Aluminium Alloy Specifications

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An ISO 9001:2008 Company

Aluminium is the world's most abundant metal and is the third most common element comprising 8% of the earth's crust. The versatility of aluminium makes it the most widely used metal after steel.
Aluminium is derived from the mineral bauxite. Bauxite is converted to aluminium oxide (alumina) via the Bayer Process. The alumina is then converted to aluminium metal using electrolytic cells and the Hall-Heroult Process.
Worldwide demand for aluminium is around 29 million tons per year. About 22 million tons is new aluminium and 7 million tons is recycled aluminium scrap. The use of recycled aluminium is economically and environmentally compelling. It takes 14,000 kWh to produce 1 tonne of new aluminium. Conversely it takes only 5% of this to remelt and recycle one tonne of aluminium. There is no difference in quality between virgin and recycled aluminium alloys.
Pure aluminium is soft, ductile, corrosion resistant and has a high electrical conductivity. It is widely used for foil and conductor cables, but alloying with other elements is necessary to provide the higher strengths needed for other applications. Aluminium is one of the lightest engineering metals, having a strength to weight ratio superior to steel.
By utilising various combinations of its advantageous properties such as strength, lightness, corrosion resistance, recyclability and formability, aluminium is being employed in an ever-increasing number of applications. This array of products ranges from structural materials through to thin packaging foils.

ALLOY DESIGNATIONS

Aluminium is most commonly alloyed with copper, zinc, magnesium, silicon, manganese and lithium. Small additions of chromium, titanium, zirconium, lead, bismuth and nickel are also made and iron is invariably present in small quantities.
There are over 300 wrought alloys with 50 in common use. They are normally identified by a four figure system which originated in the USA and is now universally accepted. Table 1 describes the system for wrought alloys. Cast alloys have similar designations and use a five digit system.

Table 1.
Designations for wrought aluminium alloys.

Alloying Element None (99%+ Aluminium) - 1XXX
Alloying Element Copper - 2XXX
Alloying Element Manganese - 3XXX
Alloying Element Silicon - 4XXX
Alloying Element Magnesium - 5XXX
Alloying Element Magnesium + Silicon - 6XXX
Alloying Element Zinc - 7XXX
Alloying Element Lithium/Other - 8XXX

For unalloyed wrought aluminium alloys designated 1XXX, the last two digits represent the purity of the metal. They are the equivalent to the last two digits after the decimal point when aluminium purity is expressed to the nearest 0.01 percent. The second digit indicates modifications in impurity limits. If the second digit is zero, it indicates unalloyed aluminium having natural impurity limits and 1 through 9, indicate individual impurities or alloying elements.

For the 2XXX to 8XXX groups, the last two digits identify different aluminium alloys in the group. The second digit indicates alloy modifications. A second digit of zero indicates the original alloy and integers 1 to 9 indicate consecutive alloy modifications.

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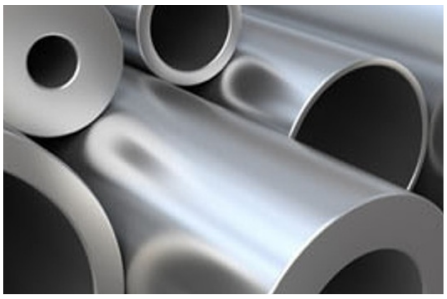
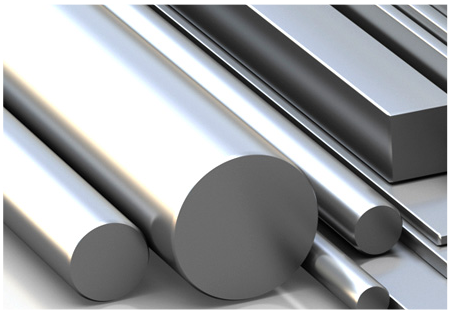
Aluminium Round Bars

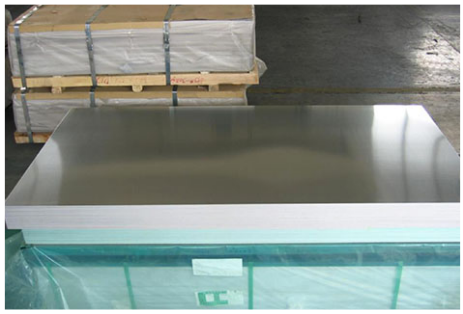


Aluminium Seamless Pipes

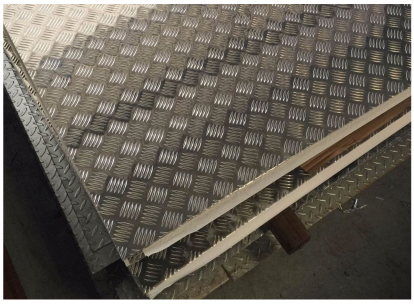
Aluminium Tubes



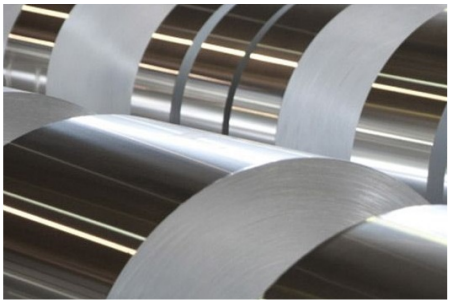
Aluminium Bars



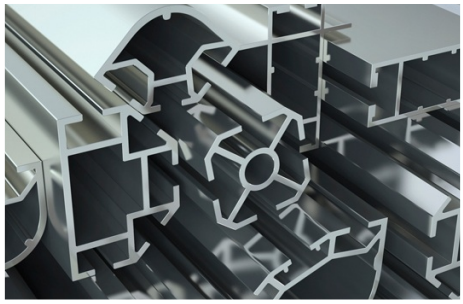
Aluminium Sheets



Aluminium Chequere Plate

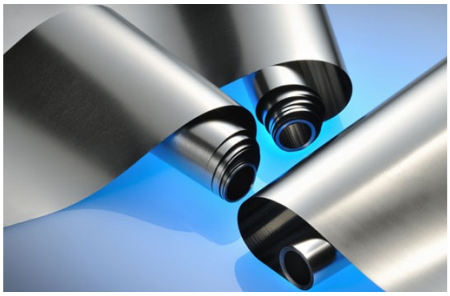


Aluminium Coils



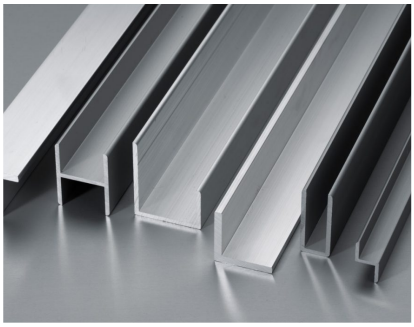
Aluminium Structurals

Aluminium Hex Bars

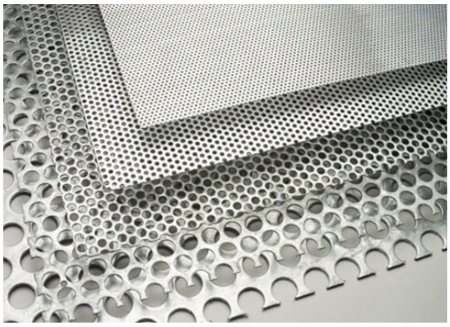


Aluminum Foils & Strips

Aluminium Flat Bars



Aluminium Angle Channel Beam



Aluminium Perforated Sheets

Aluminium Plates

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• Bharat Aluminium Company Ltd. (BALCO) • Galco

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Physical Properties

Density

Aluminium has a density around one third that of steel or copper making it one of the lightest commercially available metals. The resultant high strength to weight ratio makes it an important structural material allowing increased payloads or fuel savings for transport industries in particular.

Strength

Pure aluminium doesn't have a high tensile strength. However, the addition of alloying elements like manganese, silicon, copper and magnesium can increase the strength properties of aluminium and produce an alloy with properties tailored to particular applications.

Aluminium is well suited to cold environments. It has the advantage over steel in that its' tensile strength increases with decreasing temperature while retaining its toughness. Steel on the other hand becomes brittle at low temperatures.

Corrosion Resistance

When exposed to air, a layer of aluminium oxide forms almost instantaneously on the surface of aluminium. This layer has excellent resistance to corrosion. It is fairly resistant to most acids but less resistant to alkalis.

Thermal Conductivity

The thermal conductivity of aluminium is about three times greater than that of steel. This makes aluminium an important material for both cooling and heating applications such as heat-exchangers. Combined with it being non-toxic this property means aluminium is used extensively in cooking utensils and kitchenware.

Electrical Conductivity

Along with copper, aluminium has an electrical conductivity high enough for use as an electrical conductor. Although the conductivity of the commonly used conducting alloy (1350) is only around 62% of annealed copper, it is only one third the weight and can therefore conduct twice as much electricity when compared with copper of the same weight.

Reflectivity

From UV to infra-red, aluminium is an excellent reflector of radiant energy. Visible light reflectivity of around 80% means it is widely used in light fixtures. The same properties of reflectivity makes aluminium ideal as an insulating material to protect against the sun's rays in summer, while insulating against heat loss in winter.

Table 2. Typical properties for aluminium.

Property	Value
Atomic Number	13
Atomic Weight (g/mol)	26.98
Valency	3
Crystal Structure	FCC
Melting Point (°C)	660.2
Boiling Point (°C)	2480
Mean Specific Heat (0-100°C) (cal/g.°C)	0.219
Thermal Conductivity (0-100°C) (cal/cms. °C)	0.57
Co-Efficient of Linear Expansion (0-100°C) ($x10^{-6}$/°C)	23.5
Electrical Resistivity at 20°C (μΩ.cm)	2.69
Density (g/cm^3)	2.6898
Modulus of Elasticity (GPa)	68.3
Poissons Ratio	0.34

Mechanical Properties

Aluminium can be severely deformed without failure. This allows aluminium to be formed by rolling, extruding, drawing,

machining and other mechanical processes. It can also be cast to a high tolerance.

Alloying, cold working and heat-treating can all be utilised to tailor the properties of aluminium.

The tensile strength of pure aluminium is around 90 MPa but this can be increased to over 690 MPa for some heat-treatable alloys.

Table 3. Mechanical properties of selected aluminium alloys.

Alloy	Temper	Proof Stress 0.2% (MPa)	Tensile Strength (MPa)	Shear Strength (MPa)	Elongation A5 (%)	Hardness Vickers (HV)
AA1050A	H12	85	100	60	12	30
	H14	105	115	70	10	36
	H16	120	130	80	7	-
	H18	140	150	85	6	44
	0	35	80	50	42	20
AA2011	T3	290	365	220	15	100
	T6	300	395	235	12	115
AA3103	H14	140	155	90	9	46
	0	45	105	70	29	29
AA4015	0	45	110-150	-	20	30-40
	H12	110	135-175	-	4	45-55
	H14	135	160-200	-	3	-
	H16	155	185-225	-	2	-
	H18	180	210-250	-	2	-
AA5083	H32	240	330	185	17	95
	0/H111	145	300	175	23	75
AA5251	H22	165	210	125	14	65
	H24	190	230	135	13	70
	H26	215	255	145	9	75
	0	80	180	115	26	46
AA5754	H22	185	245	150	15	75
	H24	215	270	160	14	80
	H26	245	290	170	10	85
	0	100	215	140	25	55
AA6063	0	50	100	70	27	85
	T4	90	160	11	21	50
	T6	210	245	150	14	80
AA6082	0	60	130	85	27	35
	T4	170	260	170	19	75
	T6	310	340	210	11	100
AA6262	T6	240	290	-	8	-
	T9	330	360	-	3	-
AA7075	0	105-145	225-275	150	9	65
	T6	435-505	510-570	350	5	160

Aluminium Standards

The old BS1470 standard has been replaced by nine EN standards. The EN standards are given in table 4.

Table 4. EN standards for aluminium

Standard	Scope
EN485-1	Technical conditions for inspection and delivery
EN485-2	Mechanical properties
EN485-3	Tolerances for hot rolled material
EN485-4	Tolerances for cold rolled material
EN515	Temper designations
EN573-1	Numerical alloy designation system
EN573-2	Chemical symbol designation system
EN573-3	Chemical compositions
EN573-4	Product forms in different alloys

The EN standards differ from the old standard, BS1470 in the following areas:

- Chemical compositions – unchanged.
- Alloy numbering system – unchanged.
- Temper designations for heat treatable alloys now cover a wider range of special tempers. Up to four digits after the T have been introduced for non-standard applications (e.g. T6151).
- Temper designations for non heat treatable alloys – existing tempers are unchanged but tempers are now more comprehensively defined in terms of how they are created. Soft (O) temper is now H111 and an intermediate temper H112 has been introduced. For alloy 5251 tempers are now shown as H32/H34/H36/H38 (equivalent to H22/H24, etc). H19/H22 & H24 are now shown separately.
- Mechanical properties – remain similar to previous figures. 0.2% Proof Stress must now be quoted on test certificates.

Tolerances have been tightened to various degrees.

Heat Treatment

A range of heat treatments can be applied to aluminium alloys:

- Homogenisation – the removal of segregation by heating after casting.
- Annealing – used after cold working to soften work-hardening alloys (1XXX, 3XXX and 5XXX).
- Precipitation or age hardening (alloys 2XXX, 6XXX and 7XXX).
- Solution heat treatment before ageing of precipitation hardening alloys.
- Stoving for the curing of coatings

After heat treatment a suffix is added to the designation numbers.

- The suffix F means "as fabricated".
- O means "annealed wrought products".
- T means that it has been "heat treated".
- W means the material has been solution heat treated.
- H refers to non heat treatable alloys that are "cold worked" or "strain hardened".

The non-heat treatable alloys are those in the 3XXX, 4XXX and 5XXX groups.

Table 5. Heat treatment designations for aluminium and aluminium alloys.

Term	Description
T1	Cooled from an elevated temperature shaping process and naturally aged.
T2	Cooled from an elevated temperature shaping process cold worked and naturally aged.
T3	Solution heat-treated cold worked and naturally aged to a substantially.
T4	Solution heat-treated and naturally aged to a substantially stable condition.
T5	Cooled from an elevated temperature shaping process and then artificially aged.
T6	Solution heat-treated and then artificially aged.
T7	Solution heat-treated and overaged/stabilised.

Work Hardening

The non-heat treatable alloys can have their properties adjusted by cold working. Cold rolling is a typical example.

These adjusted properties depend upon the degree of cold work and whether working is followed by any annealing or stabilising thermal treatment.

Nomenclature to describe these treatments uses a letter, O, F or H followed by one or more numbers. As outlined in Table 6, the first number refers to the worked condition and the second number the degree of tempering.

Table 6. Non-Heat treatable alloy designations

Term	Description
H1X	Work hardened
H2X	Work hardened and partially annealed
H3X	Work hardened and stabilized by low temperature treatment
H4X	Work hardened and stoved
HX2	Quarter-hard – degree of working
HX4	Half-hard – degree of working
HX6	Three-quarter hard – degree of working
HX8	Full-hard – degree of working

Table 7. Temper codes for plate

Code	Description
H112	Alloys that have some tempering from shaping but do not have special control over the amount of strain-hardening or thermal treatment. Some strength limits apply.
H321	Strain hardened to an amount less than required for a controlled H32 temper.
H323	A version of H32 that has been specially fabricated to provide acceptable resistance to stress corrosion cracking.
H343	A version of H34 that has been specially fabricated to provide acceptable resistance to stress corrosion cracking.
H115	Armour plate.
H116	Special corrosion-resistant temper.



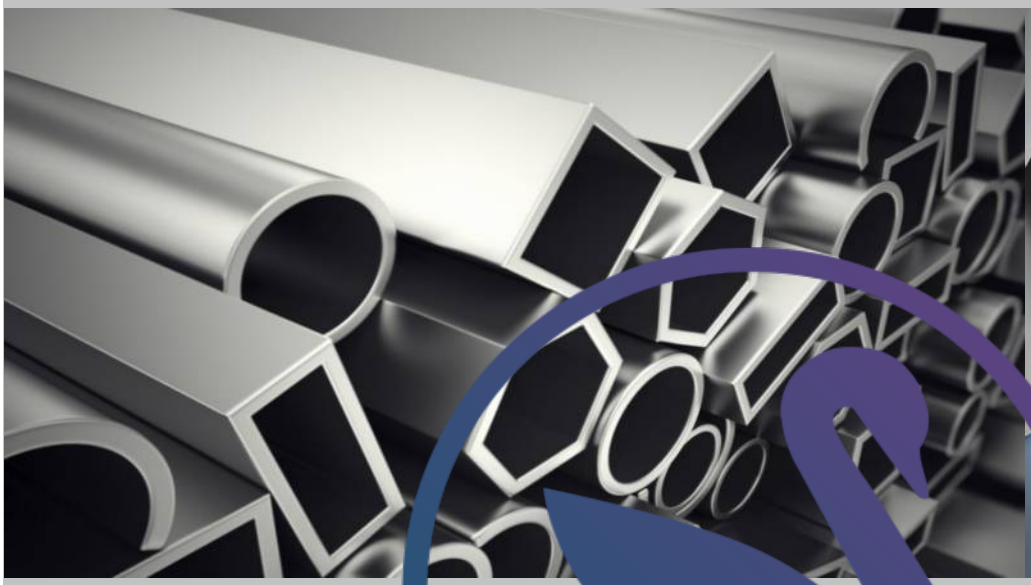
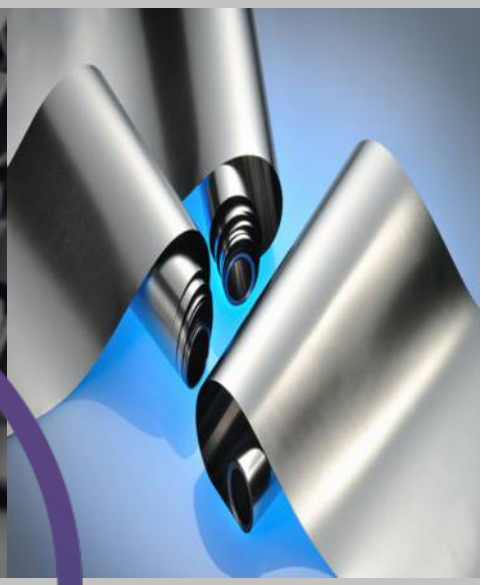
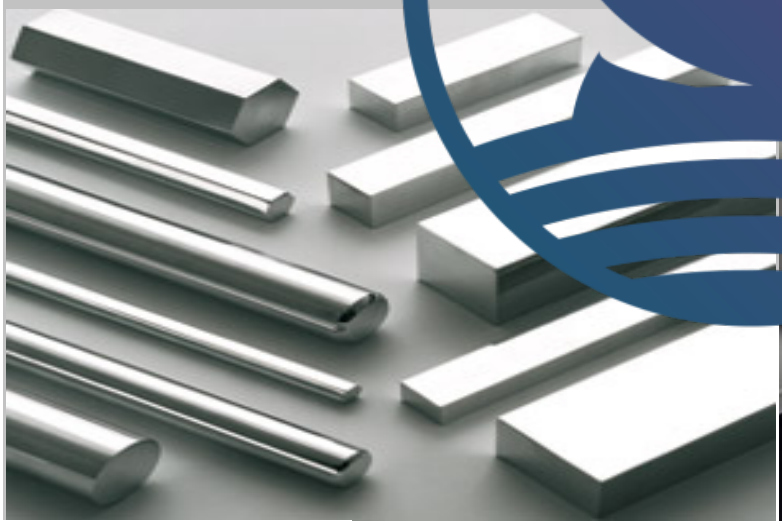


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TABLE - 1

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REPUTE STEEL & ENGG CO. Technical Data Chart

International Aluminium Material Grade Comparison Table

Non-Ferrous Materials

Aluminium Alloys

INDIA		U.S.A.	BRAITAIN	CANADA	GERMANY	RUSSIA	I.S.O.	FRENCH
NEW I.S.	OLD I.S.	(A.A)	(B.S.)		(DIN)			ND
19501	IE	1050 (E.C.)	IE	C 1S	E-Al-99.5			---
19500	IB	1050	IB	1S	A-99.5		A-99.5	1050A
19600		1060						---
19700		1070			Al-99.7		Al-99.7	---
19800	IA	1080	IA				Al-99.8	---
19000	IC	1100	IC	2S	Al·99.0	AD	Al-99.0	1200
		2011	FCI	28S	Al-Cu-Bi-Pb		Al-Cu-6 Bi Pb	2011
24345	H15	2014	H15	B26S	Al-Cu-Si	AK		---
24534	H14	2017	H14	17S/16S		D1	Al-Cu-4Mg Si	---
		2024		24S	Al-Cu-Mg.2		Al-Cu-4Mg 1	2024
31000	N3	3003	N3	3S	Al-Mn	A-Mn	Al-Mn 1	3003
43000	N21	4043	N21	33S	Al-Si-5	AK	Al-Si5	4043
46000	N2	4047	N2	35S				---
51000		5005		B57S			Al-Mg-1	---
52000	N4	5052	N4	M57S	Al-Mg.2	A-Mg	Al-Mg-2.5	5051
53000	N5	5086	N5	54S		Al.Mg-3	Al-Mg-4	---
54300	N8	5083	N8	D54S	Al-Mg-4.5 Mn		Al-Mg-4.5 Mn	5083
55000	N6	5056	N6	AS6S	Al-Mg.5		Al-Mg-5	5356
65032	H20	6061	H20	65S	Al-Mg-Si Cu		Al-Mg-Si Cu	---
63400	H9	6063	H9	50S	Al-Mg-Si 0.5		Al-Mg-Si	---
64430	H30	6351	H30	B51S	Al-Mg SI 1	AV	Al-Si-1 Mg	6081
64423	H11	6066	H11	C62S				---
62400		6005		C51S				---
63401	91E	6101	91E	D50S	E.Al.Mg.Si 0.5			---
64401		6201						---
74530		7039		D74S	Al-Zn-Mg. 1			3004
		7075	DTD 5124	75S	Al-Zn-Mg Cu1.5		Al-Zn 6 Mg Cu	7075

TABLE-2

Wrought alloys : Guide to selection

Alloy	Temper	Resistance to Corrosion	Workability (Cold)	Machinability	Brazeability	Weldability	Commonly available forms	Indications of use
EC/1050, 1060 (1B) (19501) (19500) (19600)	F,O	A	A	D	A	A	Flats, Rods, Tubes & other sections	Electrical conductors, cable sheathings, impact- extruded products, pressing utilities of anodizing quality, pen caps, piping etc.
1100 (1C) (19000)	F,O	A	A	D	A	A	Flats, Rods, Tubes & other sections	Packaging lightly stresses and decorative assemblies in architecture and transport, equipment for chemical, food and brewing industries.
2014 (H 15) (24345)	T4 T6	C C	C D	B B	D D	C C	Rods & Bars Rods & Bars	Highly stressed component of all types in aircraft, ordnance and general engineering.
2017 (H 14) (24534)	T4	C	C	B	D	C	Rods & Bars	Highly stressed parts in aircraft and other structures, screw machine products.
4043 (N 21) (43000)	F, O	A	A	D	A	A	Rods & other sections	Welding wire, architectural applications.
5005 (51000A)	F,O	A	A	D	B	A	Flats, Rods & other sections	Consumer durable with attractive anodised finish, architecturals, electrical conductors etc.
5052 (N 4) (52000)	O, F	A	A	D	C	A	Flats, Rods, Tubes & other sections	Structures exposed to marine atmosphere, aircraft parts, wire rope ferrules, rivet stock.
5086 (N 5) (53000)	O, F	A	A	D	D	A	Flats, Rods & other sections	Ship building and other marine applications, rivets, coinage etc.
5056 (N 6) (55000)	O, F	A	A	D	D	A	Rods	Zips, Welding Rods and Rivets.
6061 (H 20) (65032)	O, F T4 T6	A A A	A C D	D C C	A A A	A A A	Rods, Flats, Tubes & other sections	Heavy duty structures, building hardware, sections for bus body, truck and rail coach, furniture, rivets etc.
6063 (H9)	O,F T4 T6 T5	A A A A	A B C C	D C C C	A A A A	A A A A	Rods, Flats, Tubes & other sections	Building hardware, architectural sections with good surface finish, medium strength furniture and anodized sections.
6066 (22450)	O,F T4 T6	B B B	B C C	D B B	A A A	A A A	Rods and other solid sections	For welded structures, textile parts, heavy duty machine parts.

TABLE-2

Wrought alloys : Guide to selection

Alloy	Temper	Resistance to Corrosion	Workability (Cold)	Machinability	Brazeability	Weldability	Commonly available forms	Indications of use
6101 (91 E) (63401)	T4 T6	A A	B B	C C	A A	A A	Rods, Flats, Tubes & other sections	High strength electrical busbar sections.
6201 (64401)	T4	A	A	C	A	A	Redraw Rod	Overhead conductors, ACAR and AAAC.
6351 (H 30) (64430)	O,F T4 T6	A A A	A C D	D C C	A A A	A A A	Rods, Flats, Tubes & other sections	Structural and general engineering items such as rail & road transport vehicles, bridges, cranes, roof trusses, rivets etc.
7039 (D74S) (74530)	O,F T4 T6	A A A	A C D	D C C	A A A	A A A	Flats, Tubes, Rods & other sections	Defence structures like mobile bridges etc. Tread and chequered plates. Excellent welding property with no loss of strength in welded zone.
7075 (DTD5124)	O,F T4 T6	A A A	A A D	A A A	A A A	A A A	Rods	Highly stressed structural applications.

Notes:

1. Relative ratings for corrosion, workability and machinability in decreasing order of merit A, B, C and D.

2. Weldability & brazeability ratings A, B, C and D are relative ratings defined as follows:

   A. Generally weldable by the commercial procedure & methods.
   B. Weldable with special technique.
   C. Limited weldability due to crack sensitivity or loss in corrosion resistance and mechanical properties.
   D. Generally not weldable.

3. Availability of other forms subject to special enquiries and methods.

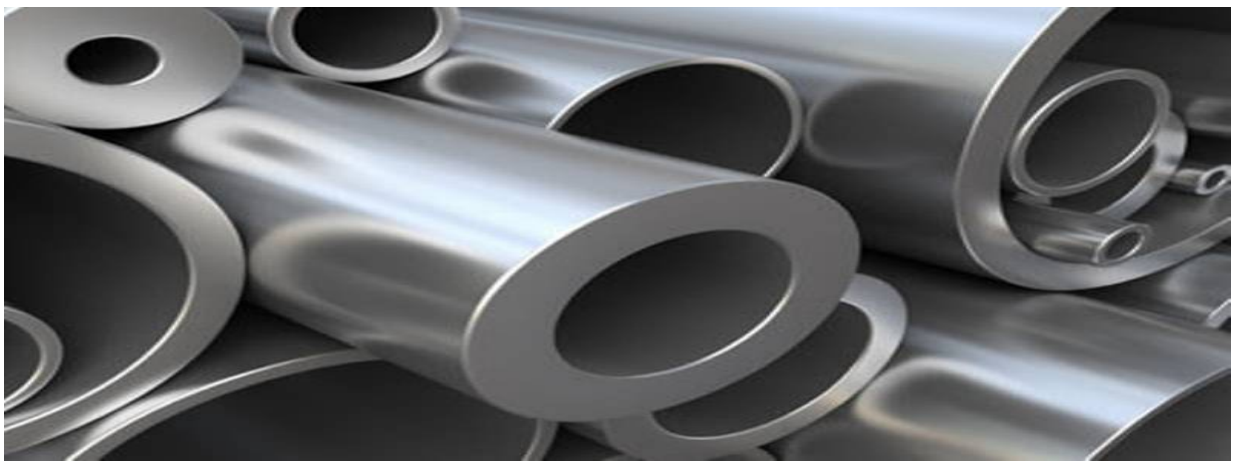

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TABLE - 3

REPUTE STEEL & ENGG CO. Technical Data Chart

Aluminium ALLOY Material Grades CHEMICAL COMPOSITION

Non-Ferrous Materials

Aluminium Alloys

ALLOY (ISS)		Equivalent Alloy (AA)	COPPER		Magnesium		Silicon		Iron	Manganese		* Others TOTAL	REMARKS
OLD	NEW	U.S.A.	Min.	Max.	Min.	Max.	Min.	Max.	Max.	Min.	Max.	Max.	
1 C	19000	1100	-	0.1	-	-	-	0.5	0.6	-	0.1	0.1	Aluminium 99.0% Min
		1200	-	0.05	-	-	Si+Fe 1.0		-		0.05	0.1	
1 B	19500	1050	-	0.05	-	-	-	0.25	0.4	-	0.05	0.1	Aluminium 99.5% Min
1 E	19501	-	-	0.04	-	-	-	0.15	0.35	-	0.03	0.1	Aluminium 99.5% Min
	-	1350	-	0.05	-	-	-	0.1	0.4	-	0.01	0.1	Aluminium 99.5% Min
-	19600	1060	-	0.05	-	-	-	0.25	0.35	-	0.03	0.1	Aluminium 99.6% Min
-	19700	1070	-	0.03	-	-	-	0.2	0.25	-	0.03	0.1	Aluminium 99.7% Min
H 15	24345	2014	3.8	5	0.2	0.8	0.5	1.2	0.7	0.3	1.2	0.5	-
H 14	24534	2017	3.5	4.7	0.4	1.2	0.2	0.7	0.7	0.4	1.2	0.5	-
N3	31000	3003	-	0.1	-	0.1	-	0.6	0.7	1	1.5	0.4	-
N21	43000	4043	-	0.1	-	0.2	4.5	6	0.6	-	0.5	0.2	-
N2	46000	4047	-	0.1	-	0.2	10	13	0.6	-	0.5	0.2	-
N4	52000	5052	-	0.1	1.7	2.6	-	0.6	0.5	-	0.5	0.4	Cr + Mn = 0.5
N5	53000	5086	-	0.1	2.8	4	-	0.6	0.5	-	0.5	0.4	Cr + Mn = 0.5
N6	55000	5056	-	0.1	4.5	5.6	-	0.6	0.7	-	0.5	0.4	Chromium upto 0.25
N8	54300	5083	-	0.1	4	4.9	-	0.4	0.7	0.5	1	0.4	Chromium upto 0.25
H 20	65032	-	0.15	0.4	0.7	1.2	0.4	0.8	0.7	0.2	0.8	0.4	**Cr =0.15-0.35
%													
-	-	6061	0.15	0.4	0.8	1.2	0.4	0.8	0.7	-	0.15	0.4	Chromium 0.04 to 0.35
H 9	63400	6063	-	0.1	0.4	0.9	0.3	0.7	0.6	-	0.3	0.4	-
-	-	6066	0.7	1.2	0.8	1.4	0.9	1.8	0.7	0.6	1.1	0.4	-
-	64423	-	0.5	1	0.5	1.3	0.7	1.3	0.8	-	1	-	-
91E	63401	6101	-	0.05	0.4	0.9	0.3	0.7	0.5	-	0.03	0.1	-
-	64401	6201	-	0.1	0.6	0.9	0.5	0.9	0.5	-	0.03	0.1	-
H 30	64430	6351	-	0.1	0.4	1.2	0.6	1.3	0.6	0.4	1	0.3	-
		6082	-	0.1	0.6	1.2	0.7	1.3	0.5	0.4	1	0.3	Chromium upto 0.25
-	74530	7039	-	0.2	1	1.5	-	0.4	0.7	0.2	0.7	0.4	Zinc 4.0 - 5.0 %
-	-	7075	1.2	2	2.1	2.9	-	0.5	0.5	-	0.3	0.2	Zinc (5.1 -6.1)% &
													Chromium(0.18-0.28) %

* Titanium and/or other grain refining elements

**Either Mn or Cr shall be present

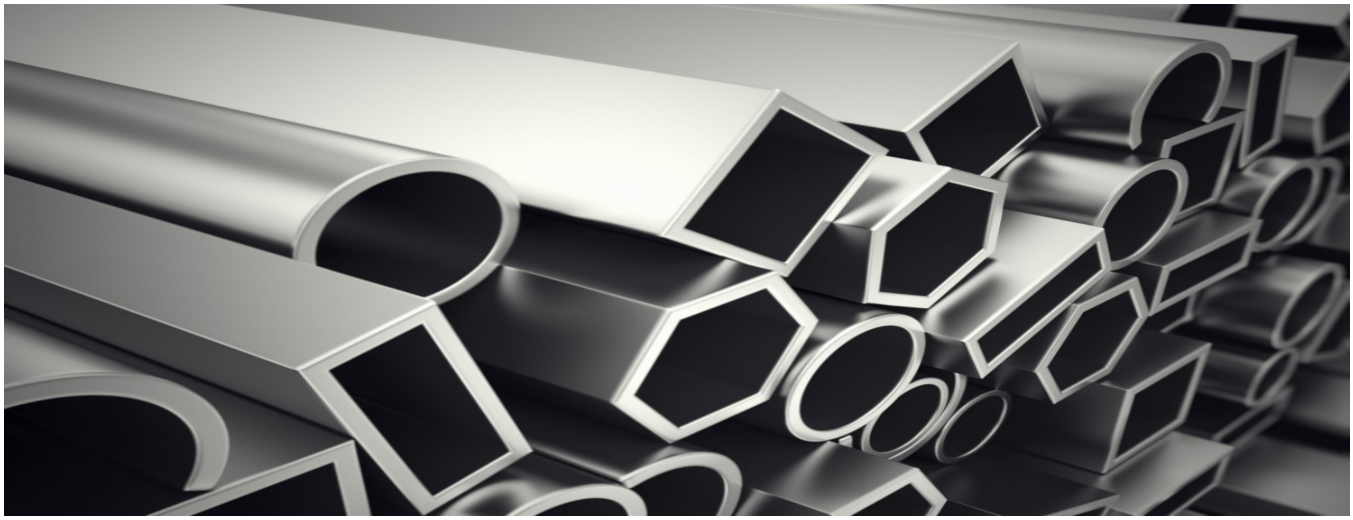


TABLE-4

Wrought alloys : Mechanical properties

Non - Heat Treatable Alloys					
Alloy AA Old (ISS) New (ISS)	Temper	Ultimate Tensile Strength Kg/mm²		0.2% Proof Stress Kg/mm²	Elongation On 50 mm GL
		Min.	Max.		
1100[1C][19000]	O	-	11.0	-	25
1050[1B][19500]	O	-	10.0	-	25
1060[19600]	O	-	9.5	-	25
1070[19700]	O	-	9.5	-	25
4043[N21][43000]	O	-	13.0	-	18
4047[N2] [46000]	O	-	15.0	-	12
5052[N4] [52000]	O	-	24.5	-	18
5086[N5] [53000]	O	-	26.5	-	16
5056[N6] [55000]	O	-	34.5	-	15
5083[N8] [54300]	O	-	35.5	-	13

Heat Treatable Alloys					
2014 [H15] [24345]	T4[W] T6 [WP]	39 49	- -	24.0 43.0	10 6
2017 [H14] [24534]	T4[W]	39	-	24.0	10
6063 [H9] [63400]	T4[W] T6 [WP]	14 19	- -	8.0 15.5	14 7
6061 [H20] [65032]	M or O T4[W] T6 [WP]	- 19 28.5	15.0 - -	- 11.5 24.0	16 14 7
6351[H30] [64430]	M or O T4[W] T6 [WP]	- 19 31.5	15 - -	- 12.0 27.5	16 14 7
6066	O T4[W] T6 [WP]	- 28 35	20.5 - -	- 17.5 31.5	16 14 7
6101[91E] [63401]	T4[W] T6 [WP]	14 20.5	- -	8.0 17.0	12 10
6201 [64401]	T4[W] T8 [WDP]	16 32	- -	7.0 -	14 3
7039 [74530]	T4[W] T6 [WP]	28 31.5	- -	23.5 26.5	9 7
7075	T6 [WP]	54	-	46.5	6

Properties indicated herein are typical properties and are given for information only. However properties of all the profiles in specific alloy shall be as per I.S. Specification.

TABLE-5

Wrought Alloys : Typical tensile properties at various temperatures (Kg/mm²)

Alloy & Temper	Tensile Strength	Temp. °C									
		Below zero			Above Zero						
		-200	-80	-25	25	100	150	200	250	300	350
1100 O (19000)	Ultimate	17.5	10.5	10.0	9.0	7.0	5.5	4.0	3.0	2.0	1.5
	Yield	4.2	3.9	3.5	3.5	3.2	3.0	2.5	2.0	1.4	1.1
2014 T6* (24345)	Ultimate	59.0	52.0	50.5	49	44.0	28.0	11.0	6.5	4.5	3.0
	Yield	50.0	45.5	43.5	42	40.0	24.5	9.0	5.0	3.5	2.5
2017 T4 (24534)	Ultimate	56.0	45.5	45.0	43.5	40.0	28.0	11.0	6.5	4.0	3.0
	Yield	37.0	29.5	29.0	28.0	27.5	21.0	9.0	5.0	3.5	2.5
3003 O (31000)	Ultimate	23.0	14.0	12.0	11.0	9.0	7.5	6.0	4.0	3.0	2.0
	Yield	6.0	5.0	4.5	4.0	4.0	3.5	3.0	2.5	1.7	1.3
5052 O (52000)	Ultimate	31.0	20.5	19.5	19.5	19.0	16.0	12.0	8.5	5.0	3.5
	Yield	11.0	9.0	9.0	9.0	9.0	9.0	7.5	5.0	4.0	2.0
5086 O (53000)	Ultimate	38.5	27.5	26.5	26.5	26.5	20.5	15.5	12.0	7.5	4.0
	Yield	17.0	15.0	15.0	15.0	15.0	13.5	12.0	7.5	5.0	3.0
6061 T4 (65032)	Ultimate	35.0	26.5	25.0	24.5	-	21.0	13.5	5.0	3.0	2.0
	Yield	19.5	15.5	15.5	14.5	-	14.5	10.5	3.8	1.8	1.5
6061 T6	Ultimate	49.0	34.5	33.0	31.5	29.5	24.0	13.5	5.0	3.2	2.1
	Yield	33.0	29.5	28.5	28.0	26.5	21.5	10.5	3.5	1.9	1.3
6063 T4 (63400)	Ultimate	26.0	20.5	19.5	15.5	-	15.5	6.5	3.5	2.1	1.8
	Yield	12.0	12.0	10.5	9.0	-	9.0	4.5	2.8	1.8	1.4
6063T6	Ultimate	33.0	26.5	25.0	24.5	21.5	14.5	6.5	3.0	2.5	1.6
	Yield	25.0	23.0	22.5	21.5	19.5	14.0	4.5	2.5	1.8	1.4

* Subject to special enquiry

TABLE-6

Wrought Aluminium & Aluminium Alloys:- Mechanical and Electrical Properties

Alloy		Temper Designation	Tensile Strength Min.	0.2 Percent Proof Stress Min.	Percent Elongation on $5.65\sqrt{Sa}$ Min.	Electrical Conductivity at 20° C, Min	Maximum Electrical Resistivity at 20° C	Thickness	Inside bend radius Min.	Coeff. Of thermal expansion	Thermal Conductivity
AA	IS		Mpa	Mpa		% IACS	ohm mm/mm²	mm		per °C at 20°C typical	CGS at 25°C typical
1050	19501	M	60	-	25	60.00	0.02874	upto 12	1x thickness	23.8×10^{-6}	0.56
6101	63401	W	140	80	12	-	-	-	-	-	-
6101	63401	WP (range 1)	170	135	12	56.50	0.03052	3.00 to 9.50	1x thickness	23.4×10^{-6}	0.52
6101	63401	WP (range 2)	200	170	10	55.00	0.03135	3.00 to 9.50	2x thickness	23.4×10^{-6}	0.52
6201	-	T81	-	-		52.50	0.03283			23.5×10^{-6}	0.50

NOTE

1MPa=1N/mm² = 0.102 kg/mm²

Properties in M temper are only typical values and are given for information only.

If required the cross-section shall be calculated from the mass and length of a straight test piece taking density 2.705 for grade 19501 and 2.700 for grade 63401

TABLE 7

Wrought alloys : Welding properties

Alloy & Temper	Relatively Suitable for Joining (*) Gas	Arc with Inert Gas	Arc With Flux	Resist. Welding	Pressure Welding	Brazing	Soldering Low Temp.	Soldering High Temp.	Filler Metal (3) †
1050 O	A	A	A	B	A	A	A	A	1260
1100 O	A	A	A	B	A	A	A	A	1100
2014 O	D	C	C	B	C	D	D	D	4145
2017 T4	D	C	C	B	D	D	D	D	4145
T6	D	C	C	B	D	D	D	D	4145
3003 O	A	A	A	B	A	A	A	A	1100
5005 O	A	A	A	B	A	B	B	A	4043
5052 O	A	A	A	B	B	C	C	C	5356
5086 O	C	A	A	B	C	D	D	D	5356
6061 O	A	A	A	B	A	A	B	A	4043
T4	A	A	A	A	B	A	B	A	4043
T6	A	A	A	A	B	A	B	A	4043
6063 T6	A	A	A	A	B	A	B	A	4043
6101 T6	A	A	A	A	B	A	B	A	4043
6201 T81	A	A	A	A	B	A	B	A	4043
7039 T6	D	C	C	A	C	D	C	C	7039

1. For general purpose only. For specialised applications, e.g. pressure vessels anodised item etc., special process should be used.

2. * Joining ratings A, B, C & D are relative ratings in order of merit.
   A – Readily weldable.
   B – Special techniques and close control of procedure are required.
   C – Limited weldability due to crack sensitivity, loss in strength and or loss in resistance to corrosion.
   D - Not recommended.

3. † Filler metals for general purpose only. For specialised applications requiring high strength ductility, colour match after anodising etc., special filler metals are recommended.

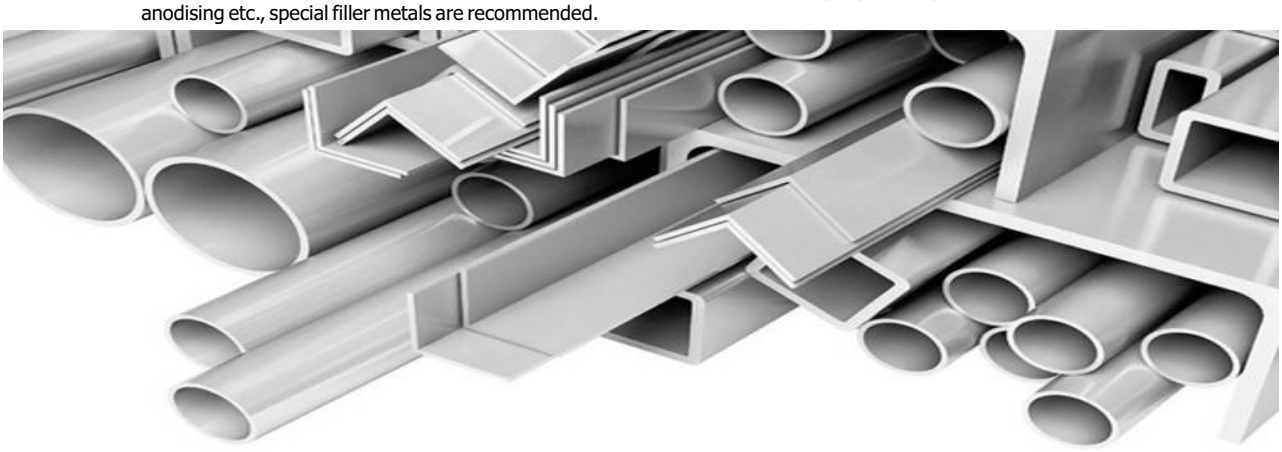
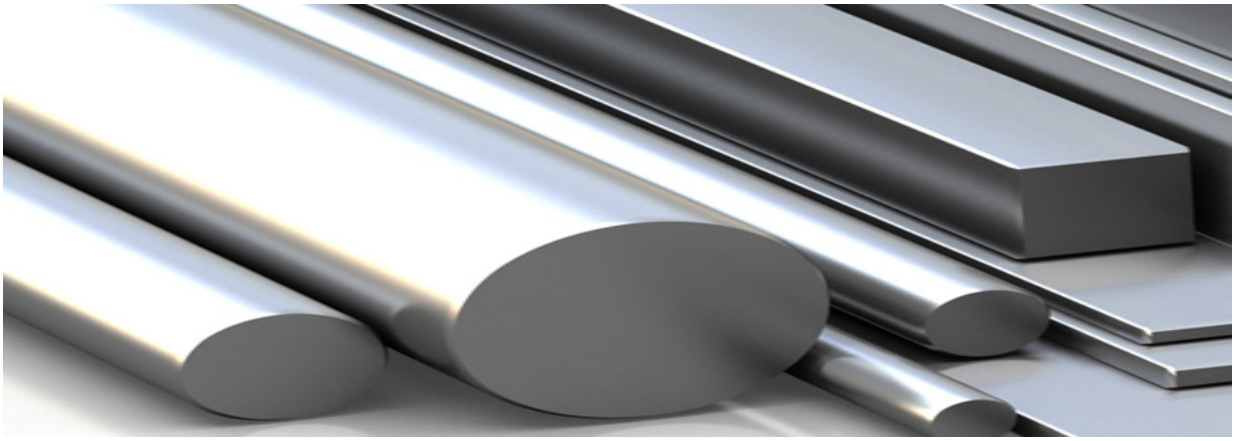


TABLE 8

Wrought Alloys : Surface Finishing (Suitability)

	Suitable for				
Alloy	Protective Anodising	Anodising & Dyeing	Bright Anodising	Plating	Vitreousea Immelgin
1050/1070	E	E	V	V	G
1100	V	V	G	V	G
2014/2017	M	M(D)	U	V	U
3003	G	G	M	G	V
4043	G	G(D)	U	O	G
5005	V	V	V	O	U
5052	V	V	G-V	O	U
5086/5056	V	V	G	O	U
6061	G	G	M	O	O
6063	V	V	G-V	O	O
6066	M	M(D)	U	V	U
6101	V	V	G-V	O	O
6351	G	G	M	O	O

E Excellent
V very good
G Good
M Moderate
U Unsuitable
D Only Suitably for dark colours
O Modified technique is essential and some initial difficulties may occur.



Standard Manufacturing Tolerances

The Standard manufacturing tolerance given here are applicable to the average shape. Wider tolerance may be required for some shapes, and closer tolerances may be possible for others. For 5052, 5056, 5083, 5086 and other high magnesium alloys, special (wider) tolerances will be applicable.

Tolerances stricter than standard shall be subjected to special enquiry.

TABLE : 9

Round Bars/Rods : Diameter Tolerance

Specified Diameter mm		Tolerance (mm) Class A		Class B
		+	-	±
	Upto 12.0	0.03	0.07	0.20
Over 12.0	Upto 25.0	0.05	0.10	0.25
Over 25.0	Upto 40.0	0.07	0.13	0.30
Over 40.0	Upto 50.0	0.13	0.13	0.38
Over 50.0	Upto 56.0	0.15	0.15	0.46
Over 56.0	Upto 71.0	0.20	0.20	0.53
Over 71.0	Upto 80.0	0.25	0.25	0.61
Over 80.0		0.5%	0.5%	1%

Notes:
1. Class 'A' is for drawn rods.
2. Class 'B' is normal tolerance for extruded rods.

TABLE : 10

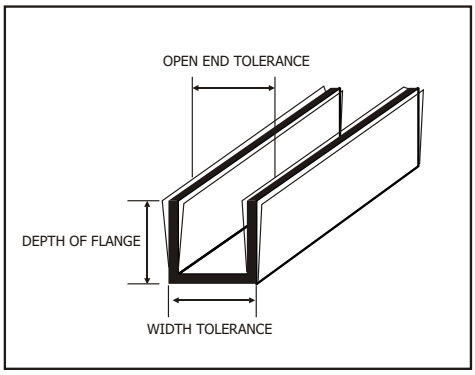
Solid Sections : Width Tolerance (at closed ends)

Specified width or Width across flats mm	Tolerance mm ±
4	0.18
5	0.20
6	0.20
8	0.23
10	0.23
12	0.25
16	0.28
20	0.30
25	0.30
32	0.38
40	0.46
50	0.46
60	0.53
80	0.69
100	0.69
120	0.76
160	1.02
200	1.14
250	1.40

Notes:
1. For intermediate size, take tolerance for the next higher value.
2. Width tolerances on open ends of Solid Sections such as Channels, I-Beams, etc. are given separately in Table-11.

TABLE - 11

Solid Sections : Width Tolerance (at open ends)



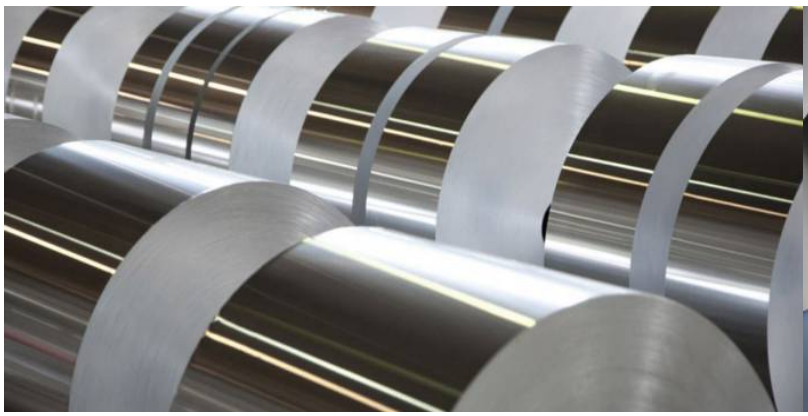
Displacement of any one leg to be controlled independently by tolerance on angle

Tolerance on open ends of channels and I-beams

Specified Width mm	Depth of flange or leg (mm)			
	6.5 to 16.0	16.1 to 32.0	32.1 to 64.0	64.1 to 150.0
	Width Tolerance mm ±			
Upto 6.0	0.30	-	-	-
6.1 to 12.0	0.35	0.40	0.45	-
12.1 to 20.0	0.40	0.45	0.50	-
20.1 to 25.0	0.45	0.50	0.55	0.65
25.1 to 38.0	0.50	0.55	0.65	0.75
38.1 to 50.0	0.60	0.70	0.80	0.90
50.1 to 100.0	0.80	0.90	1.20	1.50
100.1 to 150.0	1.10	1.30	1.70	2.00
150.1 to 200.0	1.50	1.60	2.10	2.50
200.1 to 250.0	1.70	1.90	2.70	3.00

Notes:

1. Tolerance on either internal or external gap (between flanges or legs) can be guaranteed depending on requirements.
2. Width tolerance at closed ends are given in Table – 10.
3. These tolerances are applicable to channels, I-Beam and other such sections where there are both opened and closed ends.



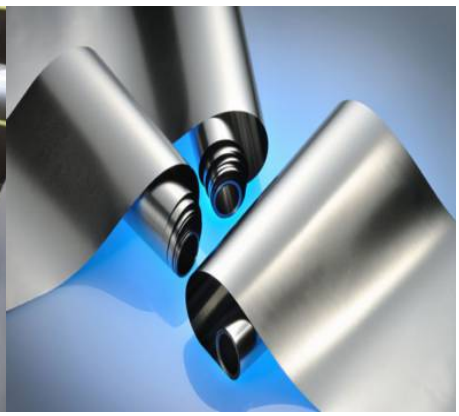


TABLE 12
Solid sections : Thickness tolerance

Specified** Thickness mm	Width of Section (mm)														
	12	16	20	25	32	40	50	63	80	100	125	160	200	250	320
1.2	0.20	0.20	0.20	0.20	0.20	*	*	*	*	*	*	*	*	*	*
1.6	0.18	0.20	0.20	0.20	0.20	*	*	*	*	*	*	*	*	*	*
2.0	0.18	0.20	0.20	0.20	0.20	0.23	0.25	0.28	0.30	0.33	0.36	0.38	0.41	0.46	*
2.5	0.18	0.20	0.20	0.20	0.20	0.23	0.25	0.28	0.30	0.33	0.36	0.38	0.41	0.46	*
3.2	0.18	0.20	0.20	0.20	0.23	0.25	0.28	0.30	0.33	0.36	0.38	0.41	0.43	0.48	*
4.0	0.20	0.23	0.23	0.23	0.25	0.28	0.30	0.33	0.36	0.38	0.43	0.43	0.46	0.51	*
5.0	0.20	0.23	0.23	0.23	0.25	0.28	0.30	0.33	0.36	0.38	0.41	0.43	0.46	0.51	*
6.0	0.20	0.23	0.23	0.23	0.25	0.28	0.30	0.33	0.36	0.41	0.46	0.51	0.56	0.66	*
8.0	0.23	0.25	0.25	0.25	0.28	0.30	0.33	0.36	0.38	0.43	0.48	0.53	0.58	0.71	*
10.0	0.23	0.25	0.25	0.25	0.28	0.30	0.33	0.36	0.38	0.43	0.48	0.53	0.58	0.71	*
12.0	0.25	0.28	0.28	0.28	0.30	0.33	0.36	0.38	0.41	0.46	0.48	0.53	0.58	0.74	0.97
16.0	0.28	0.30	0.30	0.30	0.33	0.36	0.38	0.41	0.43	0.48	0.51	0.56	0.61	0.76	1.02
20.0	-	0.30	0.30	0.30	0.36	0.38	0.41	0.43	0.46	0.51	0.53	0.61	0.69	0.79	1.04
25.0	-	0.30	0.30	0.30	0.36	0.38	0.41	0.43	0.46	0.51	0.53	0.61	0.69	0.79	1.04
32.0	-	-	-	-	0.38	0.41	0.43	0.46	0.48	0.53	0.56	0.66	0.74	-	-
40.0	-	-	-	-	-	0.46	0.48	0.51	0.53	0.56	0.61	0.71	0.79	-	-
50.0	-	-	-	-	-	-	0.53	0.56	0.58	0.61	0.66	0.76	0.84	-	-
63.0	-	-	-	-	-	-	-	0.61	0.64	0.66	0.71	0.81	0.89	-	-
80.0	-	-	-	-	-	-	-	-	0.69	0.71	0.74	0.86	0.94	-	-
100.0	-	-	-	-	-	-	-	-	-	0.76	0.79	0.91	0.99	-	-
125.0	-	-	-	-	-	-	-	-	-	-	0.89	0.97	1.04	-	-

* To be regarded as special sections.
** For intermediate size, take tolerance for the next higher value.

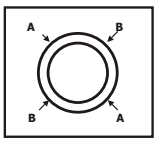
TABLE - 13
Round Tubes : Wall Thickness Tolerance

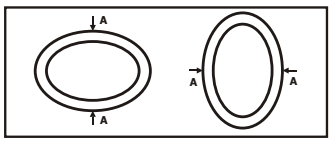
Specified Wall Thickness (mm)	Tolerance (mm)	
	Class 1 ±	Class 2 ±
Upto 1.2	0.30	-
1.60	0.30	-
1.80	0.30	-
2.00	0.30	-
2.24	0.30	-
2.50	0.33	-
2.80	0.36	-
3.15	0.40	0.90
3.55	0.43	0.94
4.00	0.48	0.97
4.50	0.51	1.02
5.00	0.56	1.07
5.50	0.61	1.12
6.30	0.67	1.18
7.10	0.76	1.27
8.00	0.97	1.47
9.00	1.10	1.60
10.00	1.22	1.73
11.20	1.28	1.79
12.50	1.35	1.85

Notes :
1. Tubes with wall thickness intermediate between standard sizes will have the tolerance of the next higher wall thickness.
2. Tolerance on standard wall thickness above 12.50 mm may be as agreed to between the purchaser and the supplier.
3. For Al-Zn-Mg, Al-Mg and Al-Cu alloys, class 2 tolerances shall apply.
4. For Al, Al-Mn and Al-Mg-Si alloys, class 1 tolerances

TABLE - 14

Round Tubes : Diameter Tolerance





Specified Diameter Outside or Inside mm	Allowable Deviation of Mean Diameter 1/2 (AA+BB) from Specified Diameter (Dia. Tolerance) mm ±	Allowable Deviation of Diameter at any point From Specified Diameter (Ovalness Tolerance) mm ±
From 9 upto 18	0.25	0.50
Over 18 upto 30	0.30	0.60
Over 30 upto 40	0.36	0.80
Over 40 upto 50	0.45	0.90
Over 50 upto 60	0.54	1.00
Over 60 upto 80	0.60	1.30
Over 80	1% of dia	2.5% of dia

Notes :

1. When outside diameter, inside diameter and wall thickness are all specified, standard tolerances are applicable to any two of these dimensions, but not to all three.
2. Mean diameter is the average of two diameter measurement taken at right angles to each other at any point along the length. In other words, mean diameter is ½ (AA + BB).
3. Ovalness tolerance is not applicable for annealed temper or if the wall thickness is less than 2.5% of the outside diameter.

TABLE 15

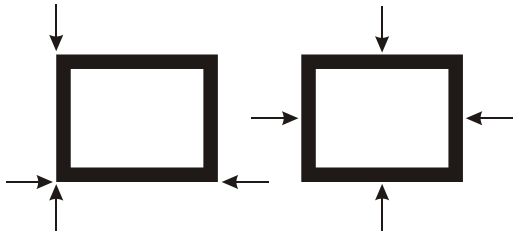
Hollow Sections: Wall Thickness Tolerance

		Width or overall dimensions (mm)													
Wall Thickness mm		Over 10.0 Upto 20.0	20.0 33.0	30.0 40.0	40.0 50.0	50.0 60.0	60.0 80.0	80.0 100.0	100.0 120.0	120.0 140.0	140.0 160.0	160.0 180.0	180.0 200.0	200.0 225.0	225.0 250.0
Class B															
Over	**Upto**														
1.0	1.5	0.28	0.28	0.28	0.30	-	-	-	-	-	-	-	-	-	-
1.5	2.0	0.30	0.33	0.33	0.36	-	-	-	-	-	-	-	-	-	-
2.0	2.5	0.33	0.33	0.36	0.38	0.43	0.46	-	-	-	-	-	-	-	-
2.5	3.0	0.41	0.43	0.46	0.48	0.51	0.53	0.56	-	-	-	-	-	-	-
3.0	4.0	0.53	0.56	0.58	0.61	0.64	0.66	0.69	0.71	0.74	-	-	-	-	-
4.0	5.0	-	0.71	0.74	0.76	0.79	0.81	0.84	0.86	0.89	0.91	0.94	1.02	-	-
5.0	6.0	-	-	0.97	0.99	1.02	1.04	1.07	1.09	1.12	1.14	1.17	1.19	1.22	1.24
6.0	8.0	-	-	-	1.22	1.24	1.27	1.30	1.32	1.35	1.37	1.40	1.42	1.45	1.47
8.0	10.0	-	-	-	-	1.47	1.50	1.52	1.55	1.57	1.60	1.63	1.65	1.68	1.70
10.0	12.0	-	-	-	-	1.73	1.75	1.78	1.8	1.83	1.85	1.88	1.90	1.93	1.96
12.0	16.0	-	-	-	-	-	1.98	2.00	2.03	2.06	2.08	2.11	2.13	2.16	2.18
16.0	20.0	-	-	-	-	-	-	2.24	2.26	2.29	2.31	2.34	2.36	2.39	2.41
20.0	25.0	-	-	-	-	-	-	2.49	2.51	2.54	2.57	2.59	2.62	2.64	2.67
Class A															
1.5	2.0	0.28	0.30	0.30	0.33	-	-	-	-	-	-	-	-	-	-
2.0	2.5	0.30	0.30	0.33	0.36	0.41	0.43	-	-	-	-	-	-	-	-
2.5	3.0	0.30	0.30	0.36	0.38	0.43	0.46	0.51	-	-	-	-	-	-	-
3.0	4.0	0.33	0.36	0.38	0.41	0.46	0.51	0.56	0.61	0.69	-	-	-	-	-
4.0	5.0	-	0.41	0.43	0.46	0.51	0.56	0.61	0.69	0.76	0.84	0.91	0.99	-	-
5.0	6.0	-	-	0.46	0.51	0.56	0.61	0.69	0.76	0.84	0.91	0.99	1.07	-	-
6.0	8.0	-	-	-	0.56	0.61	0.69	0.76	0.84	0.91	0.99	1.07	1.14	-	-
8.0	10.0	-	-	-		0.69	0.76	0.84	0.91	0.99	1.07	1.14	1.22	-	-
10.0	12.0	-	-	-	-	0.76	0.84	0.91	0.99	1.07	1.14	1.22	1.30	-	-
12.0	16.0	-	-	-	-	-	0.91	0.99	1.07	1.14	1.22	1.30	1.37	-	-
16.0	20.0	-	-	-	-	-	-	1.07	1.14	1.22	1.30	1.37	1.45	-	-

Notes:

1. These tolerances are applicable to hollow sections other than round tubes.
2. For non-heat-treatable alloys, these tolerances are applicable when wall thickness of the section is at least 1.5 mm or 1/32 of overall width, whichever is greater. For heat-treated alloys , these tolerances are applicable when wall thickness is at least 1.5 mm or 1/24 of overall width, whichever is greater.
3. Unless otherwise specified, class B tolerances will be applicable.
4. For high- magnesium non-heat-treatable alloys (5052, 5056, 5083, 5086), an extra tolerance of 50% shall be allowed.

TABLE 16
Hollow Sections: Width Tolerance

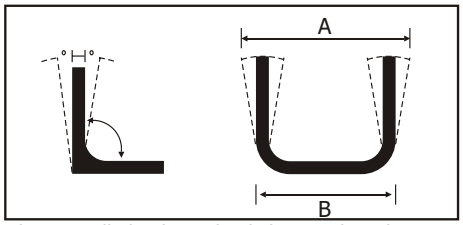


Specified Width or Width across flats (mm)		Width tolerance ± when measured at corners	Width tolerance ± when measured at centre
Over	**Upto**		
10.0	20.0	0.30	0.46
20.0	30.0	0.38	0.55
30.0	40.0	0.45	0.65
40.0	50.0	0.52	0.80
50.0	60.0	0.60	1.00
60.0	80.0	0.70	1.20
80.0	100.0	0.80	1.40
100.0	120.0	0.89	1.65
120.0	140.0	1.02	1.90
140.0	160.0	1.14	2.20
160.0	180.0	1.27	2.45
180.0	200.0	1.40	2.70

Notes:

1. These tolerances are applicable to hollow sections other than round tubes.
2. For non-heat-treatable alloys, these tolerances are applicable when wall thickness of the section is at least 1.5 mm or 1/32 of overall width, whichever is greater. For heat-treated alloys , these tolerances are applicable when wall thickness is at least 1.5 mm or 1/24 of overall width, whichever is greater.
3. For high-magnesium non-heat-treatable alloys (5052, 5056, 5083, 5086), an extra tolerance of 50% shall be allowed.

TABLE 17
Solid & Hollow Sections: Angularity Tolerance



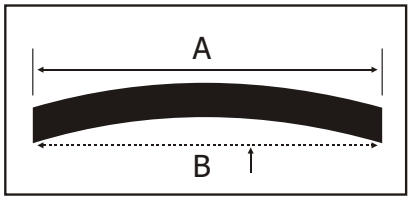
Displacement of any one leg to be controlled independently by angular tplerances

Specified thickness of thinnest leg mm	Allowable deviation from specified angle degree±
Upto 5.0	2.0
Over 5.0 upto 19.0	1.5
Over 19.0	1.0

Notes :
Angles should be measured at the extremities of the section. If the cases of the sections are convex, the angle should be measured by balancing the arms of the protractor at the middle of the section.

TABLE 18

Solid & Hollow Sections: Flatness Tolerance



Width of section (mm) A		Tolerance B
Over	Upto & including	±mm
-	25	0.18
25	38	0.25
38	50	0.30
50	-	0.30 plus 0.13 mm for every 25 mm of width (see ex.below)

Example : The tolerances for a solid section of 150 mm width shall be as follows:

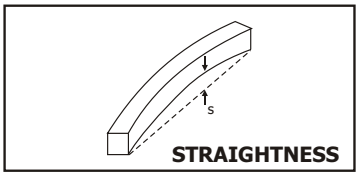
$\pm(0.30 + 0.13 \times \frac{150}{25}) = (0.30 \pm 0.13 \times 6) = \pm 1.08$ mm

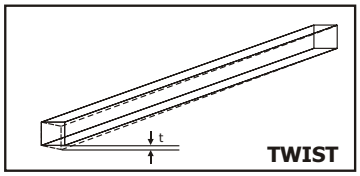
Notes :

1. Flatness tolerance is measure of concavity or convexity.
2. While measuring convexity, the straight edge shall be balanced at the middle of the section.

TABLE 19

Solid & Hollow Section: Twist & Straightness Tolerance





Diameter of circumscribing circle mm	Allowable deviation from straightness mm per metre or length
Upto & including 25.0	2.1
Over 25.0	1.7

Notes :

1. Tolerance values are same for straightness and twist.
2. Twist is normally measured by placing the extruded section on a flat surface and measuring the maximum distance at any point along its length between the bottom surface of the section and the flat surface. From this measurement, the deviation from true straightness of the section is subtracted. The reminder is the twist. To convert the standard twist tolerance to an equivalent inner value, the tangent of the standard tolerance is multiplied by the width of the surface of the section that is one of the flat surface.

TABLE 20

Solid & Hollow Section: Cut Length Tolerance

Width or diameter mm	Length tolerance mm ±
Upto 50.0	6
50.1 to 100.0	8
100.1 to 150.0	10
150.1 and above	12