 x 100) mm with the 50 mm dimension parallel to the direction of final rolling. They shall include the full-section thickness of the material, except that for material 2,5 mm or more in

thickness, 10 % of the thickness shall be removed by machining the test surface. For machined test-pieces, the machined surface shall be evaluated by exposure to the test solution ;

- the frequency of the test is left to the discretion of the producer, who shall maintain records of all lots so tested and make them available for examination at the producer's facility for not less than five years.

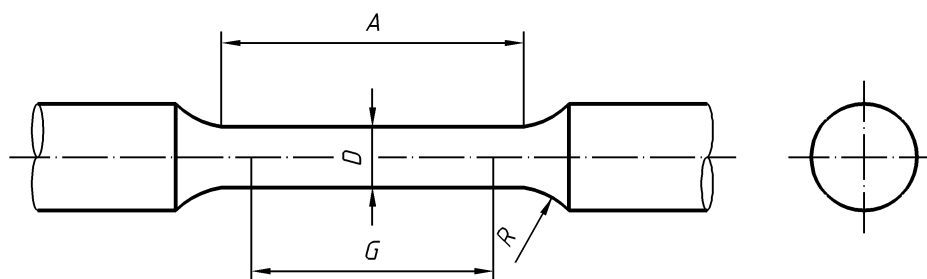
Dimensions in millimetres



Standard test-piece	
Nominal width	12,5
G - Gauge length	50,0 ± 0,5
W - Width	12,5 ± 0,10
t - Thickness	thickness of material
R - Radius of fillet, min.	12,5
L - Overall length, min.	200
A - Length of reduced section, min.	57
B - Length of grip section, min.	50
C - Width of grip section, approximate	20

Figure 1 — Standard rectangular tensile test-piece

Dimensions in millimetres



	Standard test-piece	Small-size test-pieces proportional to standard			
		10	8	6	4
Nominal diameter	10	8	6	4	
G - Gauge length	$50,0 \pm 0,5$	$40,0 \pm 0,5$	$30,0 \pm 0,5$	$20,0 \pm 0,5$	
D - Diameter	$10,0 \pm 0,10$	$8,0 \pm 0,10$	$6,0 \pm 0,10$	$4,0 \pm 0,05$	
R - Radius of fillet, min.	9	8	6	4	
A - Length of reduced section, min.	60	48	36	24	

Figure 2— Standard 10 mm tensile test-piece with 50 mm gauge length and examples of small-size proportional test-pieces

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Table 2 — Aluminium EN AW-1080A [AI 99,8(A)]

Temper	Specified thickness		R_m		$R_{p0,2}$		Elongation		Bend radius ^a		Hardness HBW ^a
	over	up to	min.	max.	min.	max.	$A_{50\text{ mm}}$	A	180°	90°	
F ^a	≥ 2,5	25,0	60								
O/H111	0,2	0,5	60	90	15		26		0 t	0 t	18
	0,5	1,5	60	90	15		28		0 t	0 t	18
	1,5	3,0	60	90	15		31		0 t	0 t	18
	3,0	6,0	60	90	15		35		0,5 t	0,5 t	18
	6,0	12,5	60	90	15		35		0,5 t	0,5 t	18
H112	≥ 6,0	12,5	70				20				
	12,5	25,0	70					20			
H12	0,2	0,5	80	120	55		5		0,5 t	0 t	26
	0,5	1,5	80	120	55		6		0,5 t	0 t	26
	1,5	3,0	80	120	55		7		0,5 t	0,5 t	26
	3,0	6,0	80	120	55		9			1,0 t	26
	6,0	12,5	80	120	55		12			2,0 t	26
H14	0,2	0,5	100	140	70		4		0,5 t	0 t	32
	0,5	1,5	100	140	70		4		0,5 t	0,5 t	32
	1,5	3,0	100	140	70		5		1,0 t	1,0 t	32
	3,0	6,0	100	140	70		6			1,5 t	32
	6,0	12,5	100	140	70		7			2,5 t	32
H16	0,2	0,5	110	150	90		2		1,0 t	0,5 t	36
	0,5	1,5	110	150	90		2		1,0 t	1,0 t	36
	1,5	4,0	110	150	90		3		1,0 t	1,0 t	36
H18	0,2	0,5	125		105		2			1,0 t	40
	0,5	1,5	125		105		2			2,0 t	40
	1,5	3,0	125		105		2			2,5 t	40
H22	0,2	0,5	80	120	50		8		0,5 t	0 t	26
	0,5	1,5	80	120	50		9		0,5 t	0 t	26
	1,5	3,0	80	120	50		11		0,5 t	0,5 t	26
	3,0	6,0	80	120	50		13			1,0 t	26
	6,0	12,5	80	120	50		15			2,0 t	26
H24	0,2	0,5	100	140	60		5		0,5 t	0 t	31
	0,5	1,5	100	140	60		6		0,5 t	0,5 t	31
	1,5	3,0	100	140	60		7		1,0 t	1,0 t	31
	3,0	6,0	100	140	60		9			1,5 t	31
	6,0	12,5	100	140	60		11			2,5 t	31
H26	0,2	0,5	110	150	80		3			0,5 t	35
	0,5	1,5	110	150	80		3			1,0 t	35
	1,5	4,0	110	150	80		4			1,0 t	35

^a For information only.

Table 3 — Aluminium EN AW-1070A [AI 99,7]

Temper	Specified thickness		R_m		$R_{p0,2}$		Elongation		Bend radius ^a		Hardness HBW ^a
	mm		MPa		MPa		min. %		180°	90°	
F ^a	over	up to	min.	max.	min.	max.	$A_{50\text{ mm}}$	A			
	≥ 2,5	25,0	60								
O/H111	0,2	0,5	60	90	15		23		0 t	0 t	18
	0,5	1,5	60	90	15		25		0 t	0 t	18
	1,5	3,0	60	90	15		29		0 t	0 t	18
	3,0	6,0	60	90	15		32		0,5 t	0,5 t	18
	6,0	12,5	60	90	15		35		0,5 t	0,5 t	18
	12,5	25,0	60	90	15			32			18
H112	≥ 6,0	12,5	70		20		20				
	12,5	25,0	70					20			
H12	0,2	0,5	80	120	55		5		0,5 t	0 t	26
	0,5	1,5	80	120	55		6		0,5 t	0 t	26
	1,5	3,0	80	120	55		7		0,5 t	0,5 t	26
	3,0	6,0	80	120	55		9			1,0 t	26
	6,0	12,5	80	120	55		12			2,0 t	26
H14	0,2	0,5	100	140	70		4		0,5 t	0 t	32
	0,5	1,5	100	140	70		4		0,5 t	0,5 t	32
	1,5	3,0	100	140	70		5		1,0 t	1,0 t	32
	3,0	6,0	100	140	70		6			1,5 t	32
	6,0	12,5	100	140	70		7			2,5 t	32
H16	0,2	0,5	110	150	90		2		1,0 t	0,5 t	36
	0,5	1,5	110	150	90		2		1,0 t	1,0 t	36
	1,5	4,0	110	150	90		3		1,0 t	1,0 t	36
H18	0,2	0,5	125		105		2			1,0 t	40
	0,5	1,5	125		105		2			2,0 t	40
	1,5	3,0	125		105		2			2,5 t	40
H22	0,2	0,5	80	120	50		7		0,5 t	0 t	26
	0,5	1,5	80	120	50		8		0,5 t	0 t	26
	1,5	3,0	80	120	50		10		0,5 t	0,5 t	26
	3,0	6,0	80	120	50		12			1,0 t	26
	6,0	12,5	80	120	50		15			2,0 t	26
H24	0,2	0,5	100	140	60		5		0,5 t	0 t	31
	0,5	1,5	100	140	60		6		0,5 t	0,5 t	31
	1,5	3,0	100	140	60		7		1,0 t	1,0 t	31
	3,0	6,0	100	140	60		9			1,5 t	31
	6,0	12,5	100	140	60		11			2,5 t	31
H26	0,2	0,5	110	150	80		3			0,5 t	35
	0,5	1,5	110	150	80		3			1,0 t	35
	1,5	4,0	110	150	80		4			1,0 t	35

^a For information only.