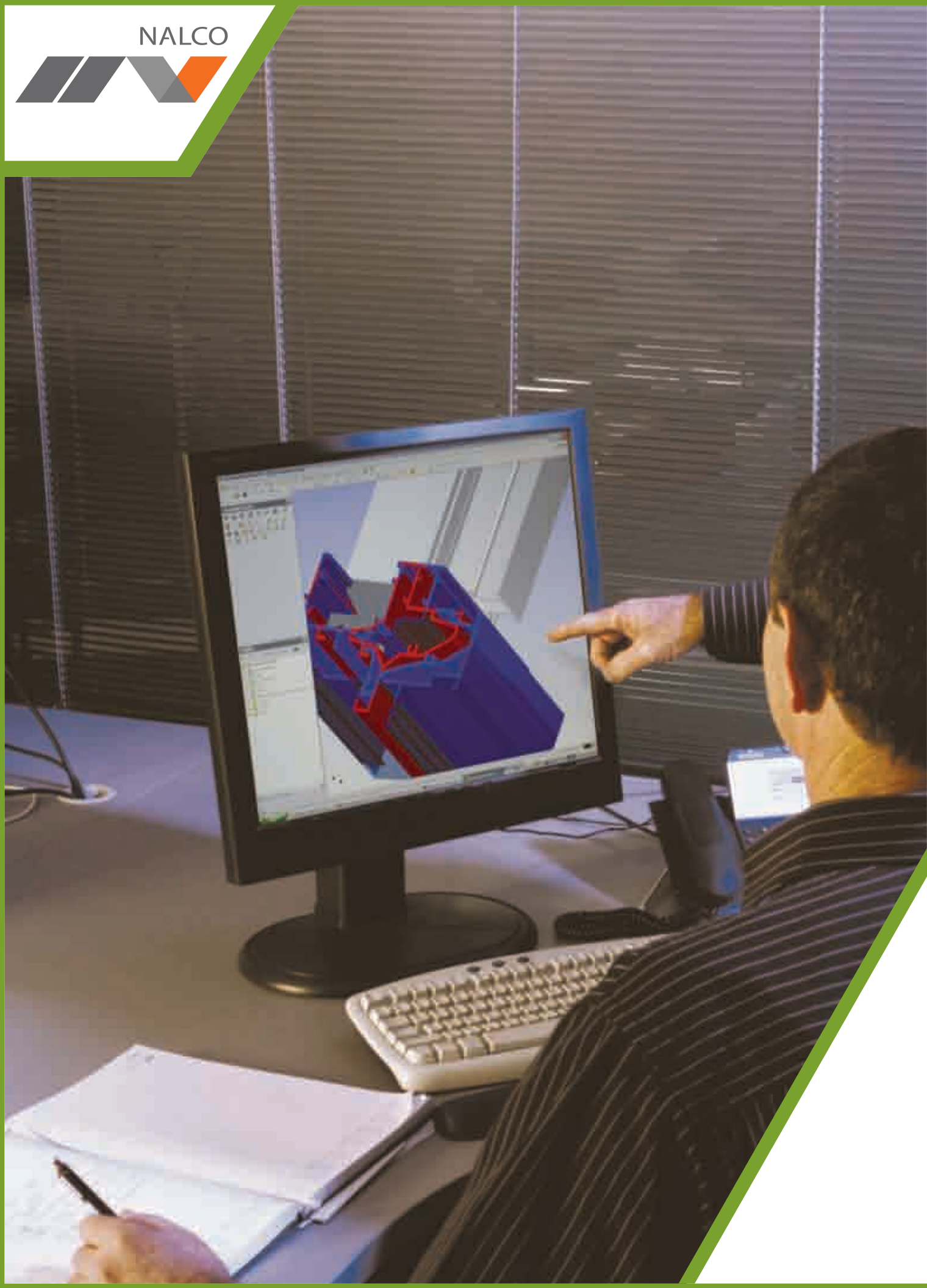
NALCO

technical

information

Aluminium Solutions

NALCO



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Welcome to NALCO

At NALCO, our company vision is creating 'a better world for our customers'. We're a truly customer-driven organization that delivers innovative aluminium solutions, tailored to our clients' specific needs across an extensive range of markets and industries.

NALCO's aluminium features in a hugely diverse range of applications - ranging from; architectural products, windows and doors, truck bodies or ship-building; to small electronic components, medical products and LED lighting.

Innovation plays an important role in our business. We're constantly evolving our technology, developing patented new products and leading industry best-practice - whether we're expanding our export markets, achieving the top level of workplace health & safety accreditation, or launching NZ's first online aluminium store. In recent years, we were proud to win the Supreme Award at the prestigious Manukau Business Awards.

We're fortunate to have many of New Zealand's most talented and experienced aluminium industry professionals within our team. Their expertise and enthusiasm is evident in all areas of our business - from R&D and design, to operations, customer support and sales.

If you'd like to know what aluminium can do for your business, we invite you to talk with us today.

Ron Holden

Managing Director
National Aluminium Ltd (NALCO)

NALCO is an award winning New Zealand designer, manufacturer and exporter of aluminium extrusions and extrusion-based building systems. We also import and distribute rolled and specialty extruded product for both local and overseas markets.

Our core business is providing a range of aluminium products and services to industry and servicing the building sector with leading proprietary windows and door systems. NALCO supports this through a capable team responsible for research and design, technical sales support, marketing and distribution.

Our operation network

At the heart of NALCO's manufacturing operations is our extrusion plant and powder coating lines, based in Hamilton. This plant supplies product to local manufacturing and export customers along with our extensive window and door fabricator network.

- NALCO Aluminium Solutions service customers via three Aluminium Branches located in Auckland, Hamilton, Christchurch and a National Distribution Centre. Our Branches stock and supply the widest range of sheet, plate, treadplate, coil and extruded aluminium profiles, along with custom design and extrude to order services.
- For the convenience of our customers, NALCO has launched the country's first online aluminium store, where orders can be place online 24/7, www.nalcoshop.co.nz
- NALCO Building Products has grown to become an industry leader, supplying the architectural windows and doors industry with a range of products, marketed under the brand names Bradnams and Nulook. The company-owned Bradnams operation has five branches nationwide; while there are 50 licensed fabricators for our well-known Nulook brand.

NALCO

- Extruders of aluminium profiles
- Die Design
- Stockists of extrusion, sheet, plate and coil
- Designers of patented windows and doors systems
- Aluminium Light Fabrication
- Powder Coating, Anodising

Aluminium Solutions

3 NALCO Branches and National Distribution Centre

- Building and Construction
- Marine
- Metal Fabrication
- Road & Transport Industry
- General Manufacturing
- Appliance Manufacturers

Building Products

5 Bradnam's Branches Nationwide

50 Nulook Fabricators Nationwide

- Group Housing and Targeted Commercial Markets
- Architectural, Residential and Commercial Markets

Extrusion Products and Services

NALCO has a reputation for high-quality extrusion and manufacture of aluminium profiles, from basic shapes to intricate complex designs.

Our stocked range of profiles include: Angles, Channels, Rod & Bar, Tubes & Hollows, Tee's, I-Beam's, Transport Sections, Insect & Security Screens, and Architectural Profiles.

We also offer made-to-order services for custom designs and large mill run orders. Our team can provide a total solution - from design, alloy selection and technical support.

Our extrusion operation is supported by:

Die Design

Our experienced Die Drawing Team assists companies with die design and modification, to ensure quality-consistent results and improved Mill performance.

Aluminium Light Fabrication (ALF)

NALCO's Aluminium Light Fabrication operation can provide cutting, drilling and punching of extrusion to meet special tolerances.

Surface Finishing

Powder Coating

NALCO's powder coating facility operates under Australian / New Zealand Standards AS/NZS3715 for powder coating applications; and is an approved Q base, EnduroColour, Gold Akzo Nobel and Orica applicator.

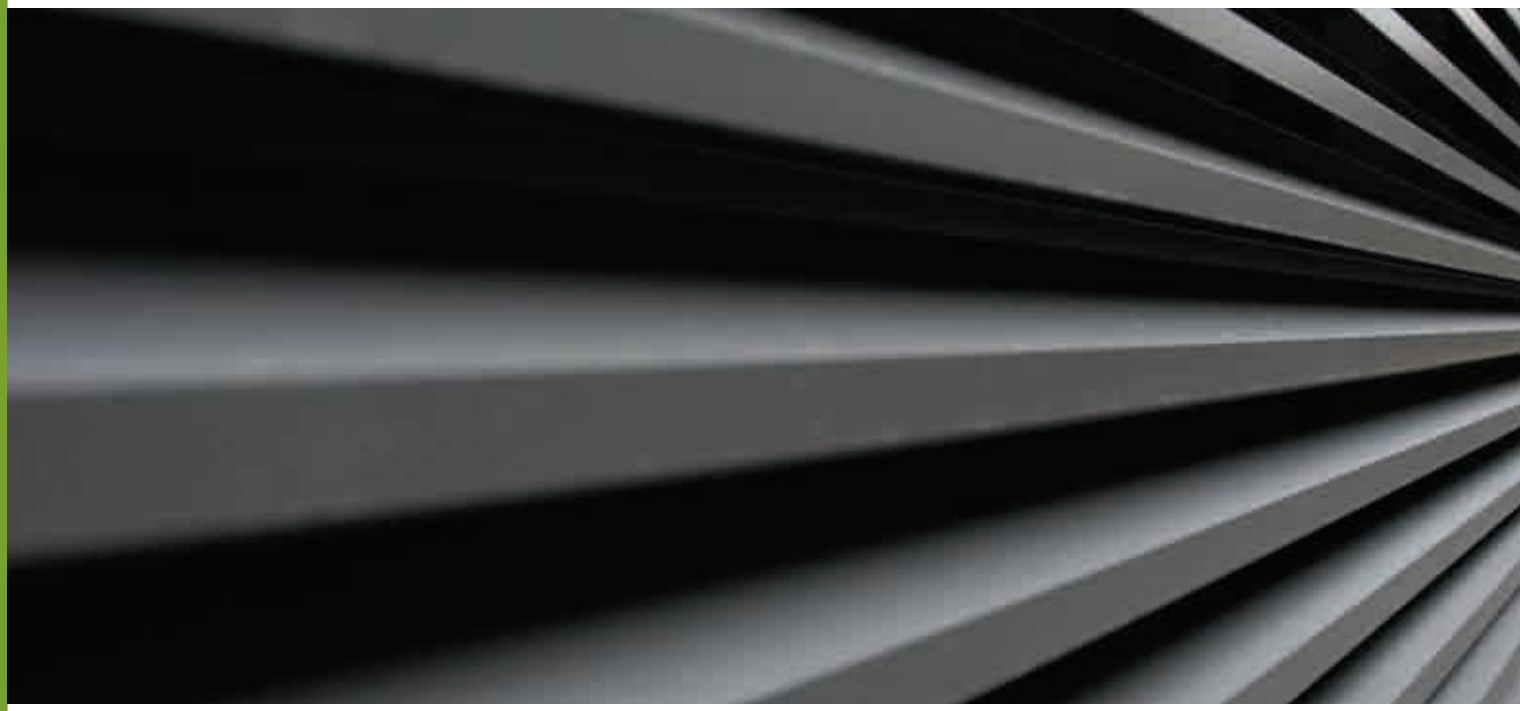
Anodising

NALCO offer anodising on mill run orders available in 12, 20 & 25 micron.

Anodising comes in Bronze, Silver and Black as defined by the WANZ Standards.

Anodising finishes are all produced to meet the Window Association of New Zealand (WANZ) standards.

NALCO



Rolled Products and Services

NALCO stock and supply one of the widest range of aluminium sheet, plate, and coil in New Zealand.

Our stocked range of products include:

- Coil
- Flat Sheet
- Heavy Gauge Flat Sheet
- Treadplate
- Stucco
- Plate

Indent Solutions

NALCO also offers indent solutions for specialist aluminium materials and special alloys. Through our extensive international trading contacts, we can procure products from major European, Asian and American manufacturers.

Cutting Services

NALCO offers a range of cutting services - providing you with products that are easier to handle, reduce waste, and speed up your manufacturing process.

CNC Router:

NALCO can profile-cut your sheet and extrusion, offering advantages in speed and precision over alternative cutting methods.

Plate and Band Saw:

NALCO have a number of saws available to cut Plate and Bar at East Tamaki, up to 300mm thick.

Export Services

NALCO's Export team provide tailored product and service solutions to customers throughout the Pacific and Australasia.

NALCO Exports offer;

- Private die extrusions
- Standard extrusion, plate and rolled products
- Residential and commercial window and door systems
- Hardware and components
- Cutting services and surface finishing

Foreword

1. Synopsis

The stocked product catalogue gives metric data for rolled and extruded products that are available from stock. The Mill product catalogue gives metric data for extruded products that are available from the Mill in standard production quantities. The Technical catalogue provides detailed technical information on the properties of aluminium and its use.

2. Special Alloys and Products

NALCO have supply partnerships with major European, Asian and American manufacturers and distributors. We can usually provide a solution to enquiries for hard to find aluminium materials.

Enquiries should be directed to your Account Manager or freephone 0800 77 77 44.

3. Range

The range of extrusions available is constantly changing, enquiries for shapes not listed may be made by contacting your Account Manager or freephone 0800 77 77 44.

4. Shape

All dimensions are in millimetres. Major dimensions only are shown. Fully dimensioned drawings are available on request via your Account Manager or freephone 0800 77 77 44.

5. Weight

Extrusion weights are in kg/m.

6. Price

Prices may be obtained on enquiry to any NALCO Aluminium Centre.

Aluminium Properties

A unique combination of properties makes aluminium and its alloys one of the most versatile engineering and construction materials available today.

Lightweight

Aluminium is one of the lightest available commercial metals with a density approximately one third that of steel or copper.

Its high strength to weight ratio makes it particularly important to transportation industries allowing increased payloads and fuel savings. Catamaran ferries, petroleum tankers and aircraft are good examples of aluminium's use in transport.

Excellent Corrosion Resistance

Aluminium has excellent resistance to corrosion due to the thin layer of aluminium oxide that forms on the surface of aluminium when it is exposed to air.

In many applications, aluminium can be left in the mill finished condition. Should additional protection or decorative finishes be required, then aluminium can be either anodised or painted.

Strong

Although tensile strength of pure aluminium is not high, mechanical properties can be markedly increased by the addition of alloying elements and tempering. You can choose the alloy with the most suitable characteristics for your application. Typical alloying elements are manganese, silicon, copper and magnesium.

Strong at Low Temperatures

Where as steel becomes brittle at low temperatures, aluminium increases in tensile strength and retains excellent toughness.

Easy to Work

Aluminium can be easily fabricated into various forms such as foil, sheets, geometric shapes, rod, tube and wire. It also displays excellent machinability and plasticity ideal for bending, cutting, spinning, roll forming, hammering, forging and drawing.

Aluminium can be turned, milled or bored readily, using the correct toolage. In fact, most aluminium alloys can be machined speedily and easily. An important factor contributing to the low cost of finished aluminium parts.

Aluminium is a popular choice of material for complex-sectioned hollow extrusions. Almost any method of joining is applicable - riveting, welding, brazing or soldering. A wide variety of mechanical aluminum fasteners simplifies the assembly of many products.

Adhesive bonding of aluminium parts is successfully employed in many applications including aircraft components, car bodies and some building applications.

Good Heat Conductor

Aluminium is about three times as thermally-conductive as steel. This characteristic is important in heat-exchange applications (whether heating or cooling).

Aluminium is used extensively in cooking utensils, air conditioning, industrial heat exchangers and automotive parts.

High Reflectivity

Aluminium is an excellent reflector of radiant energy through the entire range of wave lengths. From ultra-violet through the visible spectrum to infra-red and heat waves, as well as electromagnetic waves such as radio and radar.

Aluminium has a light reflectivity of over 80% which has led to its wide use in lighting fixtures. These reflectivity characteristics also lead to its use as an insulating material. For example, aluminium roofing reflects a high percentage of the sun's heat, promoting a cool interior atmosphere in summer, yet insulating against heat loss in winter.

Good Electrical Conductor

Aluminium is one of the two common metals having electrical conductivity high enough for use as an electrical conductor. The conductivity of electrical-conductor grade (alloy 1350) is about 62% that of the International Annealed Copper Standard.

However, aluminium is only a third the weight of copper, which means it conducts about twice as much electricity as copper of the same weight.

Aluminium is widely utilised in power-transmission cables, transformers, busbars and bases of electrical bulbs.

Easy Surface Treatment

For many applications, aluminium requires no protective or decorative coating; the surface supplied is entirely adequate without further finishing. Mechanical finishes such as polishing, embossing, sand blasting, or wire brushing meet a variety of needs.

Where the plain aluminium surface does not suffice, a wide variety of surface finishes are available to suit. Chemical, electrochemical and paint finishes are all used.

Above all, anodising treatment can provide excellent corrosion resistance and a wide range of colour variations. Such finishes are widely used for both interior and exterior applications.

advantages of aluminium continued...

Non-magnetic

Aluminium has non-magnetic properties which make it useful for electrical shielding such as busbar or magnetic compass housings. Other applications include computer disks and parabolic antennas.

Non-toxic

The fact that aluminium is essentially non-toxic was discovered in the early days of the industry. It is this characteristic which enables the metal to be used in cooking utensils without any harmful effect on the body. Aluminium with its smooth surface is easily cleaned, promoting a hygienic environment for food processing. Aluminium foil wrapping and containers are used extensively and safely in direct contact with food products.

Easy to recycle

Due to a low melting temperature, it is economically recyclable, requiring only about 5% the energy required for smelting. It is an ideal material in this age of energy and resource saving.

Sound absorbing

Used for ceilings.

Shock absorbing

Due to its low modulus of elasticity, aluminium is used for automobile bumpers and the like.

Non-sparking

Aluminium is void of sparking properties against itself and other non-ferrous metals.

These are the characteristics that give aluminium its extreme versatility....

In the majority of applications, two or more of these characteristics come prominently into play;

For example, lightweight combined with strength in aircraft, railway rolling stock, trucks and other transportation equipment.

High resistance to corrosion and high thermal conductivity are important for the chemical and petroleum industries; these properties combine with non-toxicity for food processing equipment.

Attractive appearance together with high resistance to weathering and low maintenance requirements have led to extensive use in buildings of all types.

High reflectivity, excellent weathering characteristics, and light weight are all important in roofing materials.

Light weight contributes to low handling and shipping cost whatever the application.

Many applications require the extreme versatility which only aluminium possesses. Almost daily, unique combinations of these properties are being put to work in new ways.

Aluminum Water Stain Prevention

When You Receive Metal

1. Check for wetness

(a) Is the metal wet? Is the wrapping paper puckered up or wet?
(b) If it is wet, note it on all copies of the receiving papers (Endorse freight carrier documents as damaged)
(c) Unpack and dry, if stained contact your NALCO Account Manager

2. Check to see if the metal feels cold.
If it does:
(a) Tell your supervisor immediately
(b) Leave the metal in a cool indoor area away from drafts to allow it to warm up slowly
(If this is not adhered to, and metal is put in a heated warehouse immediately, it may sweat and become water stained)
(c) After the metal is reasonably warm (about a day later), move it to the warehouse

When You Move Metal Between Areas

Check to see if the temperature in the area the metal will be taken to is higher than the temperature in the area the metal is coming from.

If the difference is more than 11°C (20°F):

(a) Only move as much metal as will be used immediately
(b) Tell your supervisor
(c) Leave the remainder of the metal where it is until ready for use

Note:
If you experience any signs of moisture, dampness or water staining on your delivery, please call your local NALCO Aluminium Distribution Centre immediately.

A Guide to Galvanic Corrosion Effects Between Aluminium and Other Metals

Metal	Galvanic Corrosion Effect When Coupled With Aluminium or an Aluminium Alloy	
Gold, Platinum, Silver	Attack accelerated in most environments	These metals, and especially those at the top of the list, are generally cathodic to aluminium and its alloys, which are therefore preferentially attacked when corrosion occurs
Copper, Copper Alloys, Silver Solder	Attack accelerated in most atmospheres and under conditions of total immersion	
Solder Coatings on steel or copper	Attack accelerated at interface in severe or moderate atmospheres and under conditions of total immersion	
Nickel and Nickel Alloys	Attack accelerated in marine or industrial atmospheres and under conditions of total immersion, but not in mild environments	
Steel, Cast Iron	Attack accelerated in marine or industrial atmospheres and under conditions of total immersion, but not in mild environments	
Lead, Tin	Attack accelerated only in severe environments such as marine and some industrial	
Tin-Zinc Plating (80-20) on steel	Attack accelerated only in severe atmospheres and under conditions of total immersion	
Pure Aluminium and Aluminium Alloys not containing substantial amounts of copper or zinc	When aluminium is alloyed with appreciable amounts of copper it becomes more noble and when it is alloyed with appreciable amounts of zinc it becomes less noble. In marine or industrial atmospheres, or when totally immersed, an aluminium alloy suffers acclerated attack when in good electrical contact with another aluminium alloy that contains substantial amounts of copper, such as the alloys in the 2000 series	
Cadmium	No acceleration of attack on cadmium except in fairly severe atmospheres in contact with an aluminium alloy containing copper and under conditions of total immersion	These metals are generally anodic to aluminium and are attacked when corrosion occurs, thereby protecting the aluminium
Zinc and Zinc Alloys	Attack on zinc is accelerated in severe environments such as marine or industrial and under conditions of total immersion	
Magnesium and Magnesium Alloys	Attack on magnesium is accelerated in severe environment such as marine or industrial and under conditions of total immersion	Attack on aluminium may also be accelerated
Titanium	Little data available, but attack on aluminium is known to be accelerated in severe marine or industrial conditions and when immersed in seawater	These metals form inert protective film that tend to reduce galvanic reaction. Where attack occurs, the aluminium base material suffers
Stainless Steel (18-8, 18-8-2 and 13% Cr)	No acceleration of attack on aluminium in moderate atmospheres, but attack may be accelerated in severe marine or industrial atmosphers and under conditions of total immersion	
Chromium Plate	No acceleration of attack on aluminium when plating is not less than 0.0025mm thick, except in severe atmospheres	

The Electro-Chemical Series

BASE METAL

Magnesium
Zinc
Aluminium
Cadmium
Mild Steel
Cast Iron
Lead
Tin
Brasses
Copper
Bronzes
Monel Metal
Silver Solders (70% Ag 30% Cu)
Nickel
Stainless Steel (Type 304)
Silver
Titanium
Graphite
Gold

NOBLE METAL

Platinum

Pitting

Pitting is the localised form of corrosion that usually occurs at random in the form of small pits or craters (of roughly hemispherical shape). Pits usually become covered with a mound of corrosion product. The rate of penetration of a pit usually diminishes with time, and frequently the pitting can be tolerated if the wall thickness is adequate. The frequency and depth of pitting vary somewhat from one alloy to another. The depth of pitting is extremely small and the process is known as "weathering". The type and level of pollution will determine general appearance.

Regular maintenance and washing down of aluminium should prevent permanent discolouration from the effects of industrial pollutants. Anodised surfaces retain their original appearance for much longer periods when regular maintenance is provided.

Poultice Action

Poultice Action is a form of corrosion that takes place under moist conditions when porous materials such as asbestos, cloth, cork, paper, etc absorb water and act as a poultice. The corrosive action is the result of differences in oxygen concentration in the water in adjacent areas of the material. It may be increased by corrosive chemicals extracted from the material.

Exposure

Aluminium and its alloys have excellent durability and corrosion resistance, but, like most materials, their behaviour can be influenced by the way in which they are used.

Aluminium's natural affinity with oxygen results in the formation of a transparent oxide film when aluminium is exposed to air. This oxide film is generally 5 to 10mu thick, extremely hard, chemically stable, corrosion resistant and adheres strongly to the parent metal surface. If damaged in anyway, it will reform if enough oxygen is available. The film is removed to facilitate anodising or welding.

In anodising, a thicker, more controlled deposit of oxide film is added. In welding, the oxide film inhibits metal fusion.

Galvanic Corrosion

Takes place when dissimilar metals are coupled together in the presence of moisture. The severity of the corrosion depends largely on the circumstances in which the electrolytic couple formed producing a current flow from the less noble metal (anode) to the more noble metal (cathode) and resulting in corrosion of the less noble metal.

Galvanic corrosion may be prevented by insulating dissimilar metals from each other with an electrically inert, non-absorbent barrier.

This type of connection is used between the aluminium superstructure and steel decking on ships.

Simple Rules to Avoid Corrosion

Since the corrosion behaviour of alloyed aluminium is influenced by the physical conditions of the environment, contact with dissimilar metals and by the presence of crevices, the design of equipment made with aluminium can have an appreciable influence on the nature and rate of corrosion.

- Never use aluminium in anaerobic (no oxygen) conditions
- Seal all joints and bolt holes
- Eliminate corners and crevices which are difficult to clean
- Butt weld where possible
- Avoid dissimilar metal contact whenever possible

Contact With Material

Wood

- Dry wood has no reaction to aluminium
- Unseasoned/damp wood should be coated with an aluminium or bituminous paint
- Treated timber may require special consideration and referral to the supplier

Insulation

- Foam, felt, fire retardant may cause corrosion of aluminium if they become wet when in contact with it
- Protect the aluminium by using an inert barrier

Concrete

- No protection under perfectly dry conditions
- As these conditions are rare, all aluminium surfaces in direct contact with concrete should be coated with bituminous paint

Chemicals

- A direct chemical attack of aluminium only occurs to any great extent in strong acid of alkaline conditions
- In some cases the temperature may significantly alter the rate of chemical reaction or be a major factor in initiating chemical attack

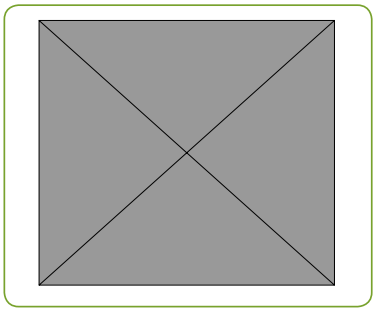
Press Brake Die Set Up

P = Inside Bend / Punch Tool Radii mm

D = Smallest Setting Side mm

V = Bottom Die V Gap Width mm

VR = Bottom Die V Shoulder Radii mm



Recommended Press Brake Die Set Up for Cold Forming of Sheet and Plate[1]

P	1.0	1.3	1.6	2.0	2.7	3.0	3.3	4.0	5.0	5.5	6.5	7.0
D	4.0	6.0	7.0	9.0	11.0	13.0	14.0	17.0	22.0	24.0	28.0	31.0
V	6.0	8.0	10.0	12.0	15.0	18.0	20.0	25.0	30.0	35.0	40.0	45.0
VR	0.8	1.0	1.3	1.6	2.2	2.4	2.6	3.2	3.9	4.2	4.9	5.3
P	8.0	10.0	11.0	13.0	16.0	19.0	21.0	23.0	24.5	26.0	28.0	32.0
D	35.0	42.0	47.0	56.0	70.0	80.0	90.0	100.0	105.0	11.0	130.0	140.0
V	50.0	60.0	70.0	80.0	100.0	120.0	130.0	140.0	150.0	160.0	180.0	200.0
VR	5.6	7.0	7.7	9.1	11.2	12.4	13.7	15.0	15.9	16.9	18.2	20.8

1. To select press brake tooling for a bending application refer to the Recommended Minimum Inside Bend Radii chart for the alloy and thickness of metal to be formed. Make sure the Bottom Die V Gap Width V is not less than that recommended above in conjunction with the Punch Tool Radii P.

Using a wider rather than narrower Bottom Die V Gap Width and tooling that is in good condition will reduce the risk of surface marking and cracking. Surface marking on the sheet from the Bottom Die V will indicate less than an optimal tooling configuration.

NALCO recomends that a test bend is made prior to fabrication. Most Press Brake tooling equiptment has been designed to bend steel rather than aluminium. Steel has more elongation than aluminium enabling it to be stretched further.

Further technical information can be obtained by contacting your NALCO Account Manager.

Bend Radii for 90 Degree Cold Forming

Recommended Minimum Inside Bend Radii for 90 Degree Cold Forming of Sheet and Plate, transverse to the rolling direction [1 2 3 4 5 6 7]

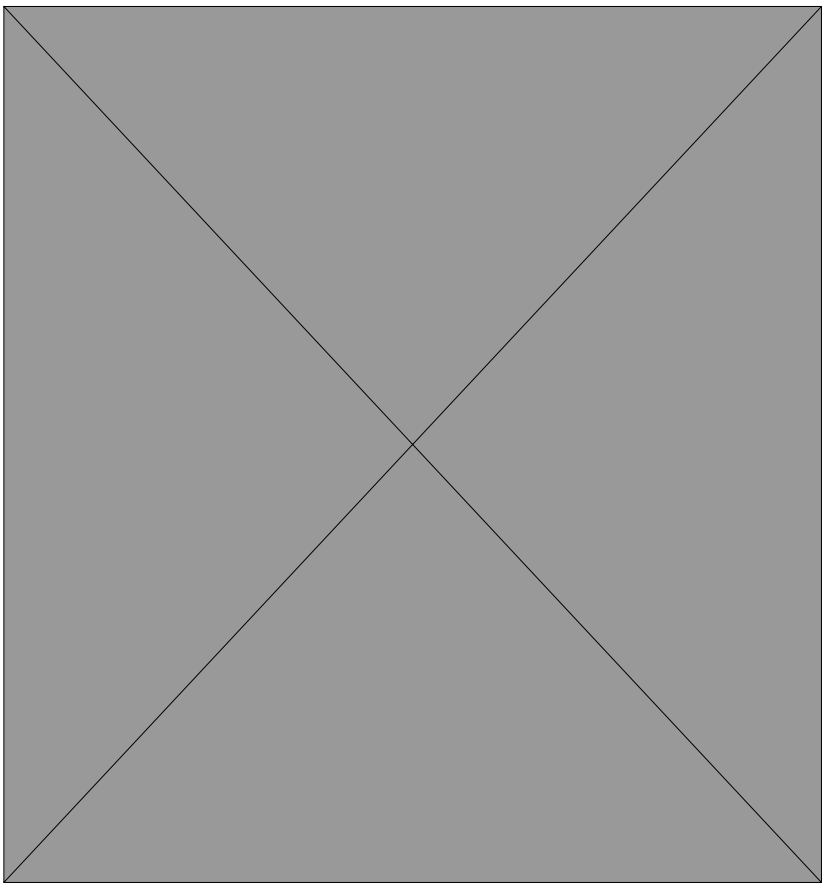
Alloys	Tempers	Radii for Various Thicknesses Expressed in Terms of Thickness t							
		0.4mm	0.8mm	1.6mm	3.0mm	4.0mm	6.0mm	10mm	12mm
1100 1200	-0	0	0	0	0	0	½	1	1 ½
	-H12	0	0	0	½	1	1	1 ½	2
	-H14	0	0	0	1	1	1½	2	2 ½
	-H16	0	½	1	1 ½				
	-H18	1	1 ½	2	3				
5005 [4]	-0	0	0	0	0	½	1	1	1 ½
	-H12	0	0	0	½	1	1	1 ½	2
	-H14	0	0	0	1	1	1 ½	2	2 ½
	-H16	½	1	1	1 ½				
	-H18	1	1 ½	2	3				
5052 [3 6] 5251	-0	0	0	0	½	1	1	1 ½	1 ½
	-H32	0	0	1	1 ½	1 ½	1 ½	1 ½	2
	-H34	0	1	1 ½	2	2	2 ½	2 ½	3
	-H36	1	1	1 ½	2 ½				
	-H38	1	1 ½	2½	3				
5454	-0	0	0	½	1	1	1	1 ½	1 ½
	-H32	0	½	1	1 ½	1 ½	2	2 ½	3 ½
	-H34	½	1	1 ½	2	2 ½	3	3 ½	4
5083 [5]	-0			½	1	1	1	1 ½	1 ½
	-H321		2	2	2	2 ¼	2 ½	3 ½	3½
	-H116			2	3	3 ½	4		
6061	-0	0	0	0	1	1	1	1½	2
	-T4	0	½	1	1 ½	2 ½	3	3 ½	4
	-T6	1	1	1 ½	2 ½	3	4	4 ½	5

1. The radii listed are the minimum recommended for bending sheets and plates without fracturing in a standard press brake with air bend dies. Other types of bending operations may require larger radii or permit smaller radii. The minimum permissible radii will also vary with the design and condition of tooling. Refer to the NALCO Recommended Press Brake Die Set Up Chart for more information.
2. Heat-treatable alloys can be formed over appreciably smaller radii immediately after solution heat treatment.
3. The H12 temper (applicable to non-heat treatable alloys) is supplied in the as-fabricated condition without special property control but usually can be formed over radii applicable to the H14 (or H34) temper.
4. Applicable to 5005 H1X and H3X tempers.
5. Use H116 bend radii if yield strength is over 255 MPa or elongation is less than 16%.
6. All recommended radii refer to bends made transverse to the rolling direction. A larger radii may be required in some materials for bends made longitudinal to the rolling direction.
7. Bend radii for tread plate in temper H112 or H114 should be based on the overall thickness (Including lozenge height) of the metal. Then use the bend radii recommended for H34.

Bending Aluminium

There are several types of forming machines suitable for bending aluminium sections. The choice depends upon the class of section, whether solid, open or hollow; the range of support tooling available; the alloy and temper. Tubing is by far the most commonly bent extruded product.

Bending may be carried out by four main methods:



The three roll bender has a central moveable roller which is gradually depressed until the desired radius is obtained.

The three point bender has a similar method of operation, the load being either applied gradually or impacted.

The roll and point methods of bending are usually applied to robust sections.

In both wrap and mandrel benders, it is possible to provide formers and other support tools which minimise the amount of buckling and enable tighter radii to be obtained.

The stretch former puts the section into tension and then, moving laterally, wraps it around a former. This method reduces the likelihood of compression failure.

Drawn tube should be specified where tight tolerances are required and where a higher level of mechanical property is necessary than is available in an extruded product. Drawn tube bends more consistently than extruded tube, again, due to the range in the mechanical properties.

Section bending is a specialist procedure and generally the soft tempers should be used, particularly for complex shapes.

Recommended Bending Radii for Round Tube

Recommended Minimum Inside Bending Radii (r) for Selected Sizes of Round Tube - Mandrel Bending

Tube Size		Radii for Various Alloys and Tempers (mm)					
Outside Diameter (mm)	Wall Thickness (mm)	1200-O 1350-O	6106-O, 6060-O 6063-O, 6061-O 6351-O	6106-T4, 6061-T4 6351-T4, 6063-T4	6060-T5 6063-T5 & T6 6101-T5 & T6 6106-T6	6005A-T6 6061-T6 6351-T6	6060-T81 6063-T81
10	1.0 1.6	12 10	15 13	16 14	18 16	20 18	18 16
12	1.0 1.6	16 12	16 15	18 17	22 20	25 23	28 26
16	1.0 1.6	19 17	22 20	30 23	32 26	35 32	38 32
20	1.0 1.6	25 22	28 25	38 32	40 32	50 40	60 40
25	1.2 1.6 3.0	38 35 30	45 45 42	50 46 40	56 50 45	62 56 52	70 65 50
28	1.2 1.6 3.0	45 42 34	54 50 40	60 54 42	68 58 45	84 64 50	98 75 50
32	1.2 2.0 3.0	54 42 38	62 48 42	80 54 46	80 60 52	100 80 60	110 80 70
40	1.6 2.0 3.0	64 56 48	72 64 54	90 80 60	95 80 70	120 100 80	140 110 85
50	1.6 2.0 3.0 4.0	90 84 70 68	112 98 80 70	125 110 95 80	140 126 110 90	175 150 125 120	220 190 150 140
60	2.0 3.0 4.0 6.0	110 100 85 70	120 105 90 80	150 120 100 90	170 130 120 100	220 180 150 130	260 220 190 150
80	2.0 3.0 4.0 6.0	165 140 135 120	190 170 150 130	220 185 160 140	240 200 180 160	340 250 220 200	400 320 280 250

It is recommended that a test bend is carried out before a final selection is made.

Mechanical Property Limits - Rolled

Tensile Strength (MPa)							
Alloy & Temper	Thickness (mm)		Ultimate		Yeild		Elongation % min. in 50mm
	Over	Up to	Min	Max	Min	Max	
5005 H12	0.4	0.63	125	165	95		2
	0.63	1.20	125	165	95		4
	1.20	6.30	125	165	95		6
5005 H34	0.3	0.8	137	180	105		3
	0.8	1.3	137	180	105		4
	1.3	3.0	137	180	105		5
	3.0	4.0	137	180	105		6
	4.0	6.0	137	180	105		7
5052 H32	0.5	1.3	213	263	158		5
	1.3	3.0	213	263	158		7
	3.0	6.0	213	263	158		9
	6.0	12.0	213	263	158		11
5052 H34	0.5	1.3	234	283	179		4
	1.3	3.0	234	283	179		6
	3.0	6.0	234	283	179		7
	6.0	12.0	234	283	179		8
5052 H36	0.2	0.8	255	304	199		3
	0.8	4.0	255	304	199		4
5052 H38	0.63	3.20	270		220		4
5083 H321	5.0	40.0	303	387	213	297	10
5083 H112	6.30	12.50	275		125		12
	12.50	40.0	275		125		10
	40.0	80.0	270		115		10
5083 H116	3.0	30.0	305		215		10
6061 T651	12.5	40.0	290		240		8
	40.0	80.0	290		240		6
	80.0	100.0	290		240		5
	100.0	150.0	275		240		5
	150.0	175.0	265		230		4

These are the minimum mechanical properties for the alloys listed. (Data obtained from AA and ADC)

Mechanical Property Limits – Extruded

Tensile Strength (MPa)							
Alloy & Temper	Thickness (mm)		Ultimate		Yeild		Elongation % min. in 50mm
	Over	Up to	Min	Max	Min	Max	5005 5050A
6060 T5		12.0	150		110		8
	12.0	25.0	145		105		6
6063 T5		12.0	151		110		8
	12.0	25.0	144		103		6
6063 T6		25.0	205		170		8
	25.0	150.0	185		160		10
6106 T6		10.0	235		210		8
	10.0	25.0	205		170		8
	25.0	150.0	185		160		10
6261 T5 or T6		All	295		255		7
6061 T6		All	262		241		8
6061 T6511	175	All	260		240		10
6082 T6511	5.0	150	310		260		8

These are the minimum mechanical properties for the alloys listed. (Data obtained from AA and ADC)

welding aluminium

Welding uses an intense heat source to cause localised melting and fusion of the parent metal of the joint. Filler metal may or may not be used.

A wide variety of processes are used to weld aluminium, some common, others highly specialised.

Arc Welding

- T.I.G. (Tungsten Inert Gas)
- M.I.G. (Metal Inert Gas)
- Pulse Arc (lower than normal currents)
- Stud (attaching studs and fasteners to metal)
- Atomic Hydrogen (intense heat - rare)
- Carbon Arc (rarely used)
- Metal Arc (not good quality - repairs)

Oxy-Gas Welding

- Standard oxy-fuel techniques (oxy acetylene/oxy hydrogen)

Resistance Welding

- Spot
- Seam
- Flash Butt
- Resistance Butt
- Projection
- Percussion

(Applicable to all aluminium alloys but more particularly to the heat-treatable alloys which are difficult to weld by the fusion process)

Specialised Welding

- Pressure
- Ultrasonic
- Friction
- Thermit
- Induction and resistance seam
- Electron Beam
- Laser Beam
- Plasma Arc

(All applicable to the joining of aluminium but very limited application)

Welding is a widely accepted method of joining aluminium and the techniques are well known in the engineering and manufacturing industries.

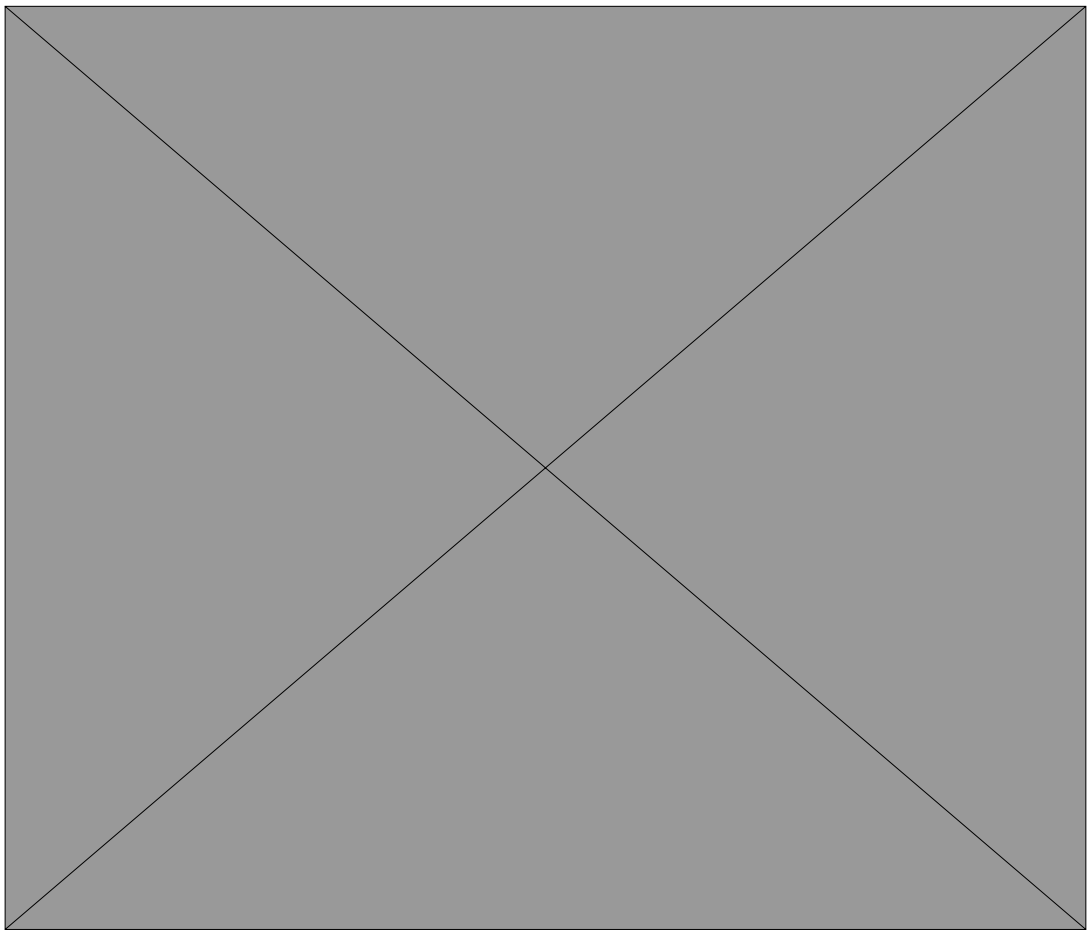
The most commonly used basic welding processes are tungsten inert gas (T.I.G.) and metal inert gas (M.I.G.). As the names suggest, both processes are inert-gas-shielded systems which shroud the weld area from the air to prevent reformation of oxide film.

Metal Thickness Capacity of TIG and MIG Welding Systems

Welding System	Thickness of Parent Metal (mm)		Welding Equipment
	min	max	
TIG	1.2	9.5 [1]	Composite unit (350A) with Transformer (350A), High Frequency or Surge Injector unit, Suppressor and Welding Torches
MIG 0.5kg	1.6	8.0 [2]	Composite unit (250A) with Wire Feed unit and Welding Gun for 0.5kg Spool
MIG 5kg	4.8	None	Composite unit (250A) with Wire Feed unit and Welding Gun for 5kg Spool

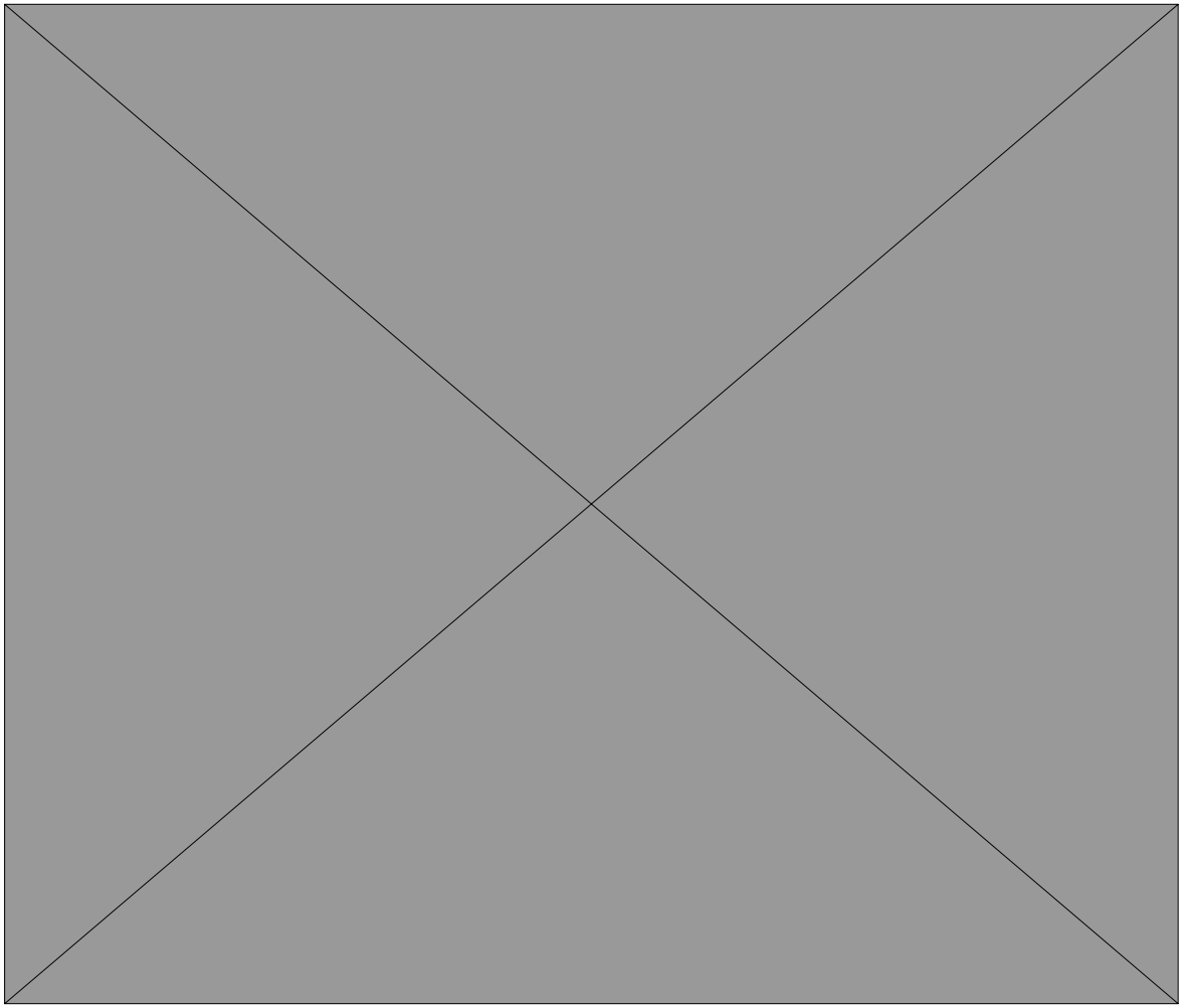
1. Although the TIG process can weld thicker material, it is not normally used for aluminium greater than 9.5mm in thickness for economic reasons.
2. In theory there is no upper limit to metal thickness for 0.5kg MIG, but it is more economical to use 5kg MIG for aluminium greater than 8.0mm in thickness.

A Typical TIG (GTAW) Welding System



Note: Composite TIG welding units include all the necessary auxiliaries. The argon and water shut off valves are usually controlled by solenoids, but may also be manually operated. The main power cable, fuse and torch can be air or water cooled.

A Typical MIG (GMAW) Welding System



1. The a.c. supply is 110v for 0.5kg MIG and 220v for 5kg MIG welding.
2. Composite MIG welding units have the contactor and control box built in.
3. The filler wire feed unit is integral with the gun in 0.5kg MIG and independent of it in 5kg MIG systems.
4. A voltage pick-up lead is required for 0.5kg MIG.
5. The main power cable and gun of 5kg MIG can be water cooled.
6. Arc voltage in MIG welding processes is measured with a voltmeter connected between the contact tube and the workpiece.

Preparation

Cleanliness and removal of the oxide film are most important. The proposed weld area must be degreased using methylated spirits, acetone, etc. Oxides, grease or oil films left on the edges to be joined will cause unsound welds and the mechanical efficiency of the weld will be adversely affected. The joint must be wiped dry.

After degreasing, the joint is cleaned with stainless steel wire brushes, or a chemical etch cleaner to remove the oxide film. Welding should be carried out as soon as possible.

The majority of T.I.G. and M.I.G. welding is done manually, however, they are ideal processes for mechanising. This leads to improvements in terms of increased welding speed, more consistent penetration, bead shape and general appearance and a greater degree of repeatability which is essential for volume production welding work.

The chief differences between the T.I.G. and M.I.G. processes are in the electrodes and the characteristics of the power used. In T.I.G. welding, the electrode is tungsten (non-consumable), which is used to maintain the arc; an appropriate aluminium filler material is added separately as required. Argon is fed to the torch through a flexible tube so that the whole of the arc and the weld pool are shrouded with argon, effectively preventing oxidation.

Conventional T.I.G. welding of aluminium is performed with AC current.
In M.I.G. welding, the electrode is aluminium filler wire fed continuously through the gun or torch from a reel into the weld pool as fast as it is consumed; the arc is struck between the tip of this wire and the metal being welded. For welding aluminium, the gas may be argon, helium, or a mixture of both, which is fed through the torch to provide a protective shroud. The current supply is DC (reverse polarity) with the electrode positive.

The choice of correct fill composition is of fundamental importance when fusion welding the various aluminium alloys. As well as the important consideration of corrosion resistance and the strength required of the weld, the filler metal must be compatible with the alloy to be welded. Weld cracking may result from using incorrect filler alloys.

The correct joint design is important to ensure adequate penetration. Backing strips should be used where feasible; the backing bar may be of steel, stainless steel, copper or aluminium.

For the T.I.G. process, the joint design and root openings required are determined by the thickness of the aluminium to be jointed and the structural requirements of the weldment.

For the M.I.G. process, the square butt joint is satisfactory up to 6mm. For thicker material either a single-vee or double-vee bevel may be necessary.

The four primary conditions which must be correct for a good weld are:

- Volts
- Amps
- Gas Flow
- Arc Travel Speed

Each job requires a particular set of welding conditions depending on the type and position of weld and the thickness of the metal.

Filler Wire

Alloys in the 5000 and 6000 series can be welded readily to a wide range of other aluminium alloys. The table that follows shows the preferred weld filler wire for such combinations of parent metals and, where appropriate, gives an alternative filler wire which can be used when the finished component is to be anodised and a close colour match is required between the weld area and the parent metal. Alloys in the 2000 series are not shown in the table since they are not recommended for fusion welding using the TIG and MIG processes.

Filler Metal Selection Chart for the Welding of Wrought Alloys[1,2]

The following table is extracted from "Successful Welding of Aluminium" published by WTIA (Welding Technology Institute of Australia) and should be used as a guide only.

First alloy subgroup	Second alloy subgroup						
	Itself (or same subgroup)	7005	6006[3] 6061 6082	5154A 5454	5083 5086	5052 5251	5005 5050A
1050[4]	1100[7]	5356[7]	4043	4043[9]	5356[7]	4043[9]	4043[9]
5005 5050A	4043[8,9]	5356[9]	4043[6]	5356[6]	5356[9]	4043[9]	4043[9]
5052 5251	5356[5,6,7]	5356[9]	5356[6,7]	5356[6]	5356[9]		
5083	5183[9]	5183[9]	5356[9]	5356[9]			
5086	5356[9]	5356[9]	5356[9]	5356[9]			
5154A 5383	5356[5,6,8] 5183[9]	5356[6] 5183[9]	5356[6,7] 5356[9]	5356[6] 5356[9]	5356[9]		
5454	5554[7,9,11]	5356[6]	5356[6,7]				
6060[3] 6061 6082	4043[6]	5356[6,7]					
7005	5356[9,10]						

1. Service conditions such as immersion in fresh or salt water, exposure to specific chemicals, or a sustained high temperature (over 65°C) may limit the choice of filler metals. Filler metals 5356, 5183, 5556 and 5654 are not recommended for sustained temperature service over 65°C.
2. Recommendations in the main body of this table are the preferred choice and apply for most applications.
3. Other alloys in this group include: 6005A, 6101, 6106 and 6261.
4. Other alloys in this group include: 1080A, 1150, 1350 and 3203.
5. 5654 filler is used for welding base metal alloys for low-temperature hydrogen peroxide service (less 65°C).
6. 5183, 5356, 5554, 5556 and 5654 may be used. 5554 is only 5xxx series filler alloy listed suitable for service temperature over 65°C.
7. 4043 may be used.
8. Filler metal with the same analysis as the base metal may be used.
9. 5183, 5356 or 5556 may be used.
10. 5039 is preferred but not readily available.
11. 5554 is only 5xxx series filler alloy listed suitable for service temperatures over 65°C.

understanding tolerances

What Tolerances Are

Every manufacturing process has limits of accuracy, imposed by technology or economics, which are routinely taken into account in design and production.

Most manufacturers and customers expect to provide, or receive, products whose dimensions are reliable within mutually acceptable deviation limits. Those limits are called tolerances, and a clear agreement on them at the time of ordering benefits both the extrusion supplier and the user. It protects the user by ensuring that the extruded product will be suitable for use and it protects the extruder from having products rejected by a customer with unreasonable expectations.

Where Tolerances Are Applied

The shape of an aluminium extruded product is described by specifying the dimensions of its cross-sectional profile on an engineering drawing, and by specifying the delivered length.

The allowed tolerances are usually expressed in plus-or-minus fractions or percentages of a dimension, applied to zones where the dimensions are to be held within these specified limits.

Unless otherwise specified, standard industry tolerances are applied. Special tolerances may be specified in consultation with the extruder. Extrusion tolerances are applied to a variety of physical dimensions.

Standard tolerances for extruded rod, bar and shapes are applied to cross section/wall thickness, length, straightness, twist, flatness, surface roughness, end cut squareness (vertical and transverse), contour (curved surfaces), corner and fillet radii and angularity.

Extruded tube has standard tolerances for diameter, wall thickness, width and depth for square or rectangular tubes.

Standard Tolerances

The industry's standard tolerances were developed by technical committees of the Australian Aluminium Council, taking into account both the capabilities of extruders and the needs of users.

These Industry Standards are published in Australian Standards AS/NZS1866 and AS/NZS1734. Both publications are updated periodically to reflect improvements in extruder capabilities and changes in user needs.

Standard tolerances are not simple, uniform fractional formulas. There are many different specific numbers of formulas published in tables. The various tolerances are established to match the various degrees of difficulty an extruder faces in controlling different toleranced dimensions. As a result, tolerances vary with cross-sectional size (as measured by the profile's fit within a circumscribing circle), and even with the location of each dimension on a complex shape. Alloy composition and temper also influence certain tolerances, and are reflected in the standard tolerance tables. Because of all these important considerations, tolerancing tables are complex. But their significance is simple and important: under standard tolerances, aluminium extrusions are routinely produced with dimensions accurate within tenths or hundredth of a millimetre. For most purposes, that is a more than ample degree of precision.

Rolled & Imported Extruder Product Tolerances

Unless otherwise stated, tolerances published by the Aluminium Association Inc are applied to materials sold by NALCO.

Special Tolerances

Even tighter tolerances than the Industry Standard can be specified when necessary.
To achieve them, however, requires more involved die corrections, slower extrusion rates, increased inspections, and sometimes a higher rejection rate. All that special care adds up, of course, to higher costs to the extruder and higher prices to the customer.

In rare instances, a desired tolerance may not be possible; but an experienced extrusion supplier such as NALCO may be able to suggest a design change that solves the problem and still meets the purchaser's economic and functional requirements.

The purchaser and the vendor should agree on any special tolerances at the time an order is entered, and should specify them on the order and engineering drawing.

If no special tolerances are ordered, standard tolerances will be applied.

concavity & convexity tolerances

Concavity & Convexity

The function of any particluar shape is paramount, and under this provision, negotiation and agreement between customer and extruder is encouraged, particularly at the design stage.

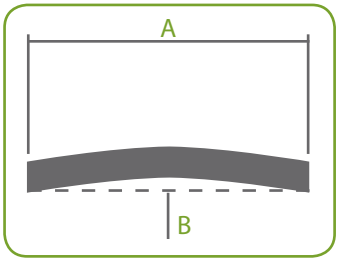
All manufacturing tolerances are subject to review from time to time.

Width (mm)	Tolerance
	Maximum (mm)
25mm	0.125
50mm	0.25
75mm	0.375
100mm	0.5
150mm	0.75
200mm	1
250mm	1.25
300mm	1.5

Dimensional tolerances are rounded down to the nearest 0.05mm, because all callipers used to measure metal dimensions are almost universally graduated at intervals of 0.05mm.

Concavity and Convexity Tolerances:

Over the width (A) of the section, the maximum tolerance on concavity and convexity (B) shall be 0.05mm per 10mm of width.



Bow

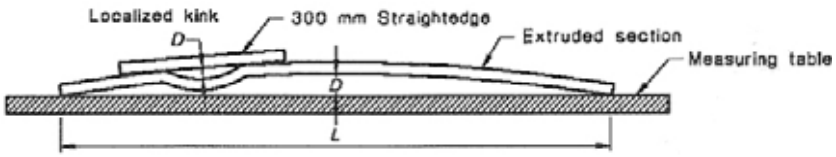
The function of any particluar shape is paramount, and under this provision, negotiation and agreement between customer and extruder is encouraged, particularly at the design stage.

All manufacturing tolerances are subject to review from time to time.

Width (mm)	Tolerance
	Maximum (mm)
25mm	0.125
50mm	0.25
75mm	0.375
100mm	0.5
150mm	0.75
200mm	1
250mm	1.25
300mm	1.5

Dimensional tolerances are rounded down to the nearest 0.05mm, because all callipers used to measure metal dimensions are almost universally graduated at intervals of 0.05mm.

Straightness Tolerance for Extruded Products:



Alloy and Temper	Allowable deviation from straightness, D, mm	
	In any length ≤300mm	Maximum (mm)
6101-T5	0.2	0.7 L
6063-T5 & T52	0.2	0.7 L
6060-T5 & T52	0.2	0.7 L
All other alloys and tempers	0.6	2 L

twist tolerances

Twist

The function of any particluar shape is paramount, and under this provision, negotiation and agreement between customer and extruder is encouraged, particularly at the design stage.

All manufacturing tolerances are subject to review from time to time.

Length (mm)	Tolerance
	Maximum (mm)
2000mm	2
3200mm	3.2
4400mm	4
5000mm	5
6000mm	6

Twist Tolerance:

Take the overall length of the section;

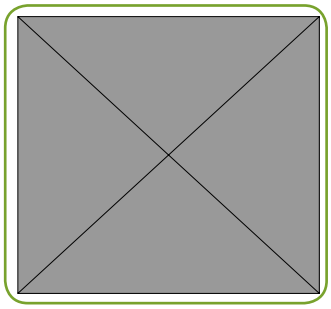
the maximum tolerance on twist shall be 1mm per 1000mm of length

Example:

If the length of the section is 5000mm the maximum

twist allowable would be 5x1mm

= 5mm



Circumscribing Circle Diameter	Angle of Twist (t)	Total Angle of Twist
	per 300mm run	per length
Under 40mm	1°	5°
Between 40mm - 80mm	½°	3°
Diameters over 80mm:		
Lengths up to 8000mm	¼°	2°
Lengths over 8000mm	¼°	3°

Width and Diameter

Diameter, width or width across flats		Tolerance + (mm) - (mm)
Over (mm)	Up to and including (mm)	
	3	0.16
3	10	0.20
10	18	0.26
18	30	0.32
30	40	0.40
40	60	0.45
60	80	0.50
80	100	0.65
100	120	0.80
120	140	0.90
140	160	1.00
160	180	1.10
180	200	1.20
200	240	1.30

Thickness

Width or width across flats		Thickness (mm)												
Up to and incl. (mm)		Over		1.6	3.0	6	10	18	30	40	60	80	100	120	140
		Up to & incl.	1.6	3.0	6	10	18	30	40	60	80	100	120	140	160
-	10	Tolerance + - (mm)	0.16	0.18	0.20	0.22									
10	18		0.18	0.20	0.22	0.24	0.26								
18	30		0.22	0.24	0.26	0.28	0.30	0.32							
30	60		0.24	0.26	0.28	0.30	0.33	0.36	0.40						
60	80		0.28	0.30	0.32	0.34	0.37	0.40	0.43	0.45	0.50				
80	120		0.32	0.34	0.36	0.39	0.42	0.45	0.48	0.52	0.57	0.65	0.80		
120	180			0.36	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.82	0.90	1.00
180	240				0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.05

Lengths up to 5000mm (-0 +10mm), over 5000mm (on application).

Tolerances on length provide for out of squareness of cut to the extent of 1°. They are measured at a temperature of 16°C.

hollow section & tubing tolerances

Width, (width across flats & thickness)

Width or width across flats			Thickness (mm)						
Over (mm)	Up to and incl. (mm)	Tolerance [1] + (mm) - (mm)	Over		1.6	3.0	6	10	18
			Up to & incl.	1.6	3.0	6	10	18	30
3	3 10	0.16 0.20	Tolerance + - (mm)						
10 18	18 30	0.26 0.32		0.20 0.26	0.22 0.28	0.32			
30 40	40 60	0.40 0.45		0.32 0.32	0.36 0.36	0.41 0.41	0.48 0.48		
60 80	80 100	0.50 0.65		0.36	0.41 0.48	0.48 0.58	0.58 0.68	0.68 0.82	1.0
100 120 140	120 140 160	0.80 0.90 1.00			0.48 0.65 0.65	0.58 0.75 0.75	0.68 0.85 0.85	0.82 0.95 0.95	1.0 1.10 1.10

Diameter of Tubing

Nominal outside diameter		Tolerance on actual diameter [3] + (mm) - (mm)	Tolerance on mean diameter [3] + (mm) - (mm)
Over (mm)	Up to and incl. (mm)		
12 18	18 30	0.25 0.30	0.19 0.23
30 40	40 50	0.36 0.45	0.27 0.34
50 60 80	60 80 150	0.54 0.60 1% of diameter	0.40 0.45 3/4% of diameter

1. Measured at the corners
2. The tolerances apply to non-heat treated sections and tubing of wall thickness not less than 1.6mm or 1/32 of the overall width or outside diameter (whichever is greater), and to heat treated sections and tubing of wall thickness not less than 1.6mm or 1/24 of the overall width or outside diameter (whichever is the greater). The maximum tolerance on concavity and convexity is 0.05mm per 10.0mm of width.
3. In the case of tubing in straight lengths, the tolerance limits are inclusive of ovality.

Wall Thickness of Tubing

Nominal thickness	Tolerance on mean thickness + (mm) - (mm)	Thickness at any point	
		Max (mm)	Min (mm)
1.6 2.0	0.18 0.20	1.84 2.27	1.36 1.73
2.5 3.0	0.22 0.27	2.80 3.36	2.20 2.64
4.0 5.0	0.31 0.37	4.42 5.49	3.58 4.51
6.0 7.0	0.43 0.51	6.58 7.67	5.42 6.33
8.0 10.0	0.56 0.65	8.76 10.85	7.24 9.15
12.0 14.0	0.77 0.88	13.03 15.24	10.97 12.76

These tolerances on wall thickness do not apply where tolerances on both outside and inside diameter are required. Mean thickness is the average of the wall thickness measured at four equidistant points around the circumference.

Open End, Channel & i beam

Overall width of channel (C) in mm		Minimum thickness of web, flange (T_1, T_2)		External (A) or internal (B) tolerance at top of gap for depth (D) in mm									
Between & Incl.		Between & Incl.		Over		10	18	30	40	60	80	100	120
				Up to & incl.	10	18	30	40	60	80	100	120	140
0	10	0 1.50 3.00	1.50 3.00 -	Tolerance + - (mm)	0.25 0.23 0.22	0.32 0.28 0.26	0.41 0.34 0.30						
10	18	0 1.50 3.00	1.50 3.00 -		0.31 0.29 0.28	0.38 0.34 0.32	0.47 0.40 0.36	0.56 0.46 0.41	0.70 0.55 0.47				
18	30	0 3.00 6.00	3.00 6.00 -		0.37 0.37 0.35	0.47 0.44 0.41	0.57 0.53 0.48	0.68 0.62 0.55	0.84 0.76 0.64	1.05 0.93 0.78	1.26 1.11 0.91		
30	40	0 3.00 6.00	3.00 6.00 -		0.45 0.45 0.43	0.55 0.52 0.49	0.65 0.61 0.56	0.76 0.70 0.63	0.92 0.84 0.72	1.13 1.01 0.86	1.34 1.19 0.99	1.55 1.36 1.12	1.76 1.54 1.25
40	60	0 3.00 6.00	3.00 6.00 -			0.60 0.57 0.54	0.70 0.66 0.61	0.81 0.75 0.68	0.97 0.89 0.77	1.18 1.06 0.91	1.39 1.24 1.04	1.60 1.41 1.17	1.81 1.59 1.30
60	80	0 3.00 6.00	3.00 6.00 -			0.65 0.62 0.59	0.75 0.71 0.66	0.86 0.80 0.73	1.02 0.94 0.82	1.23 1.11 0.96	1.44 1.29 1.09	1.65 1.46 1.22	1.86 1.64 1.35
80	100	0 6	6 -				0.90 0.86	1.01 0.95	1.17 1.09	1.38 1.26	1.59 1.44	1.80 1.61	2.01 1.79
100	120	0 6	6 -				1.05 1.01	1.16 1.10	1.32 1.24	1.53 1.41	1.74 1.59	1.95 1.76	2.16 1.94
120	140	0 6	6 -				1.15 1.11	1.26 1.20	1.42 1.34	1.63 1.51	1.84 1.69	2.05 1.86	2.26 2.04
140	160	0 6	6 -				1.25 1.21	1.36 1.30	1.52 1.44	1.73 1.61	1.94 1.79	2.15 1.96	2.36 2.14
160	180	0 6	6 -				1.35 1.31	1.46 1.40	1.62 1.54	1.83 1.71	2.04 1.89	2.25 2.06	2.46 2.24
180	200	0 6	6 -				1.45 1.41	1.56 1.50	1.72 1.64	1.93 1.81	2.14 1.99	2.35 2.16	2.56 2.34

Metallurgical Aspects

In high purity form, aluminium is soft and ductile. Most commercial users, however, require greater strength than pure aluminium affords. This is achieved in aluminium by the addition of other elements to produce various alloys which alone, or in combination, impart strength to the metal. Further strengthening is possible by means which classify the alloys roughly into two categories, non-heat treatable and heat-treatable.

Non-heat Treatable Alloys

The initial strength of alloys in this group depends upon the hardening effect of elements such as manganese, silicon, iron and magnesium. The non-heat treatable alloys are therefore usually designated in the 1000, 3000, 4000 and 5000 series.

Since these alloys are able to be workhardened further strengthening is possible with various degrees of cold working, denoted by the H series of tempers. Alloys containing appreciable amounts of magnesium when supplied in strain-hardened tempers are usually given a final elevated-temperature treatment called stabilising to ensure stability of properties.

Heat Treatable Alloys

The initial strength of alloys in this group is enhanced by the addition of alloying elements which, either between themselves or in conjunction with aluminium, form compounds which show increasing solid solubility in aluminium with increasing temperature. This phenomenon has enabled this group of alloys to be developed so that their strength may be improved by carefully controlled thermal treatment.

The first step, called heat treatment or solution heat treatment, is an elevated temperature process designed to put the soluble element in solid solution. This is followed by rapid quenching, usually in water, which temporarily "stabilises" the structure and for a short time renders the alloy very workable. It is at this stage that some fabricators retain this more workable structure by storing the alloys at sub zero temperatures until they are ready to form them. At room or elevated temperatures, supersaturated solution begins. After a period of several days at room temperature, termed ageing or room temperature precipitation, the alloy is considerably stronger. Many alloys approach a stable condition at room temperature, but some alloys, particularly those containing magnesium and silicon or magnesium and zinc, continue to age-harden for longer periods of time at room temperature.

By heating for a controlled time at slightly elevated temperatures even further strengthening is possible and properties are stabilised. This process is called artificial ageing or precipitation hardening. By the proper combination of solution heat treatment, quenching, artificial ageing, and cold working the highest strengths are obtained.

Rolled Products

Alloy	Typical application (✓)	Forms available				Characteristics					
		Plate	Flat Sheet	Coiled Sheet	Circle Blanks	Corrosion Resistance	Machining	Anodising	Forming	Welding	Heat Treatable
1050	Chemical, process plant and equipment	✓	✓	✓		aa	dc	bb	ad	aa	no
1150	Commercially pure aluminium that has been specially processed to give a reasonably streak free surface when mechanically polished and anodised. Suitable for chemical brightening before anodising. Typical uses saucepan lids, beakers and decorative trim and panels.		✓	✓	✓	aa	dc	aa	ad	bc	no
1200	Commercial pure aluminium. Uses include cooking utensils, packing containers, building components (not stressed) and domestic appliances. Deep drawing quality available.		✓	✓	✓	aa	dc	bb	ac	ba	no
3003	Chemical equipment, sheet metalwork, rigid foil containers, closures		✓	✓		aa	dc	bb	ac	ba	no
3004	Sheet metal work, car bodies, seam welded tubing, roofing sheet		✓	✓		aa	dc	bb	ac	ba	no
3105	Painted sheet products, sheet metal work, closure sheet, finstock.		✓			aa	dc	bb	ac	ba	no
5005	A stronger alloy than 1200. This is a general purpose alloy suitable to welding.	✓	✓	✓	✓	aa	dc	bb	ac	ba	no
5083	Used in high strength structural applications principally in the form of sheet and plate for welded marine applications and road transport vehicles.	✓	✓			ac	cb	cc	ac	ba	no
5251 5052	A medium strength alloy with reasonable ductility-work hardens rapidly. Very suitable for welding with a high corrosion resistance, particularly in marine atmospheres. Uses include boats, panelling and pressing for transport, boxes and containers. Suitable for applications specifying 5052.	✓	✓	✓		aa	cb	cc	ac	ba	no
5454	Welded structures, pressure vessels for use at elevated temperatures, marine applications.	✓	✓	✓		aa	cb	cc	ac	ba	no
6061	Structural applications where corrosion resistance is required. Transport, marine, aircraft landing mats.	✓	✓			bb	bc	bb	ac	ba	yes
7075	High Strength and surface hardness, susceptible to stress corrosion cracking.	✓				cc	bb	dd	dd	bc	yes

Relative ratings in decreasing order of merit = a b c d (where a = most applicable) two ratings:
e.g. ac are for annealed and hardest tempers.

Extruded Products

Alloy	Typical application (✓)	Forms Available						Characteristics					
		Forms Available				Drawn							
		Rod & Bar	Solid Shapes	Hollow Shapes	Tube	Rod & Bar	Tube	Corrosion Resistance	Machining	Anodising	Forming	Welding	Heat Treatable
2011	Commercial machining alloy.	✓	e			✓		d	aa	d	cd	d	✓
3003	Drawn tube for heat exchangers, chemical equipment and hardware.				e		✓	a	dc	b	ac	a	nr
6060 / 6063	Most commonly used extrusion alloy. Architectural and general purpose	✓	✓	✓	✓	✓	✓	a	cc	a	ac	a	✓
6061	Structural alloy with medium weld strength and good corrosion resistance.	✓	✓	✓	✓	✓	✓	b	bc	b	ac	a	✓
6101	Electrical conductors.	✓	✓	✓	✓	✓	✓	ab	bc	a	ac	a	✓
6106	General purpose and light structural.	✓	✓	✓	✓	✓	✓	a	cb	a	ac	a	✓
6261	Commercial machining alloy with good anodising.	✓	e	e	✓	✓		b	aa	b	ac	a	✓
6082	Heavy duty structures with good corrosion resistance and medium weld strength. Transport, marine etc.	✓	✓	✓	✓			ab	bc	b	ac	a	✓
6463A	Trims requiring decorative finishing.	e	e					a	c	a	a	a	✓

Relative ratings are in decreasing order of merit = a,b,c,d

e = Special enquiry needed to clarify application

Nr = Not recommended

Where applicable, ratings for both annealed and hardest temper are given, e.g. a,c

Ratings inicates suitability of alloy for decorative quality anodising; all aluminium alloys can be anodised for increased corrosion and wear resistance.

useful formulae

Sheet

To calculate the mass of a sheet:		
Alloy	Factor	Calculation
5083	0.982	Length (m) x Width (m) x Thickness (mm) x 2.71 x factor = Kg Example: To calculate mass of 5005 sheet 1800 x 763 x 1.2mm thick 1.8 x 0.763 x 1.2 x 2.71 x 0.996 = 4.448 kg
5251	0.993	
1150	0.996	
5005	0.996	
1200	1.000	
3105	1.004	
3003	1.007	

Coiled Sheet

Coil density (kg per mm of width) = $2.128 (D + d) (D - d) 10^{-6}$

D = outside diameter of coil (mm)

d = inside diameter of coil (mm)

Circles

Mass per circle = $2.1^{3} D^{2} t \times 10^{-6}$ = kg

D = diameter (mm)

t = thickness (mm)

Extrusions

Mass per unit length for Extrusions		
Alloy	Density ($kg/m^3 \times 10^3$)	Conversion Factor
2011	2.77	1.044
3003	2.73	1.007
6060	2.70	0.996
6106	2.70	0.996
6061	2.70	0.996
6082	2.70	0.996

Circles

Mass per metre (kg) = $2.71 \times A \times 10^{-3} \times$ Factor

Tubes

Mass per metre (kg) = $8.51t (D-t) \times 10^{-3} \times$ Factor

Round Bar & Wire

Mass per metre (kg) = $2.13 \ D^2 \times 10^{-3} \times$ Factor

D = outside diameter (mm)

d = inside diameter (mm)

t = thickness

A = cross section area (mm^2)

gauge conversion chart

Gauge to millimetre conversion chart

Gauge	Conversion to mm
25g	.50
24g	.60
22g	.70
20g	.90
18g	1.20
16g	1.60
14g	2.00
12g	2.80
10g	3.00
3/16	5.00
1/4	6.00

Conversion basics

Linear	
1 inch	25.4mm
1 foot	0.3048m
1mm	0.0394 inches
1m	3.28 feet
Area	
1 sq inch	645 sq mm
1 sq foot	0.0929 sq m
1 sq mm	0.00155 sq in
1 sq m	10.84 sq ft
Volume	
1 cubic inch	16387 cu mm
1 cu mm	0.000061 cu in
Force	
1 pound force	4.45 newtons
1 newton	0.225 pound force
Pressure	
1 lb per sq in	0.00689 MPa
1 MPa	145 lbs per sq in
Weight	
1 Kg	2.204 lb

linear conversion tables imperial - metric

Inches	mm
1/64	0.3969
1/32	0.7938
3/64	1.1906
1/16	1.5875
5/64	1.9844
3/32	2.3813
7/64	2.7781
1/8	3.1750
9/64	3.5719
5/32	3.9688
11/64	4.3656
3/16	4.7625
13/64	5.1594
7/32	5.5563
15/64	5.9531
1/4	6.3500
17/64	6.7469
9/32	7.1438
19/64	7.5406
5/16	7.9375
21/64	8.3344
11/32	8.7313
23/64	9.1281
3/8	9.5250
25/64	9.9219
13/32	10.3188
27/64	10.7156
7/16	11.1125
29/64	11.5094
15/32	11.9063
31/64	12.3031
1/2	12.7000

Inches	mm
33/64	13.0969
17/32	13.4938
35/64	13.8906
9/16	14.2875
37/64	14.6844
19/32	15.0813
39/64	15.4781
5/8	15.8750
41/64	16.2719
21/32	16.6688
43/64	17.0656
11/16	17.4625
45/64	17.8594
23/32	18.2563
47/64	18.6531
3/4	19.0500
49/64	19.4469
25/32	19.8438
51/64	20.2406
13/16	20.6375
53/64	21.0344
27/32	21.4313
55/64	21.8281
7/8	22.2250
57/64	22.6219
29/32	23.0188
59/64	23.4156
15/16	23.8125
61/64	24.2094
31/32	24.6063
63/64	25.0031
1 inch	25.4000

Inches	mm
1 1/32	26.1938
1 1/16	26.9875
1 3/32	27.7813
1 1/8	28.5750
1 5/32	29.3688
1 3/16	30.1625
1 7/32	30.9563
1 1/4	31.7500
1 9/32	32.5438
1 5/16	33.3375
1 11/32	34.1313
1 3/8	34.9250
1 13/32	35.7188
1 7/16	36.5125
1 15/32	37.3063
1 1/2	38.1000
1 17/32	38.8938
1 9/16	39.6875
1 19/3	40.4813
1 5/8	41.2750
1 21/32	42.0688
1 11/16	42.8625
1 23/32	43.6563
1 3/4	44.4500
1 25/32	45.2438
1 13/16	46.0375
1 27/32	46.8313
1 7/8	47.6250
1 29/32	48.4188
1 15/16	49.2125
1 31/32	50.0063
2 inches	50.8000

Inches	mm
2 1/32	51.5938
2 1/16	52.3875
2 3/32	53.1813
2 1/8	53.9750
2 5/32	54.7688
2 3/16	55.5625
2 7/32	56.3563
2 1/4	57.1500
2 9/32	57.9438
2 5/16	58.7375
2 11/32	59.5313
2 3/8	60.3250
2 13/32	61.1188
2 7/16	61.9125
2 15/32	62.7063
2 1/2	63.5000
2 17/32	64.2938
2 9/16	65.0875
2 19/32	65.8813
2 5/8	66.6750
2 21/32	67.4688
2 11/16	68.2625
2 23/32	69.0563
2 3/4	69.8500
2 25/32	70.6438
2 13/16	71.4375
2 27/32	72.2313
2 7/8	73.0250
2 29/32	73.8188
2 15/16	74.6125
2 31/32	75.4063
3 inches	76.2000

Inches	mm
3 1/32	76.9938
3 1/16	77.7875
3 3/32	78.5813
3 1/8	79.3750
3 5/32	80.1688
3 3/16	80.9625
3 7/32	81.7563
3 1/4	82.5500
3 9/32	83.3438
3 5/16	84.1375
3 11/32	84.9313
3 3/8	85.7250
3 13/32	86.5188
3 7/16	87.3125
3 15/32	88.1063
3 1/2	88.9000
3 17/32	89.6938
3 9/16	90.4875
3 19/32	91.2813
3 5/8	92.0750
3 21/32	92.8688
3 11/16	93.6625
3 23/32	94.4563
3 3/4	95.2500
3 25/32	96.0438
3 13/16	96.8375
3 27/32	97.6313
3 7/8	98.4250
3 29/32	99.2188
3 15/16	100.0120
3 31/32	100.8060
4 inches	101.6000

Inches	mm
4 1/32	102.3940
4 1/16	103.1880
4 3/32	103.9810
4 1/8	104.7750
4 5/32	105.5690
4 3/16	106.3620
4 7/32	107.1560
4 1/4	107.9500
4 9/32	108.7440
4 5/16	109.5380
4 11/32	110.3310
4 3/8	111.1250
4 13/32	111.9190
4 7/16	112.7120
4 15/32	113.5060
4 1/2	114.3000
4 17/32	115.0940
4 9/16	115.8880
4 19/32	116.6810
4 5/8	117.4750
4 21/32	118.2690
4 11/16	119.0620
4 23/32	119.8560
4 3/4	120.6500
4 25/32	121.4440
4 13/16	122.2380
4 27/32	123.0310
4 7/8	123.8250
4 29/32	124.6190
4 15/16	125.4120
4 31/32	126.2060
5 inches	127.0000

Inches	mm
5 1/32	127.794
5 1/16	128.588
5 3/32	129.381
5 1/8	130.175
5 5/32	130.969
5 3/16	131.762
5 7/32	132.556
5 1/4	133.350
5 9/32	134.144
5 5/16	134.938
5 11/32	135.731
5 3/8	136.525
5 13/32	137.319
5 7/16	138.112
5 15/32	138.906
5 1/2	139.700
5 17/32	140.494
5 9/16	141.288
5 19/32	142.081
5 5/8	142.875
5 21/32	143.669
5 11/16	144.462
5 23/32	145.256
5 3/4	146.050
5 25/32	146.844
5 13/16	147.638
5 27/32	148.431
5 7/8	149.225
5 29/32	150.019
5 15/16	150.812
5 31/32	151.606
6 inches	152.400

Inches	mm
6 1/16	153.988
6 1/8	155.575
6 3/16	157.162
6 1/4	158.750
6 5/16	160.338
6 3/8	161.925
6 7/16	163.512
6 1/2	165.100
6 9/16	166.688
6 5/8	168.275
6 11/16	169.862
6 3/4	171.450
6 13/16	173.038
6 7/8	174.625
6 15/16	176.212
7 inches	177.800
7 1/16	179.388
7 1/8	180.975
7 3/16	182.562
7 1/4	184.150
7 5/16	185.738
7 3/8	187.325
7 7/16	188.912
7 1/2	190.500
7 9/16	192.088
7 5/8	193.675
7 11/16	195.262
7 3/4	196.850
7 13/16	198.438
7 7/8	200.025
7 15/16	201.612
8 inches	203.200

Inches	mm
8 1/16	204.788
8 1/8	206.375
8 3/16	207.962
8 1/4	209.550
8 5/16	211.138
8 3/8	212.725
8 7/16	214.312
8 1/2	215.900
8 9/16	217.488
8 5/8	219.075
8 11/16	220.662
8 3/4	222.250
8 13/16	223.838
8 7/8	225.425
8 15/16	227.012
9 inches	228.600
9 1/16	230.188
9 1/8	231.775
9 3/16	233.362
9 1/4	234.950
9 5/16	236.538
9 3/8	238.125
9 7/16	239.712
9 1/2	241.300
9 9/16	242.888
9 5/8	244.475
9 11/16	246.062
9 3/4	247.650
9 13/16	249.238
9 7/8	250.825
9 15/16	252.412
10 inches	254.000

Inches	mm
10 1/16	255.588
10 1/8	257.175
10 3/16	258.762
10 1/4	260.350
10 5/16	261.938
10 3/8	263.525
10 7/16	265.112
10 1/2	266.700
10 9/16	268.288
10 5/8	269.875
10 11/16	271.462
10 3/4	273.050
10 13/16	274.638
10 7/8	276.225
10 15/16	277.812
11 inches	279.400
11 1/16	280.988
11 1/8	282.575
11 3/16	284.162
11 1/4	285.750
11 5/16	287.338
11 3/8	288.925
11 7/16	290.512
11 1/2	292.100
11 9/16	293.688
11 5/8	295.275
11 11/16	296.862
11 3/4	298.450
11 13/16	300.038
11 7/8	301.625
11 15/16	303.212
12 inches	304.800

linear conversion tables imperial - metric

ft/Inches		mm
1	1	330.200
1	2	355.600
1	3	381.000
1	4	406.400
1	5	431.800
1	6	457.200
1	7	482.600
1	8	508.000
1	9	533.400
1	10	558.800
1	11	584.200
2		609.600
2	1	635.000
2	2	660.400
2	3	685.800
2	4	711.200
2	5	736.600
2	6	762.000
2	7	787.400
2	8	812.800
2	9	838.200
2	10	863.600
2	11	889.000
3		914.400

ft/Inches		mm
3	1	939.800
3	2	965.200
3	3	990.600
3	4	1016.00
3	5	1041.40
3	6	1066.80
3	7	1092.20
3	8	1117.60
3	9	1143.00
3	10	1168.40
3	11	1193.80
4		1219.20
4	1	1244.60
4	2	1270.00
4	3	1295.40
4	4	1320.80
4	5	1346.20
4	6	1371.60
4	7	1397.00
4	8	1422.40
4	9	1447.80
4	10	1473.20
4	11	1498.60
5		1524.00

ft/Inches		mm
5	1	1549.40
5	2	1574.80
5	3	1600.20
5	4	1625.60
5	5	1651.00
5	6	1676.40
5	7	1701.80
5	8	1727.20
5	9	1752.60
5	10	1778.00
5	11	1803.40
6		1828.80
6	1	1854.20
6	2	1879.60
6	3	1905.00
6	4	1930.40
6	5	1955.80
6	6	1981.20
6	7	2006.60
6	8	2032.00
6	9	2057.40
6	10	2082.80
6	11	2108.20
7		2133.60

ft/Inches		mm
7	1	2159.00
7	2	2184.40
7	3	2209.80
7	4	2235.20
7	5	2260.60
7	6	2286.00
7	7	2311.40
7	8	2336.80
7	9	2362.20
7	10	2387.60
7	11	2413.00
8		2438.40
8	1	2463.80
8	2	2489.20
8	3	2514.60
8	4	2540.00
8	5	2565.40
8	6	2590.80
8	7	2616.20
8	8	2641.60
8	9	2667.00
8	10	2692.40
8	11	2717.80
9		2743.20

ft/Inches		mm
9	1	2768.60
9	2	2794.00
9	3	2819.40
9	4	2844.80
9	5	2870.20
9	6	2895.60
9	7	2921.00
9	8	2946.40
9	9	2971.80
9	10	2997.20
9	11	3022.60
10		3048.00

feet	mm
11	3352.80
12	3657.60
13	3962.40
14	4267.20
15	4572.00
16	4876.80
17	5181.60
18	5486.40
19	5791.20
20	6096.00

feet	mm
21	6400.80
22	6705.60
23	7010.40
24	7315.20
25	7620.00
26	7924.80
27	8229.60
28	8534.40
29	8839.20
30	9144.00

feet	mm
31	9448.80
32	9753.60
33	10,058.4
34	10,363.2
35	10,668.0
36	10,972.8
37	11,277.6
38	11,582.4
39	11,887.2
40	12,192.0

feet	mm
41	12,496.8
42	12,801.6
43	13,106.4
44	13,411.2
45	13,716.0
46	14,020.8
47	14,325.6
48	14,630.4
49	14,935.2
50	15,420.0

feet	mm
51	15,544.8
52	15,849.6
53	16,154.4
54	16,459.2
55	16,764.0
56	17,068.8
57	17,373.6
58	17,678.4
59	17,983.2
60	18,288.0

feet	mm
61	18,592.8
62	18,897.6
63	19,202.4
64	19,507.2
65	19,812.0
66	20,116.8
67	20,421.6
68	20,726.4
69	21,031.2
70	21,336.0

feet	mm
71	21,640.8
72	21,945.6
73	22,250.4
74	22,555.2
75	22,860.0
76	23,164.8
77	23,469.6
78	23,774.4
79	24,079.2
80	24,384.0

feet	mm
81	24,688.8
82	24,993.6
83	25,298.4
84	25,603.2
85	25,908.0
86	26,212.8
87	26,517.6
88	26,822.4
89	27,127.2
90	27,432.0

feet	mm
91	27,736.8
92	28,041.6
93	28,346.4
94	28,651.2
95	28,956.0
96	29,260.8
97	29,565.6
98	29,870.4
99	30,175.2
100	30,480.0

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NALCO Head Office

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