



HULAMIN
EXTRUSIONS

Data Book
November 2014
Edition 18

Guide to aluminium extrusions, alloys and tolerances

Introduction

Hulamin Extrusions is the largest, best equipped aluminium extruder on the African continent, with many years of extrusion experience. To best serve the market at point of sale, Hulamin Extrusions has facilities in Gauteng, Kwa-Zulu Natal with a sales office in the Cape. These include:

- * Four extrusion presses
- * Billet casting
- * Advanced extrusion die making
- * SABS approved anodising
- * Powder coating
- * Comprehensive further finishing
- * Product design and development

Improved productivity, coupled with modernised and progressive technology, has increased extrusion capacity so that Hulamin Extrusions will be able to satisfy total market requirements for many years to come.

Hulamin Extrusions plants operate Quality Management Systems that comply with the SABS ISO 9000 Code of Practice. This is one of several steps taken to assure customers of superior service, quality and competitiveness.

This Data Book is intended to give details of the manufacturing limits and tolerances applicable to the Hulamin Extrusions alloys and the extrusion process.

For more information on the company and the range of profiles available, please contact your nearest sales office or visit our website at: www.hulaminextrusions.co.za.

www.hulaminextrusions.co.za

Edition 18
First Release July 2012
Reprint November 2014

Note:

The controlled version of this document can be found on our website, www.hulaminextrusions.co.za. Although Hulamin Extrusions endeavours to have the latest version available in printed format, please always check the version on our website to ensure that the printed copy you have is still relevant. If your version is no longer relevant you are welcome to request a new printed version from your local sales office or sales representative.

All the information has been provided in good faith. However, if there is an error in the information, whether due to the negligence of the company or otherwise, the company cannot accept liability for any loss caused by such an error. Similarly, the company accepts no liability of any nature whatsoever, whether arising through damage or loss caused by the customer's negligence or other fault.

Hulamin Extrusions reserves the right to modify any specifications and/or dimensions without prior notice in the interest of product development.

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1. Technical Information

1.1 Alloy Nomenclature

The four-digit system of alloy nomenclature used by **Hulamin Extrusions**, in common with the International Aluminium Institute, uses a block number to indicate the main alloying constituents.

Alloy Series	Main alloying constituent
1xxx	Aluminium, 99,0% minimum and greater
2xxx	Copper
3xxx	Manganese
4xxx	Silicon
5xxx	Magnesium
6xxx	Magnesium and Silicon
7xxx	Zinc, Magnesium and / or Copper

1.2 Alloy Designations

Alloy	EN Equivalent	Previous German Equivalent
1070A	Al 99,7	Al 99,7
6005A	Al SiMg (A)	AlMgSi 0,7
6061	Al MgSiCu	-
6063	Al Mg0,7Si	AlMgSi 0,5 F22
6082	Al Si1MgMn	AlMgSi 1

1.3 Tempers

Temper	Description	Applications
F	As fabricated	Forging stock: Maximum formability
O	Annealed	Forging stock: Maximum formability
T4	Solution heat-treated and naturally aged	Formability with higher properties than F or O conditions
T5	Cooled from an elevated shaping process temperature and artificially aged	Where highest mechanical properties are not required by end of use (i.e. non-structural)
T6	Solution heat-treated and artificially aged	Where highest possible mechanical properties are required

Notes:

Extruded products are normally available in the tempers listed above. Tempers other than those listed may be available upon request.

1.4 Alloy Compositions

Alloy	Percentages									
	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Others	
									Each	Total
1070A	0,20	0,25	0,03	0,03	0,03	-	0,07	0,03	0,03	-
6005A	0,5-0,9	0,35	0,30	0,50	0,40-0,7	0,30	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
6063	0,20-0,6	0,35	0,10	0,10	0,45-0,9	0,10	0,10	0,10	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:

Single figures denote maximum content. Aluminium remainder.
Other alloys may be available - subject to enquiry.

1.5 Physical Properties

Based on 99,95% minimum purity.

Density	2 700 kg/m ³
Melting range	645 - 660 °C
Boiling point at 760 mm mercury	2 327 °C
Thermal conductivity at 250 °C	2,1 - 2,3 W/cm K
Mean specific heat (0 °C to 100 °C)	942 J/kg K
Coefficient of linear thermal expansion (20 °C to 100 °C)	2,4 x 10 ⁻⁵ °C ⁻¹
Latent heat of fusion	389,4 x 10 ³ J/kg
Crystal structure	Face-centered cubic
Modulus of elasticity (Young's)	69 x 10 ³ MPa
Modulus of rigidity (Shear)	26,14 x 10 ³ MPa
Poisson's ratio	0,33
Electrical conductivity at 200 °C	3,6 x 10 ⁷ S/m

1.6 Guaranteed Mechanical Properties - Extruded Products

Alloy	Temper	Thickness		0,2% Proof stress Min MPa	Ultimate tensile strength		Elongation Min	
		Over mm	Up to and including mm		Min MPa	Max MPa	A % Min	A _{50 mm} % mm
1070A	F	-	All	-	60	-	25	23
6005A SOLID PROFILES	T4	-	10	90	180	-	15	13
	T6	-	5	225	270	-	8	6
	T6	5	10	215	260	-	8	6
	T6	10	80	200	250	-	8	6
6005A HOLLOW PROFILES	T4	-	10	90	180	-	-	13
	T6	-	5	215	255	-	-	6
	T6	5	15	200	250	-	-	6
6061	O	-	-	-	-	150	16	14
	T4	-	25	110	180	-	15	13
	T6	-	80	240	260	-	8	6
6063	O	-	100	-	-	130	18	16
	T4	-	25	65	120	-	14	12
	T5	-	3	130	175	-	8	6
	T5	3	25	110	160	-	7	5
	T6	-	10	170	215	-	8	6
	T6	10	80	160	195	-	8	6
6082	O	-	100	-	-	160	16	14
	F	-	100	-	110	-	13	12
	T4	-	80	110	205	-	14	12
	T6	-	5	250	290	-	8	6
	T6	5	80	260	310	-	8	-

Notes:

Thickness is defined as the diameter of solid rod or the wall thickness or the equivalent major solid cross-section thickness. Thicknesses greater than those shown are subject to enquiry.

The 0.2% Proof Stress is used to identify the elastic limit for aluminium alloys in the same way that Yield Stress is used for steels.

The 0.2% Proof Stress fixes the elastic limit for all practical purposes as the stress causing a permanent deformation (strain) at 0.2%.

This approach is necessary because, unlike steels, which yield elastic, aluminium show no such clearly identified yield point.

Mechanical properties in the F temper are not guaranteed.

1 MPa = 1MN/m²; 1 Pascal [Pa] = 1 N/m²

A Value = $5.65 \sqrt{S_2}$, where S_2 is the initial cross-sectional area of the test piece.

1.7 Technical Grade

Technical grade implies that the following tests will be carried out:

Ultrasonic testing

The aluminium billet to be used will be ultrasonically tested to a level to detect inclusions and cracks. Should a customer require the billet to be to a higher standard, the standard of acceptance shall be agreed with the customer prior to manufacture and clearly stated on the order.

Etch test pieces

For extruded lengths or bar or section produced, test pieces of the full cross-section shall be taken from the back end of the extruded length. The specimen shall be suitably prepared, etched and inspected. The etched surface shall be free from harmful defects*. If any specimen reveals a harmful defect, the relevant length of bar or section shall be scrapped.

* Definition - Harmful defects in the above context refers to any physical defect such as cracks and over extrusion, which can be seen with the naked eye. It is up to the purchaser to inform the manufacturer of any other possible defects for which the product should be checked.

Longer than normal discards

For each billet extruded, a longer than normal discard will be set and maintained so as to obviate the risk of over extrusion.

Drift testing

All hollow sections with wall thickness up to 12 mm produced by the porthole type extrusion die shall have test pieces cut from every extruded length. Test pieces shall be subjected to an expansion test to determine the soundness of the extruded seam welds. Hulamin Extrusions can however not provide a 100% guarantee on the weld soundness even though the above testing has been carried out. It is the responsibility of the end user to ensure that the product is entirely suitable for its intended use. Profiles with wall thickness greater than 12 mm cannot be drift tested.

Traceability

All test pieces and heat treatment records relating to Technical Grade lots are kept for a period of six months and five years respectively to enable traceability and ongoing evaluation of quality.

Other

Over and above these tests, other tests may be required for specific applications for example, automotive. These should be requested at the enquiry stage.

2. Manufacturing Limits

2.1 General Notes

Manufacturing limits are imposed by available production facilities and also by nature of the extrusion processes. The size and power of available extrusion presses limit the overall cross-sectional dimensions of sections. The stretching, handling and heat-treatment equipment limit cross-sectional areas and lengths. Lengths may also be limited by transport restrictions. Minimum thickness, shape configuration and complexity of detail may be limited by the extrusion process as well as by press capacity. Manufacturing limits for sections of complicated shape and abnormal design may be narrower than stated. The limits given are for sections designed according to accepted extrusion design practice. The maximum circumscribing circle diameters given on Page 7 are a guide and must not be read as being available at the minimum thickness shown in the adjacent column. A guide as to this ratio of circumscribing circle to minimum thickness may be obtained from the diagram on Page 8. The maximum limits as dictated by press capacity, are given on Page 9.

Whilst Hulamini Extrusions may be able to meet many of the requirements customers may have, some of these may incur extra costs and charges. It is essential that as much information as possible be provided to the extruder at the enquiry stage.

Additional charges are likely to be applied to orders requesting the following:

Technical Grade, back end etch tests, identification stamping, drift test of tubes and hollows, peripheral grain control, ultrasonic testing of billets and longer than normal billet discard resulting in a higher scrap rate.

Manufacturing Tolerances

As with all manufacturing and fabrication processes, the process whereby aluminium is extruded sets a range of manufacturing tolerances within which aluminium extrusion products can be expected to vary.

The extrusion process is remarkable in its ability to produce lengths of intricate shapes within close shape and dimensional tolerances. Normal deviations are proved to be small and to have little impact in a very wide range of applications. Although dies are produced to exact size with virtually no tolerances allowed in manufacture, the extruded profile emerging from the die is subject to:

- * Extrusion flow effects (influenced by die design and shape design);
- * Cooling effects (both cooling medium and profile design can lead to irregular cooling);
- * Handling effects (transfer and stretching).

Minor deviations to shape and size can be expected to occur no matter how experienced the die designer, how good the handling equipment or how well-trained the operating staff. It is against this background that extrusion tolerances need to be part and parcel of the extrusion process. In no way are published tolerances to be seen as the extruder's choice of how accurately he decides or wishes to work. Rather, extrusion tolerances need to be seen and understood to be the range of shape and dimensional variations, which can be expected from the process.

The choice open to the extruder faced with requests for closer than standard or published tolerances depends on the nature of the request.

- * If a metal dimension is involved, i.e. across the web of a channel, the prospects are good that closer than normal tolerances may be achieved provided the dimension is measurable. Shorter die life is likely to be incurred because the die may need to be replaced earlier than normally is the case, due to die wear.
- * If a space dimension is involved, i.e. the width across the open flanges of a channel. Only in exceptional cases where it is vital for an assembly, will closer than Data Book tolerances be considered.

The straightness of a length of extrusion can depend on the degree to which the shape can be stretcher-straightened without incurring shape distortion. A compromise between straightness and shape may result. Both straightness and twist can be influenced by imbalance of the shape itself.

It is most important that new users of extruded products are aware from the design stage that machining tolerances cannot be expected from the extrusion process. All too often designers and draughtsman have had experience of machine shop tolerances only and need guidance in the understanding of extrusion tolerances or they are likely to specify the tolerances they are most familiar with. This can result in needless communications with producer plants, possibly obscuring, as a result, very real needs a designer may have for closer than normal tolerances.

The time to discuss extrusion tolerances is thus at the design stage rather than after delivery of the product which may be found to be difficult to use because allowance has not been made for normal tolerances.

The tolerances used by our extrusion plants as published in the Data Book are those published by the British Standards institute in BS EN 755. Deviations from this standard are indicated at the appropriate sections.

Requests for tighter tolerances than these may be considered. Requests to produce to other specifications such as DIN, ASTM, BS EN 12020 and ISO will be considered but this must be made clear to the producing plant at the enquiry stage.

2.2 Dimensions⁽¹⁾

Alloy	Maximum circumscribing circle diameter mm	Minimum ⁽²⁾ thickness mm	Range of cross-sectional areas and mass				
			Maximum		Minimum		
			Area ⁽³⁾ mm ²	Mass kg/m	Area mm ²	Mass kg/m	
SOLIDS	1070A	320	1,20	5000	13,6	26	0,07
	6005A	320	1,40	5000	13,6	48	0,13
	6061	320	1,50	5000	13,6	55	0,15
	6063	320	1,20	5000	13,6	29	0,08
	6082	320	1,60	5000	13,6	55	0,15
HOLLOWES	1070A	200	1,25	5000	13,6	55	0,15
	6005A	200	1,50	5000	13,6	195	0,53
	6061	200	1,50	5000	13,6	195	0,53
	6063	200	1,25	5000	13,6	55	0,15
	6082	200	1,60	5000	13,6	195	0,53

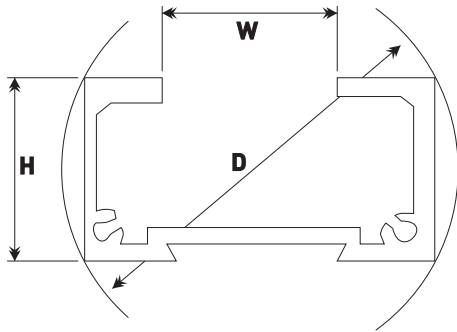
Notes:

1. The manufacturing limits above are given as guidelines only and profiles outside of these limits may be available upon request.
2. The minimum thickness at which a section can be extruded is dependent on the alloy, circumscribing circle diameter, shape configuration and the complexity of detail. A guide as to the relationship between circumscribing circle diameter and minimum wall thickness is shown on page 8. The minimum thickness listed above does thus not relate to the maximum circumscribing circle diameters.
3. The maximum limit on cross-sectional area is imposed by extrusion ratio and stretching capacity. Sections of greater cross-sectional area may be supplied in the unstretched condition, on enquiry, but mechanical properties and straightness will not be guaranteed.

Hollow Profiles

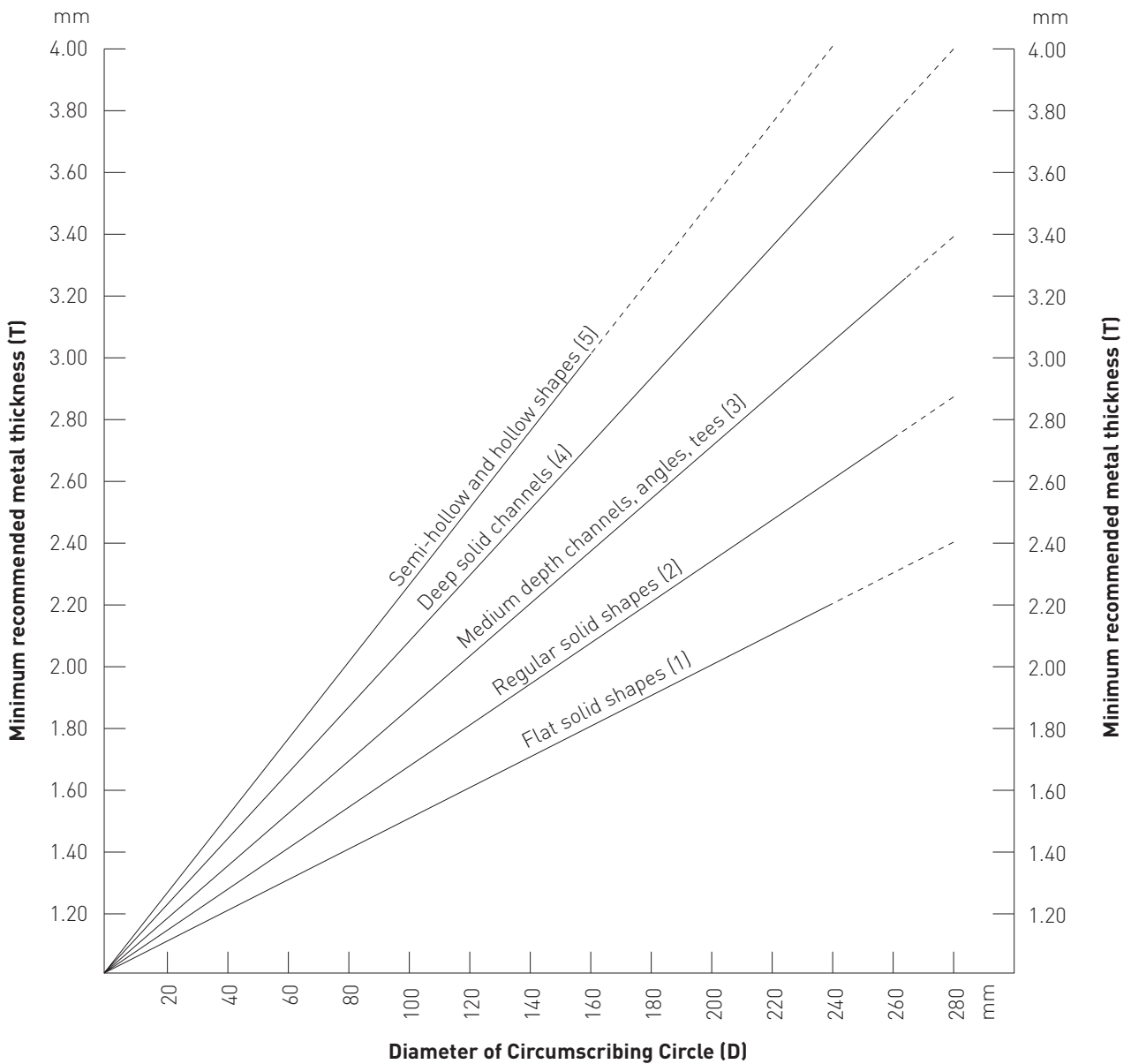
Tube and hollow shapes for the architectural and general engineering markets are produced by the porthole extrusion process. In this process the seam welds are formed in the dies during the extrusion process. Although considerable tonnages of hollow shapes and tubing are regularly and successfully extruded and put to good use, it is possible for weld soundness to be adversely affected by process factors. In spite of all measures normally taken during extrusion to achieve sound welds, the weld quality may vary along the extruded length. Notwithstanding the successful use made regularly of hollow shapes and tubing produced by the porthole extrusion method, it is not possible to guarantee such welds. Drift testing as described in the section of Technical Grade, can be performed and gives a reasonable degree of assurance of the seam weld quality. However, this test can only be carried out on the ends of hollow profiles and tubes. Where physical injury or danger can result from seam weld failure, e.g. hang glider tubing, yacht masts, drift testing is recommended. Where tubing is required to contain pressurised fluids, pressure testing is recommended before use.

2.3 Metal Thickness Chart



Definitions

1. Flat solid shapes:
Shape to be basically flat.
Thickness to be uniform.
No dovetails or screw receiving slots.
2. Regular solid shapes:
 $H = \frac{1}{3}D$ $W = \frac{3}{4}D$
3. Medium depth channels:
 $H = \frac{1}{3}D$ $W = \frac{1}{2}D$
4. Deep solid channels:
 $H = \frac{1}{2}D$ to $3W$
5. Semi-hollow and hollow shapes



2.4 Lengths

Maximum:

The normal maximum straight length is 12 meters but 14,5 meter lengths may be available, subject to enquiry and dependent on transport conditions. Maximum length may also be limited by the maximum mass of section that can be supplied.

Minimum:

Pieces less than 500 mm in length are generally available but are subject to enquiry.

Random lengths:

Where customer accepts random lengths and orders are endorsed accordingly, between 2 meters and 6 meters will be supplied. It is possible to supply most of an order to a length suitable to the customer within this range, and the balance only in random lengths.

Multiple Lengths:

Sections can be supplied in multiples of the required unit length. In calculating the overall length an allowance of 5 mm must be made for each saw cut.

Specified Lengths:

When a specified length is ordered, all lengths will be cut to specification within the limits of the length tolerance, specified in the relevant Table on page 14.

Standard Lengths:

Lengths between 3 and 8 meters are considered as standard lengths.

2.5 General

Products outside these limits will be subject to enquiry.

Tubing and Hollow Sections

Maximum Limits

Maximum Wall Thickness	12,0 mm
Maximum Mass per Meter	13,0 kg/m

Minimum Limits

Minimum Tube Wall Thickness	1,5 mm
Minimum Tube outside Diameter	10,0 mm

Rod and Bar (including Non-Spreader Sections)

Maximum Limits for Normal Extrusion

Maximum Diameter	80 mm (area 5 000 mm ²)
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Spreader Sections

All spreader sections are prone to defective areas at the front and back of each extruded length (apart from the front of the very **FIRST** billet during a production run), which necessitates the removal of a rejection of up to 3 meters of metal from the front and 1 meter from the back end of the pressed lengths.

e.g. Maximum Mass per Meter	=	13,6 kg/m
Maximum Length of a 13,6 kg/m section	=	6,5 m
Maximum Length of a 10 kg/m section	=	9,0 m
Maximum Useable Billet Mass (length 910 mm)	=	105 kg

Important: Due to high mass per meter, profiles greater than 12 kg/m will be supplied in Technical Grade only.

3. Manufacturing Tolerances

3.1 General Notes

All tolerances given apply to mill finished products only.

Tolerances not shown in this Data Book shall be agreed upon prior to manufacture.

All dimensions and tolerances (unless otherwise stated) are in millimeters.

3.2 Alloy Groups

Alloy Series	Main Alloying Constituent
Group 1	1070A
	6005A
	6063
Group 2	6061
	6082

3.3 Extruded Profile Dimensions and Shape

The tolerances on the dimensions listed below (see Figure 1) are specified in Tables 1 to 5.

A: Wall thickness except those enclosing the hollow spaces in a hollow profile.

B: Wall thickness enclosing the hollow spaces in hollow profiles except those between two hollow spaces..

C: Wall thickness between two hollow spaces in hollow profiles.

E: Length of the shorter length of profiles with open ends.

H: All dimensions except wall thickness.

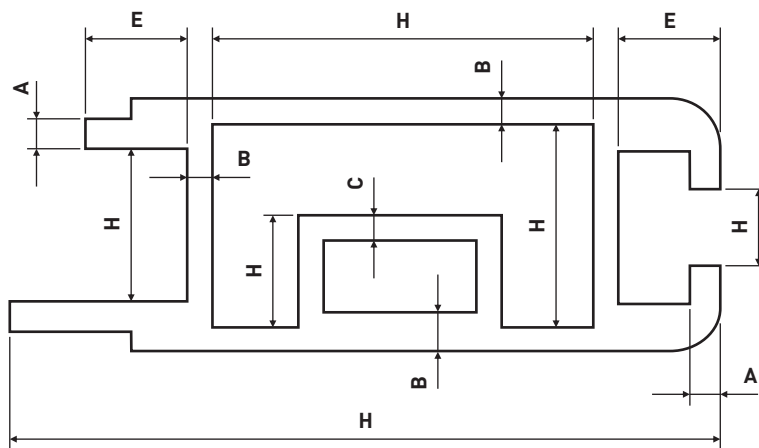


Figure 1: Measurement of dimensions A, B, C, E & H

3.4 Dimensions other than Wall Thickness

The tolerances on dimensions shall be as specified in Tables 1 and 2. For profiles with open ends (see Figures 2 and 3 and the relevant examples) the tolerances specified in Table 3 shall be added to those of Table 1 and 2 for dimension H across open-ended legs in order to obtain the tolerances on the gap between any opposite points on these ends.

**Table 1: Tolerances on cross-sectional dimensions of solid and hollow profiles
Alloy Group 1**

Dimension <i>H</i>		Tolerances on <i>H</i> for circumscribing circle <i>CD</i> ^{ab}			
Over	Up to and including	<i>CD</i> ≤ 100	100 < <i>CD</i> ≤ 200	200 < <i>CD</i> ≤ 300	300 < <i>CD</i> ≤ 350
-	10	± 0,25	± 0,30	± 0,35	± 0,40
10	25	± 0,30	± 0,40	± 0,50	± 0,60
25	50	± 0,50	± 0,60	± 0,80	± 0,90
50	100	± 0,70	± 0,90	± 1,10	± 1,30
100	150	-	± 1,10	± 1,30	± 1,50
150	200	-	± 1,30	± 1,50	± 1,80
200	300	-	-	± 1,70	± 2,10
300	350	-	-	-	± 2,80

**Table 2: Tolerances on cross-sectional dimensions of solid and hollow profiles
Alloy Group 2**

Dimension <i>H</i>		Tolerances on <i>H</i> for circumscribing circle <i>CD</i> ^{ab}			
Over	Up to and including	<i>CD</i> ≤ 100	100 < <i>CD</i> ≤ 200	200 < <i>CD</i> ≤ 300	300 < <i>CD</i> ≤ 350
-	10	± 0,40	± 0,50	± 0,55	± 0,60
10	25	± 0,50	± 0,70	± 0,80	± 0,90
25	50	± 0,80	± 0,90	± 1,00	± 1,20
50	100	± 1,00	± 1,20	± 1,30	± 1,60
100	150	-	± 1,50	± 1,70	± 1,80
150	200	-	± 1,90	± 2,20	± 2,40
200	300	-	-	± 2,50	± 2,80
300	350	-	-	-	± 3,50

- a. These tolerances do not apply to extrusions in O temper condition. For these tempers, tolerances shall be subject to agreement between the supplier and the purchaser.
- b. For profiles with open ends, see figures 2 and 3, the tolerances for H in the area of the open ends shall be increased by the values specified in Table 3.

3.5 Channel

Table 3: Additions to the tolerance on cross-sectional dimensions H of solid and hollow profiles with open ends - Alloy Groups 1 and 2

Dimension E		Additions on tolerances on H in Tables 1 and 2 for dimensions across the ends of open ended profiles
Over	Up to and including	
-	20	-
20	30	± 0,15
30	40	± 0,25
40	60	± 0,40
60	80	± 0,50
80	100	± 0,60
100	125	± 0,80
125	150	± 1,00
150	180	± 1,20
180	210	± 1,40
210	250	± 1,60
250	-	± 1,80

Figures 2 and 3 below show open ends on hollow and solid profiles. The determination of tolerances on cross-sectional dimensions H is shown in the following calculation examples 1 and 2.

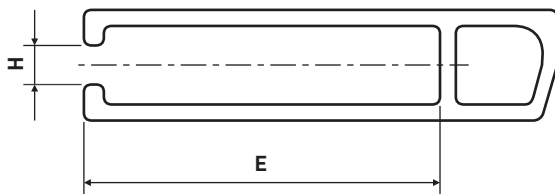


Figure 2: Hollow profile with open end

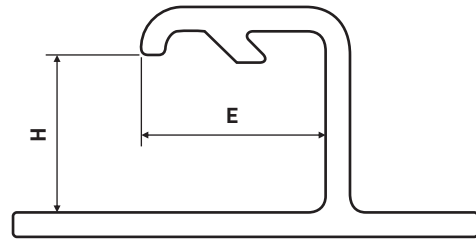


Figure 3: Solid profile with open end

Notes:

The tolerances as calculated in Example 1 is given as a guide only.
Tolerance of gaps on channels with return legs to be agreed upon between manufacturing plant and customer.

Example 1 (Figure 2)

Dimension H: 20mm
Dimension E: 100mm
Circumscribing circle CD: 100mm to 200mm
Alloy Group 1

The tolerance on H according to Table 1 is ±0,40mm plus the additional tolerance according to Table 3 which is ±0,60 mm; total tolerance on H is ±1,0 mm.

Example 2 (Figure 3)

Dimension H: 40mm
Dimension E: 50mm
Circumscribing circle CD: 100mm to 200mm
Alloy Group 2

The tolerance on H according to Table 1 is ±0,90mm plus the additional tolerance according to Table 3 which is ±0,40 mm; total tolerance on H is ±1,3 mm.

3.6 Wall Thickness

Table 4: Tolerance on wall thickness for profiles with a circumscribing circle up to and including 400 mm - Alloy Group 1*

Nominal wall thickness A, B or C		Tolerances on wall thicknesses						
		Solid			Hollow (outside)		Hollow (inside)	
		Wall thickness A Circumscribing circle			Wall thickness B Circumscribing circle		Wall thickness C Circumscribing circle	
Over	Up to and including	CD ≤ 100	100 < CD ≤ 300	300 < CD ≤ 400	CD ≤ 100	100 < CD ≤ 300	CD ≤ 100	100 < CD ≤ 300
-	1,5	± 0,15	± 0,20	± 0,25	± 0,20	± 0,30	± 0,25	± 0,35
1,5	3	± 0,15	± 0,25	± 0,35	± 0,25	± 0,40	± 0,30	± 0,50
3	6	± 0,20	± 0,30	± 0,40	± 0,40	± 0,60	± 0,50	± 0,75
6	10	± 0,25	± 0,35	± 0,45	± 0,60	± 0,80	± 0,75	± 1,00
10	15	± 0,30	± 0,40	± 0,50	± 0,80	± 1,00	± 1,00	± 1,20
15	20	± 0,35	± 0,45	± 0,55	± 1,20	± 1,50	± 1,50	± 1,90
20	30	± 0,40	± 0,50	± 0,60	± 1,50	± 1,80	± 1,90	± 2,20
30	40	± 0,45	± 0,60	± 0,70	-	± 2,00	-	± 2,50
40	50	-	± 0,70	± 0,80	-	-	-	-

Table 5: Tolerance on wall thickness for profiles with a circumscribing circle up to and including 400 mm - Alloy Group 2*

Nominal wall thickness A, B or C		Tolerances on wall thicknesses						
		Solid			Hollow (outside)		Hollow (inside)	
		Wall thickness A Circumscribing circle			Wall thickness B Circumscribing circle		Wall thickness C Circumscribing circle	
Over	Up to and including	CD ≤ 100	100 < CD ≤ 300	300 < CD ≤ 400	CD ≤ 100	100 < CD ≤ 300	CD ≤ 100	100 < CD ≤ 300
-	1,5	± 0,20	± 0,25	± 0,35	± 0,30	± 0,40	± 0,35	± 0,50
1,5	3	± 0,25	± 0,30	± 0,45	± 0,35	± 0,50	± 0,45	± 0,65
3	6	± 0,30	± 0,35	± 0,60	± 0,55	± 0,70	± 0,60	± 0,90
6	10	± 0,35	± 0,45	± 0,65	± 0,75	± 1,00	± 1,00	± 1,30
10	15	± 0,40	± 0,50	± 0,70	± 1,00	± 1,30	± 1,30	± 1,70
15	20	± 0,45	± 0,55	± 0,75	± 1,50	± 1,80	± 1,90	± 2,20
20	30	± 0,50	± 0,60	± 0,80	± 1,80	± 2,20	± 2,20	± 2,70
30	40	± 0,60	± 0,70	± 0,90	-	± 2,50	-	-
40	50	-	± 0,80	± 1,00	-	-	-	-

* See page 10 "Alloy groups"

3.7 Length

If fixed lengths are to be supplied, this shall be stated on the order. The tolerances on fixed lengths are specified in Table 6.

Table 6: Tolerances on fixed lengths

Circumscribing circle diameter CD		Tolerances on fixed length L			
Over	Up to and including	$L \leq 2\,000$	$2\,000 < L \leq 5\,000$	$5\,000 < L \leq 10\,000$	$10\,000 < L \leq 15\,000$
-	100	+6	+7	+10	+16
		0	0	0	0
100	200	+7	+9	+12	+18
		0	0	0	0
200	450	+8	+11	+14	+20
		0	0	0	0

If no fixed length is specified in the order, profiles may be delivered in random lengths. The length range and the tolerances on the random length shall be subject to agreement between purchaser and supplier.

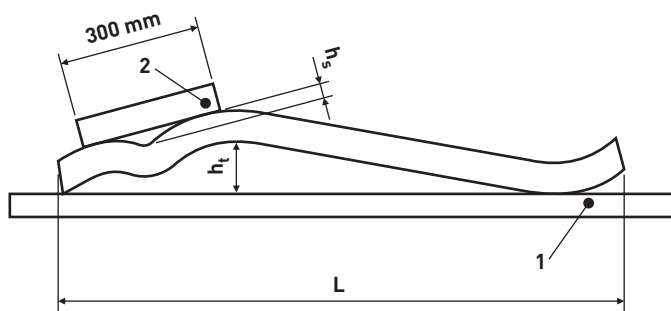
3.8 Squareness of Cut Ends

The squareness of cut ends shall be within half of the fixed length tolerance range specified in Table 6 for both fixed and random length, e.g. for a fixed length tolerance of -0 to +10 mm, the squareness of cut ends shall be within 5 mm.

3.9 Straightness

Table 7: Straight tolerances

$h_t = 1,5 \text{ mm / m of length}$
$h_s = 0,60 \text{ mm / 300 mm length}$



Key
 1. Base plate
 2. Ruler

Figure 4: Measurement of deviation from straightness

Deviations from straightness h_s and h_t shall be measured as shown in Figure 4 with the profile placed on a horizontal base plate so that its own mass decreases the deviation.

3.10 Convexity - Concavity

The convexity - concavity shall be measured as shown in figure 5. The maximum allowable deviation on convexity - concavity for solid and hollow profiles shall be as specified in Table 8 as a function of profile width W and thickness t .

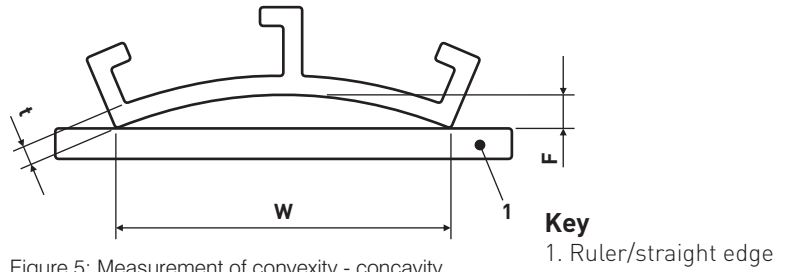


Figure 5: Measurement of convexity - concavity

Table 8: Convexity - concavity tolerances

Width W		Deviation F		
		Hollow Profiles		Solid Profiles
Over	Up to and including	Wall thickness $t \leq 5$	Wall thickness $t > 5$	
-	30	0,30	0,20	0,20
30	60	0,40	0,30	0,30
60	100	0,60	0,40	0,40
100	150	0,90	0,60	0,60
150	200	1,20	0,80	0,80
200	300	1,80	1,20	1,20
300	400	2,40	1,60	1,60

If the profile has varying wall thickness in the measurement range, the thinnest wall thickness shall be used. In the case of solid and hollow profiles with a width W of at least 150mm, the local deviation F , shall not exceed 0,7 mm for any 100 mm of width W .

3.11 Twist

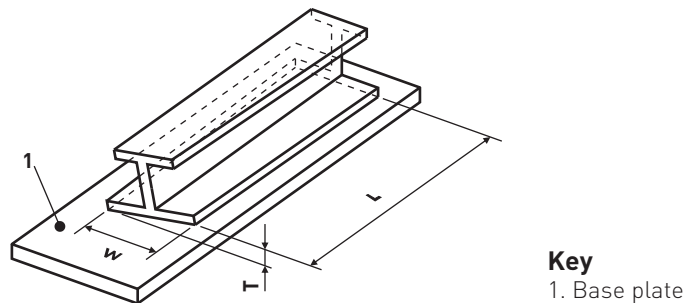


Figure 6: Measurement of twist

Table 9: Twist tolerances

Width W		Twist tolerance T for length L		
		Per 1 000 of length	On total profile length L	
Over	Up to and including			Over 1 000 and including 6 000
-	30	1,20	2,50	3,00
30	50	1,50	3,00	4,00
50	100	2,00	3,50	5,00
100	200	2,50	5,00	7,00
200	300	2,50	6,00	8,00
300	450	3,00	8,00	1,50 x L

Twist tolerances for lengths less than 1 000 mm shall be subject to agreement between purchaser and supplier. Twist T shall be measured as shown in Figure 6 by placing the profile on a flat base plate (1), the profile resting under its own mass, and measuring the maximum distance at any point along the length between the bottom surface of the profile and the base plate surface. Tolerances are specified in Table 9 as a function of the width W and the length L of the profile.

3.12 Angularity

The deviation from a specified angle shall be measured as shown in Figures 7 and 8.

The angularity tolerance for right angles is specified in Table 10 as a function of profile width W .

The maximum allowable deviation in an angle other than a right angle shall be ± 1 .

In the case of unequal side lengths the tolerance of angularity shall apply to the shorter side of the angle, i.e. it is measured starting from the longer side.

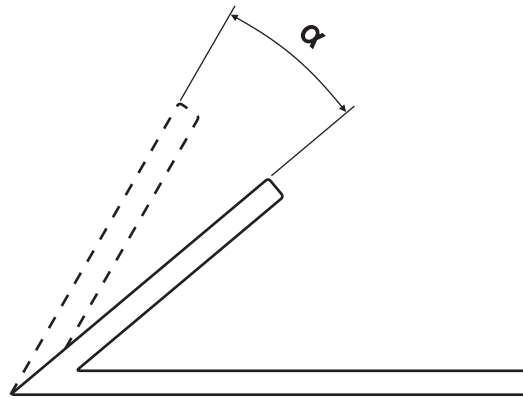


Figure 7: Measurement of angularity in an angle other than a right angle.

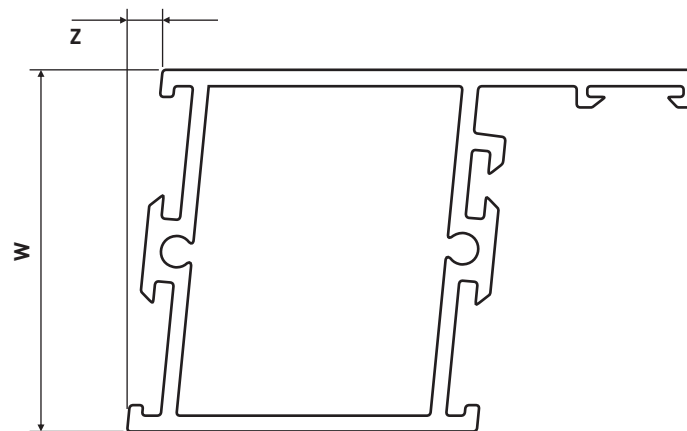


Figure 8: Angularity tolerances

Table 10: Angularity tolerances for right angles

Over	Width W	Maximum allowable deviation, Z from a right angle
	Up to and including	
-	30	0,40
30	50	0,70
50	80	1,00
80	120	1,40
120	180	2,00
180	240	2,60
240	300	3,10
300	400	3,50

3.13 Contour

For profiles with curved cross sections, the deviation at any point of the curve from the theoretically exact line as defined by the drawing, shall not be greater than the appropriate tolerance C specified in Table 11. Considering all points in the curve, a tolerance zone shall be defined as the zone between two envelopes running tangentially to all circles of diameter C which can be drawn with their centers lying along the theoretically exact line: this is shown in Figure 9(a) and 9(b).

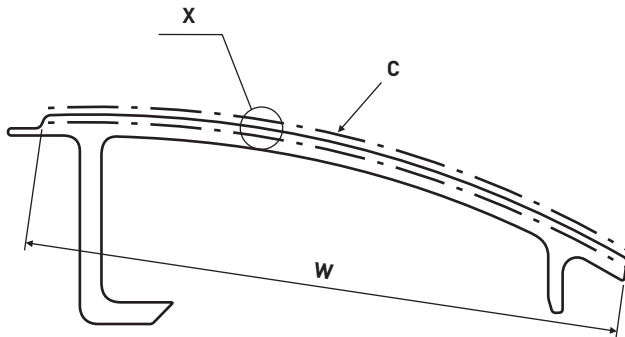


Figure 9 (a): Definition of contour tolerances

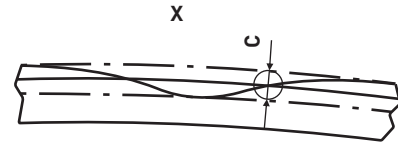


Figure 9 (b)

Table 11: Contour tolerances

Width W of the contour		Contour tolerances = diameter C of the tolerance circle
Over	Up to and including	
-	30	0,30
30	60	0,50
60	90	0,70
90	120	1,00
120	150	1,20
150	200	1,50
200	250	2,00
250	300	2,50
300	400	3,00

Notes:

Contour tolerances can be checked by placing a section of the profile on a 1:1 scale projection of the drawing with the contour tolerance indicated on the drawing. Another recommended method is the use of suitable gauges (min/max).

3.14 Corner and Fillet Radii

When a corner or fillet radius is specified, the maximum allowable deviation from this radius shall be as specified in Table 12.

Table 12: Maximum allowable deviation from specified corner and fillet radii

Specified radius	Maximum allowable deviation from specified radius
≤ 5	± 0,5 mm
> 5	± 10%

3.15 Round Bar

Tolerance on dimensions and form

Diameter

The tolerances on diameter are specified in Table 13. For the purpose of this standard the alloys are distributed into two groups, which correspond to varying difficulty when manufacturing the products. The division into group 1 and group 2 of the most commonly used general engineering alloys is specified in section 3.2 (page 10).

Table 13: Diameter Tolerances (D)

Diameter <i>D</i>		Tolerances	
Over	Up to	Alloy Group 1	Alloy Group 2
> 8	18	± 0,22	± 0,30
18	25	± 0,25	± 0,35
25	40	± 0,30	± 0,40
40	50	± 0,35	± 0,45
50	65	± 0,40	± 0,50
65	80	± 0,45	± 0,70
80	100	± 0,55	± 0,90
100	120	± 0,65	± 1,00
120	150	± 0,80	± 1,20

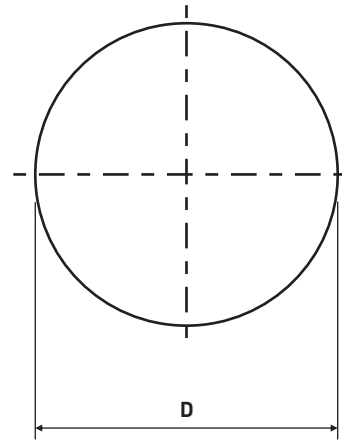


Figure 10

3.16 Square Bar

Tolerance on dimensions and form

Width across flats

The tolerances on width across flats are specified in Table 14.

For the purpose of this standard the alloys are distributed into two groups, which correspond to varying difficulty when manufacturing the products.

The division into group 1 and group 2 (see page 10) of the most commonly used general engineering alloys is specified in Table 14.

Table 14: Width across flats tolerances (W)

Width across flats <i>W</i>		Tolerances	
Over	Up to	Alloy Group 1	Alloy Group 2
10	18	± 0,22	± 0,30
18	25	± 0,25	± 0,35
25	40	± 0,30	± 0,40
40	50	± 0,35	± 0,45
50	65	± 0,40	± 0,50
65	80	± 0,45	± 0,70
80	100	± 0,55	± 0,90
100	120	± 0,65	± 1,00

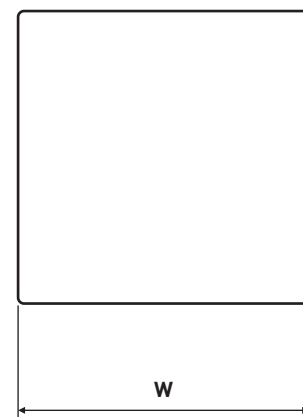


Figure 11

Squareness tolerance = 0,01 x width

Convexity - concavity tolerance = Included within width tolerance

3.17 Rectangular Bar

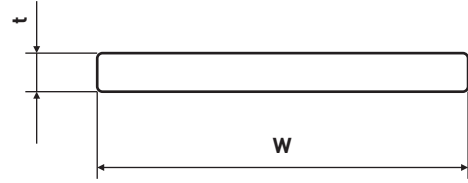


Figure 12

Table 15: Width and thickness tolerance - Alloy group 1

Width W			Thickness t tolerance for thickness ranges				
Over	Up to	Tolerance	$2 \leq t \leq 6$	$6 < t \leq 10$	$10 < t \leq 18$	$18 < t \leq 30$	$30 < t \leq 50$
≥ 10	18	$\pm 0,25$	$\pm 0,20$	$\pm 0,25$	$\pm 0,25$	-	-
18	30	$\pm 0,30$	$\pm 0,20$	$\pm 0,25$	$\pm 0,30$	$\pm 0,30$	-
30	50	$\pm 0,40$	$\pm 0,25$	$\pm 0,25$	$\pm 0,30$	$\pm 0,35$	$\pm 0,40$
50	80	$\pm 0,60$	$\pm 0,25$	$\pm 0,30$	$\pm 0,35$	$\pm 0,40$	$\pm 0,50$
80	120	$\pm 0,80$	$\pm 0,30$	$\pm 0,35$	$\pm 0,40$	$\pm 0,45$	$\pm 0,60$
120	180	$\pm 1,00$	$\pm 0,40$	$\pm 0,45$	$\pm 0,50$	$\pm 0,55$	$\pm 0,60$
180	240	$\pm 1,40$	-	$\pm 0,55$	$\pm 0,60$	$\pm 0,65$	$\pm 0,70$
240	350	$\pm 1,80$	-	$\pm 0,65$	$\pm 0,70$	$\pm 0,75$	$\pm 0,80$

Table 16: Width and thickness tolerance - Alloy group 2

Width W			Thickness t tolerance for thickness ranges				
Over	Up to	Tolerance	$2 \leq t \leq 6$	$6 < t \leq 10$	$10 < t \leq 18$	$18 < t \leq 30$	$30 < t \leq 50$
≥ 10	18	$\pm 0,35$	$\pm 0,25$	$\pm 0,30$	$\pm 0,35$	-	-
18	30	$\pm 0,40$	$\pm 0,25$	$\pm 0,30$	$\pm 0,40$	$\pm 0,40$	-
30	50	$\pm 0,50$	$\pm 0,30$	$\pm 0,30$	$\pm 0,40$	$\pm 0,50$	$\pm 0,50$
50	80	$\pm 0,70$	$\pm 0,30$	$\pm 0,35$	$\pm 0,45$	$\pm 0,60$	$\pm 0,70$
80	120	$\pm 1,00$	$\pm 0,35$	$\pm 0,40$	$\pm 0,50$	$\pm 0,60$	$\pm 0,70$
120	180	$\pm 1,40$	$\pm 0,45$	$\pm 0,50$	$\pm 0,55$	$\pm 0,70$	$\pm 0,80$
180	240	$\pm 1,80$	-	$\pm 0,60$	$\pm 0,65$	$\pm 0,70$	$\pm 0,90$
240	350	$\pm 2,20$	-	$\pm 0,70$	$\pm 0,75$	$\pm 0,80$	$\pm 0,90$

Table 18: Convexity - concavity tolerances

Width W		Tolerances for convexity - concavity
Over	Up to	
> 10	30	0,20
30	50	0,30
50	80	0,40
80	120	0,60
120	180	0,90
180	240	1,20
240	350	1,50

Table 17: Squareness tolerances

Thickness t		Maximum deviation from square
Over	Up to	
> 2	10	0,10
10	100	0,01 x thickness
100	180	1,00
180	240	1,50

Table 19: Twist tolerances

Width W		Twist tolerances T	
Over	Up to	Per 1 000 mm of length	Over the total length
≥ 10	30	1,00	3,00
30	50	1,50	4,00
50	120	2,00	5,00
120	240	3,00	8,00
240	350	4,00	10,00

3.18 Hexagonal Bar

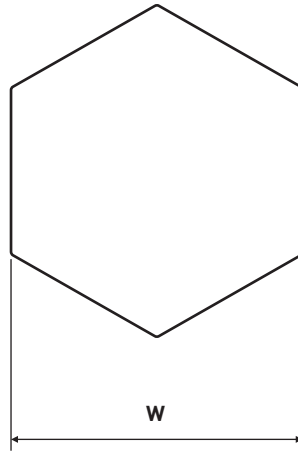


Figure 13

Table 20: Tolerance on width across flats *W*

Width across flats <i>W</i>		Tolerances	
Over	Up to	Alloy Group 1	Alloy Group 2
≥ 10	18	± 0,22	± 0,30
18	25	± 0,25	± 0,35
25	40	± 0,30	± 0,40
40	50	± 0,35	± 0,45
50	65	± 0,40	± 0,50
65	80	± 0,50	± 0,70
80	100	± 0,55	± 0,90

Table 21: Twist tolerances

Width across flats <i>W</i>		Twist tolerances <i>T</i>	
Over	Up to	Per 1 000 mm of length	Over the total length
≥ 10	30	1,00	1,50
30	80	1,50	2,50
80	120	2,00	3,00

For straightness tolerance on round bar, square bar, rectangular and hexagonal bar refer to Table 7 on page 14.

3.19 Round Tube

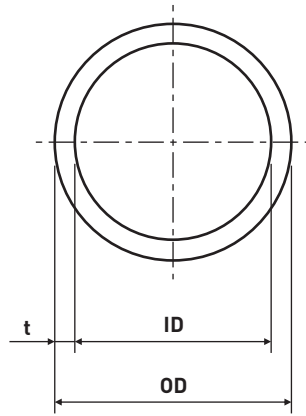


Figure 14: Round tube

Diameter - round tube

Mean diameter is defined as the average of two diameter measurements taken at right angles to each other at any point along the length.

Table 22: Tolerance on diameter of round tube

Diameter (OD or ID)		Tolerance on diameter	
		Maximum allowable deviation of mean diameter from specified diameter	Maximum allowable deviation of diameter at any point from specified diameter
Over	Up to including		
> 8	18	± 0,25 ^[3]	± 0,60
18	30	± 0,30	± 0,70
30	50	± 0,35	± 0,90
50	80	± 0,40	± 1,10
80	120	± 0,60	± 1,40
120	200	± 0,90	± 2,00

1. Not applicable to tubes having a wall thickness less than 2,5% of the specified outside diameter. The tolerance for tubes with wall thickness less than 2,5% of the specified outside diameter shall be determined by multiplying the applicable tolerance as follows:

- Wall thickness over 2,0% up to and including 2,5% of outside diameter: 1,5 x tolerance.
- Wall thickness over 1,5% up to and including 2,0% of outside diameter: 2,0 x tolerance.

2. Applies to all alloys in T4, T5 and T6. Other tempers subject to enquiry.

3. This tolerance applies for outside diameter only, i.e. tube in this size range can only be specified as "Outside Diameter x Wall Thickness".

Wall thickness

The tolerance on wall thickness are specified in Table 23 for round tubes and in Table 24 for other than round tubes.

Table 23: Tolerance on wall thickness for round tube

Wall Thickness		Tolerance	
		Alloy Group 1*	Alloy Group 2*
1,00	1,50	± 0,15	-
1,50	3,00	± 0,20	± 0,25
3,00	6,00	± 0,25	± 0,30
6,00	10,00	± 0,35	± 0,40

Note: The above table of wall thickness tolerances are a departure from BS EN 755. To simplify the understanding of wall thickness tolerances, Hulamin has chosen to opt for the tolerances as presented in the above table.

* Refer to Section 3.2 for Alloy Groups

3.20 Square Rectangular, Hexagonal and Octagonal Tubes

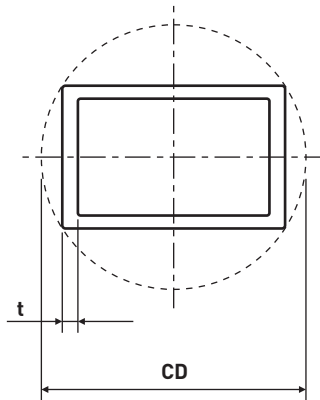


Figure 15: Circumscribing circle for other than round tube

Table 24: Tolerance on width, depth or width across flats

Width, depth or width across flats		Tolerances on width, depth or width across flats ^{(1) (2)}					
		$CD \leq 100$		$100 < CD \leq 200$		$200 < CD \leq 300$	
Over	Up to and including	Alloy group 1	Alloy group 2	Alloy group 1	Alloy group 2	Alloy group 1	Alloy group 2
-	10	± 0,25	± 0,40	± 0,30	± 0,50	± 0,35	± 0,55
10	25	± 0,30	± 0,50	± 0,40	± 0,70	± 0,50	± 0,80
25	50	± 0,50	± 0,80	± 0,60	± 0,90	± 0,80	± 1,00
50	100	± 0,70	± 1,00	± 0,90	± 1,20	± 1,10	± 1,30
100	150	-	-	± 1,10	± 1,50	± 1,30	± 1,70
150	200	-	-	± 1,30	± 1,90	± 1,50	± 2,20
200	300	-	-	-	-	± 1,70	± 2,50

- Not applicable to tubes having a wall thickness less than 2,5% of the specified outside width, depth or width across flats. The tolerance for tubes with wall thickness less than 2,5% of the specified width, depth or width across flats shall be determined by multiplying the applicable tolerance as follows:
 - Wall thickness over 2,0% up to and including 2,5% of outside parameter: 1,5 x tolerance.
 - Wall thickness over 1,5% up to and including 2,0% of outside parameter: 2,0 x tolerance.
- These tolerances do not apply to tempers O and Tx510. For these tempers the tolerances shall be subject to agreement between the supplier and the purchaser.

Table 25: Tolerance on wall thickness other than round tube

Nominal wall thickness t		Tolerances on wall thickness for circumscribing circle CD					
		$CD \leq 100$		$100 < CD \leq 300$		$300 < CD \leq 350$	
Over	Up to and including	Alloy group 1	Alloy group 2	Alloy group 1	Alloy group 2	Alloy group 1	Alloy group 2
≥ 0,5	1,5	± 0,20	± 0,30	± 0,30	± 0,40	-	-
1,5	3	± 0,25	± 0,35	± 0,40	± 0,50	± 0,60	± 0,70
3	6	± 0,40	± 0,55	± 0,60	± 0,70	± 0,80	± 0,90
6	10	± 0,60	± 0,75	± 0,80	± 1,00	± 1,00	± 1,20
10	15	± 0,80	± 1,00	± 1,00	± 1,30	± 1,20	± 1,50
15	20	± 1,20	± 1,50	± 1,50	± 1,80	± 1,70	± 2,00
20	30	± 1,50	± 1,80	± 1,80	± 2,20	± 2,00	± 2,50
30	40	-	-	± 2,00	± 2,50	± 2,00	± 3,00

3.21 Shipping

Extruded products will, within practical limits be supplied in the number of pieces ordered. Unless otherwise agreed and stated on the order, orders will be subject to a weight or piece quantity tolerance of plus or minus 10%.

If over shipment is not permissible, the order shall be endorsed "Do not overship weight" or "Pieces" as the case may be, in which case an under shipment of 10% may be applied.

If an exact number of pieces is required, the order shall be endorsed "Ship pieces specified". This is, however, subject to prior agreement and an extra charge.

Unless otherwise agreed and endorsed on the order, normal Hulamin Extrusions packing methods will apply.

Should wet or water-stained metal be delivered, kindly contact your Regional Customer Service immediately so that remedial action can take place

Register of Amendments

Edition	Description of change	Page affected
18-2	Edition number 18 2 nd print November 2014	Front cover
18-2	Introduction updated - "Five" changed to "Four"	Inside front cover
18-2	Note amended – controlled copy on website	Inside front cover
18-2	Footnotes updated	All pages
18-2	Modified Footnotes	All pages
18-2	Table heading amended - "weight" to "mass"	7
18-2	"N.B." changed to "Important"	9
18-2	Note reference corrected	21
18-2	Addition of Amendment Register	Inside back cover

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