Introduction :

Aluminium is found primarily in bauxite ore .Pure aluminium is soft, silvery , ductile of the poor metal group of chemical elements ,which is corrosion resistant, light weight and high electrical conductivity . It has the symbol Al and atomic number 13.
The metal is used in many industries to manufacture a large variety of products and is very important to the world economy. Structural components made from aluminium and its alloys are vital to the aerospace industry and very important in other areas of transportation and building. 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.

Properties :

1.Aluminium is a soft, lightweight metal with normally a dull silvery appearance caused by a thin layer of oxidation that forms quickly when the metal is exposed to air.
2.Aluminium oxide has a higher melting point than pure aluminium.
Aluminium is nontoxic (as the metal), nonmagnetic, and nonsparking.
3.It has a tensile strength of about 49 megapascals (MPa) in a pure state and 400 MPa as an alloy.
4.Aluminium is about one-third as dense as steel or copper; it is malleable, ductile, and easily machinable and castable.
5.It has excellent corrosion resistance and durability because of the protective oxide layer.
6.Aluminium mirror finish has the highest reflectance of any metal in the 200-400 nm (UV) and the 3000-10000 nm (far IR) regions, while in the 400-700 nm visible range it is slightly outdone by silver and in the 700-3000 (near IR) by silver, gold, and copper.
7.It is the second-most malleable metal (after gold) and the sixth-most ductile. Aluminium is a good thermal and electrical conductor.

Aluminium :
General
TABLE A :

Name, Symbol, Number	Aluminium, Al, 13
Group, Period, Block	13, 3, p
Appearance	Silvery
Crystal Structure	Face centred cubic
Atomic mass	26.9815386(8) g/mol
Electron configuration	[Ne] 3s2 3p1
Electrons per shell	2, 8, 3

Physical properties :

TABLE B :

Phase	Solid
Density (near r.t.)	2.70 g·cm−3
Liquid density at m.p.	2.375 g·cm−3
Melting point	933.47 K (660.32 °C, 1220.58°F)
Boiling point	2792 K (2519 °C, 4566 °F)
Heat of fusion	10.71 kJ·mol−1
Heat of vaporization	294.0 kJ·mol−1
Heat capacity	(25 °C) 24.200 J·mol−1·K−1

Miscellaneous :

TABLE C :

Electrical Resistivity (20 °C)	26.50 nΩ·m
Mean Specific Heat (0-100°C)	0.219 cal/g.°C
Thermal Conductivity (300 K)	237 W·m−1·K−1
Thermal Expansion (25 °C)	23.1 µm·m−1·K−1
Speed of Sound (thin rod) (r.t.) (rolled)	5000 m·s−1
Young's Modulus	70 GPa
Shear Modulus	26 GPa
Bulk Modulus	76 Gpa
Poisson Ratio	0.35
Mohls Hardness	2.75
Vickers Hardness	167 Mpa
Brinell Hardness	245 MPa

WROUGHT ALLOYS : NEAR EQUIVALENT DESIGNATIONS :
TABLE D1 :

INDIA		USA	BRITAIN	CANADA	GERMANY	RUSSIA	I.S.O	FRENCH
NEW I.S	OLD I.S	(A.A.)	(B.S.)		(DIN)			ND
19500	1 E	1050 (E.C)	1 E	C 15	E-AL 99.5	-	-	-
19500	1 B	1050	1 B	1 S	A-99.5	-	Al - 99.5	1050 A
24345	H 15	2014	H 15	B 26 S	Al-Cu-Si	AK	-	-
24534	H 14	2017	H 14	17S / 16S	-	D 1	Al-Cu-4Mg Si	-
31000	N3	3003	N3	3 S	Al-Mn	A - Mn	Al - Mn 1	3003
52000	N4	5052	N4	M 57 S	Al-Mg.2	A - Mg	Al - Mg - 2.5	5051
53000	N5	5086	N5	54 S	-	A - Mg - 3	Al - Mg - 4	-
54300	N8	5083	N8	D 54 S	Al-Mg-4.5Mn	-	Al - Mg -4.5 Mn	5083
65032	H 20	6061	H 20	65 S	Al-Mg-Si Cu	-	Al - Mg -1Si Cu	-
63400	H 9	6063	H 9	50 S	Al-Mg-Si 0.5	-	Al - Mg -Si	-
64430	H 30	6351	H 30	B 51 S	Al-Mg-Si 1	Av	Al - Si - 1Mg	6081
64423	H 11	6066	H 11	C 62 S	-	-	-	-
62400		6005		C 51 S	-	-	-	-
63401	91 E	6101	91 E	D 50 S	E.Al.Mg.Si.0.5	-	-	-

TABLE D2 :

S.NO	USA	I S
1	AA 4047	46000
2	AA 5251	52000
3	AA 5050	51000 B
4	AA 5005	51000 A
5	AA 5056	55000
6	AA 5086	53000
7	AA 6201	64401
8	AA 7039	74530
9	AA 8011	40800

Aluminum When compared with Steel :

:

1.Aluminum is three times lighter than steel and yet can offer high strength when alloyed with the right elements.
2. Aluminum can conduct electricity six times better than steel and nearly 30 times better than stainless steel.
3. Aluminum provides excellent corrosion resistance.
4. Aluminum is easy to cut and form.
5. Aluminum is nontoxic for food applications.
6. Aluminum is non-magnetic therefore arc blow is not a problem during welding.
7. Aluminum has a thermal conductivity rate five times higher than steel. The high thermal conductivity creates a great heat sink which can create insufficient weld fusion on parts over 4 mm and weld burn through issues on parts less than 3 mm.
8. Aluminum provides welds that are less viscous which is a problem when trying to get weld fusion with the short circuit mode. Pulsed MIG is beneficial on all aluminum applications. The viscosity is beneficial when using spray or pulsed transfer for all position welds.
9. Aluminum has a low melting point 1,200 degrees F, this is more than half that of steel. For a given MIG wire diameter the transition short to spray weld current for aluminum is much lower than it is for steel.

Aluminum Alloy :

Aluminum is alloyed with a number elements to provide improved weldability, strength and corrosion resistance. The primary elements that alloy with aluminum are,

- copper,
- silicon,
- manganese,
- magnesium,
- zinc.

TABLE E :

First digit is principle aluminum alloy. First digit also describes the aluminum series. Ksi is ultimate tensile strength range. Metric Conversion of Filler Strength. ksi x 6.894 = MPa			
1X XX	> 99% Aluminum	Non heat treatable	10-27 ksi
2X XX	Alu - Copper approx. 2 - 10% provides strength and allows precipitation hardening.	Heat treatable	27-62 ksi
3X XX	Alu-Manganese. Provides increased strength	Non heat treatable	16-41 ksi
4X XX	Alu-Silicon. Reduces melting temperature, welds more fluid. When combined with magnesium provides an alloy that can be heat treated.	Both heat treatable and non heat treatable	25-55 ksi
5X XX	Alu - Magnesium. Increases strength	Non heat treatable	18-51 ksi
6X XX	Alu Magnesium and Silicon Creates a unique compound magnesium silicide Mg_2Si. Allows special heat treat properties, suitable for extrusion components	Heat treatable	18 - 58 ksi

7X XX	Alu- Zinc. When you add zinc copper and magnesium you get a heat treatable alum alloy of very high strength.	Heat treatable	32 -88 ksi

The typical weld characteristics of steel or stainless don't apply when welding aluminum. Aluminum has higher thermal conductivity and lower melting temperatures, both factors will influence weld solidification & weld burn through potential.

WROUGHT ALLOYS : CHEMICAL COMPOSITION LIMITS :
TABLE F :

Printable Form:

Alloy (ISS)		Equivalent Alloy (AA)	Copper		Magnesium		Silicon		Iron	Manganese		*Others (Total)	Remarks
Old	New		Min	Max	Min	Max	Min	Max	max	Min	Max	Max	
1 C	19000	1100		0.1				0.5	0.6		0.1	0.1	Alu. 99.0 %
		1200		0.05			Si + Fe 1.0				0.05	0.1	Alu. 99.0 %
1 B	19500	1050		0.05				0.25	0.4		0.05	0.1	Alu. 99.5 %
1 E	19501			0.04				0.15	0.35		0.03	0.1	Alu. 99.5 %
	19600	1060		0.05				0.25	0.35		0.03	0.1	Alu. 99.6 %
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	
N 3	31000	3003		0.1		0.1		0.6	0.7	1	1.5	0.4	
N 4	52000	5052		0.1	1.7	2.6		0.6	0.5		0.5	0.4	Cr + Mn = 0.5
N 5	53000	5086		0.1	2.8	4		0.6	0.5		0.5	0.4	Cr + Mn = 0.5
N 8	54300	5083		0.1	4	4.9		0.4	0.7	0.5	1	0.4	Chromium up to 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		
91 E	63401	6101		0.05	0.4	0.9	0.3	0.7	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 up to 0.25
		7018		0.2	1.2	1.4		0.35	0.4	0.05	0.5	0.15	Zn 3.5 - 4.5

* Titanium and / or other grain refining elements
** Either Mn or Cr Shall be present.

Wrought aluminum alloys are alloys that are rolled from ingot or extruded.

Designations for Wrought and Cast Aluminium Alloys

The main alloying elements are 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 G describes the system for wrought alloys. Cast alloys have similar designations and use a five digit system (table G).

Table G :

Designations for alloyed wrought and cast aluminium alloys :

Major Alloying Element	Wrought	Cast
None (99%+ Aluminium)	1XXX	1XXX0
Copper	2XXX	2XXX0
Silicon +Cu and or Mn	3XXX	
Silicon	4XXX	4XXX0
Magnesium	5XXX	5XXX0
Magnesium + Silicon	6XXX	6XXX0
Zinc	7XXX	7XXX0
Lithium	8XXX	
Unused		9XXX0

Alloys can also be divided into a cast group of alloys. Cast alloys are those used to manufacture parts from molten alloys of aluminum poured into moulds. Cast alloys are precipitation hardenable but never strain hardenable. The weldability of cast alloys is affected by casting type - permanent mould, die cast, and sand. A three-digit number, plus one decimal i.e. 2xxx designates the copper cast alloys.

Cast Aluminum Alloy Designations:

Aluminum Casts have three digits and one decimal place (XXX.X.

XXX .X (.X - .O= casting - .1 or .2 = ingot)
If a capital letter precedes the numbers this is a modified version.

Weldable grades of aluminum castings are
319.0, 355.0, 356.0, 443.0, 444.0, 520.0, 535.0, 710.0 and 712.0.

Aluminum Descriptions :

1XXX. Minimum 99% aluminum: (i)This very low strength series is considered non -heat treatable and is used primarily for Electrical bus bars and some pipe and chemical tanks.

(ii) This alloy provides superior corrosion resistance.

(iii) Alloys with purity levels greater than 99.5% are used for electrical conductors. (for example alloy 1350).

(iv) 1XXX series are easily welded with 1100 and 4043 alloys.

2XXX. Alu-Copper : (i) This contains approx. 2 to 6% Cu with small amounts of other elements. The Cu increases strength and enables precipitation hardening.

(ii) The 2XXX series is mainly used in the aerospace industry. Most of the 2XXX alloys have poor weldability due to their sensitivity to hot cracking.

(iii) These alloys are generally welded with 4043 or 4145 series filler electrodes. These filler metals have low melting points which help reduce the probability of hot cracking. Exceptions to this are alloys 2014, 2219 and 2519, which are readily welded with 2319 filler wires.

(iv) Hot cracking sensitivity in these Al-Cu alloys increases as copper is added up to 3% and decreases when the copper is above 4.5% Be ware of Alloy 2024 as it is crack sensitive.

3XXX. Alu-Manganese: (i)when added to aluminum produces a moderate strength, non -heat treatable series typically used for radiators, cooking pans, air conditioning components and beverage containers and storage equipment.

(ii) The 3XXX series is improved through strain hardening which provides improved corrosion properties and improved ductility.

(iii) Typically welded with 4043 or 5356 electrode, the 3XXX series is excellent for welding and not prone to hot cracking.

(iv) The Moderate strength of this series prevent these alloys from being utilized in specific fabrication or structural applications.

4XXX. Alu-Silicon : (i) Silicon reduces melting temperature improves fluidity. The most common use is as a welding filler material.

(ii) The 4xxx-series alloys have limited industrial application in wrought form. If magnesium added it produces a precipitation hardening, heat treatable alloy.

(iii) The 4XXX series has good weldability and can be a non-heat-treatable and heat treatable alloy. Used for castings, weld wires.

5XXX. Alu-Magnesium : (i) Magnesium Content increases mechanical properties through solid solution strengthening and improves strain hardening potential.

(ii) These alloys have excellent weldability with a minimal loss of strength. The 5XXX series has lower tendency for hot cracking. The 5XXX series provide the highest strength of the non heat-treatable aluminum alloys.

(iii) These alloys are used for cryo vessels, chemical storage tanks, auto parts, pressure vessels at elevated temperatures, cryogenic vessels as well as structural applications, railway cars, trailers, dump trucks and bridges because of the corrosion resistance.

(iv) 5xxx looses ductility when welded with 4xxx series fillers due to formation of Mg2Si.

6XXX. Alu-Magnesium & Silicon : (i)Magnesium-silicides combine to serve as alloying elements for this medium-strength, heat-treatable series.

(ii) 6XXX are principally used in automotive, pipe, structural, railings and extruded parts.

(iii) This series is prone to hot cracking, but this problem can be overcome by the correct choice of joint and filler metal and weld procedures that minimize weld heat input. This series can be welded with either 5XXX or 4XXX series, adequate dilution of the base alloys with selected filler alloy is essential. 4043 electrode is the most common filler metal for this series.

(iv) Be ware of liquation cracking in the Heat Affecting Zone when using specific 5xxx alloys.

6xxx Crack Sensitivity: (i) As many of the 6xxx alloys have 1.0% magnesium silicide, these alloys are crack sensitive. Avoid welding without filler metal and do not use a 6xxx material as a filler metal. Using 4xxx or 5xxx filler metals reduces crack sensititivity as long as sufficient weld metal is added and good weld dilution occurs with the 6xxx base metals.

(ii) Avoid weld joints in which minimal weld dilution occurs, a vee prep is superior to a square groove. All 6xxx aluminum applications that have concave welds and concave craters are sensitive to hot cracks.

7XXX. Alu-Zinc : (i) Zinc when added to aluminum with magnesium and copper permits precipitation hardening and produces the highest strength heat-treatable aluminum alloy.

(ii) These alloys are primarily used in the aircraft industry, armoured vehicles and bike frames.

(iii) The weldability of the 7XXX series is compromised in higher copper grades, as many of these grades are crack sensitive (due to wide melting ranges and low solidous melting temperatures.) And susceptible to stress corrosion cracking.

(iv) Grades 7005 and 7039 are weldable with 5XXX fillers.

7xxx Crack Sensitivity: (i)The 7xxx Al-Zn-Mg alloys (typically welded with 5356 avoid 4043) resist hot cracking better than the 7xxx Al-Zn-Mg-Cu alloys.

8XXX : (i) Other elements that are alloyed with aluminum (i.e. lithium) all fall under this series. Most of these alloys are not commonly welded, though they offer very good rigidity and are principally used in the aerospace industry.

(ii) Filler metal selection for these heat-treatable alloys include the 4XXX series.

Aluminum Welding :

The reason why aluminum is specified for so many jobs is aluminum alloys can provide unique physical properties.

Weight: Aluminum is three times lighter than steel and yet aluminium can provide higher strength when alloyed with specific elements.

Conductivity. Aluminum can conduct electricity six times better than steel. With alum being more sluggish and less fluid, aluminum can be welded in all positions with spray and pulsed with relative ease. In contrast to steel the high conductivity of aluminum acts as a heat sink making weld fusion and weld penetration more difficult to achieve.

Non Magnetic. Since its non-magnetic, arc blow is not a problem during aluminum welding.

Thermal Conductivity. With a thermal conductivity rate that is five times higher than steel and the aluminum welds

Data on Aluminum Alloys : Welding is not recommended on alum casts 242 - 520 - 535 - 705 - 707 - 710 - 711 - 713 – 771.Check filler recommendations to ensure color match, crack resistance, strength, ductility, or corrosion resistance. Also clarify if heat treatmant required.

Non Heat Treatable are used in the strain hardened (WORK HARDENED) condition to improve the alloys mechanical properties. While welding, the weld heat will return the HAZ to its annealed condition. This condition typically reduces the strength in the HAZ area.

Heat Treatable alum alloys are often in the T-4 or T-6 condition, solution heat treated and naturally aged, or solution heat treated and artificially aged. These metals after heat treat provide optimum mechanical properties. Weld heat (time and temperature) will change these properties. Typically the result of a weld is a partial anneal and an overaging affect.

The bottom line, the reduction in mechanical properties of the heat treated alum alloys is greatly affected by the "time and temp" of the weld. Minimum preheat, low weld paramerters, welds made at high speeds, stringer rather than weaves, along with low weld interpass temperatures can minimize the heat effects, however you will experience a considerable loss in the tensile properties in the HAZ adjacent the weld.

1XXX Series Aluminum Alloys Min 99% Aluminum. Non Heat Treatable. Ultimate tensile 10 - 27 ksi. Selected for superior corrosion resistance. Typically welded with matching alloy or 4xxx filler.		
Alloy	Designation	Alloy Content / Description
1XXX 99% min alum. Non Heat Treat. 1050	UNS A91050 ASTM B 491 UNI 4507 Italy P-ALP99.5 USA/UK/Japan/ISO/ Germany = Al 99.5	99.5% Alum
1050-H16		Tensile 19 ksi 130 MPa Yield 18ksi 125 MPa
1060	UNS A91060 ASTM B209 SAE J454 AMS 4000	99.6% Alum Melts 1195F
1060-H14		Tensile 14 ksi Yield 13 ksi
1100	UNS A91100 AMS 4001 ASTM B209 SAE J454 ISO/Germany AL99.0	99% Alum + 0.12 Cu Melts 1190F This series used for cooking containers food and chemical handling
1100-H16		Tensile 21 ksi Yield 20 ksi
1100-O		Tensile 13 ksi Yield 5 ksi
1xxx and 3xxx welded with 1xxx potential for excess porosity on components > 6 mm consider 60 helium 40 argon		
2XXX Aluminum Alloys Aluminum Copper, Heat Treatable. Ultimate Tensile Strength 27 to 62 ksi. High strength high performance alloys often used in aero space. Some are none weldable as susceptibility to hot cracking or stress corrosion cracking. For the weldable grades these are typically welded with high strength 2xxx filler metals, or 4xxx		
2011		welding not recommended
2014	Germany AlCuSiMn Italy P-AlCu4.4 Si/Mn/Mg UNI 3581	93.5% Alum Si 0.8 Cu 4.4 - Mn 0.8 - Mg 0.5 Melts 950F - 510C
2014 -O		Tensile 27ksi Yield 14 ksi
2014- T4	T-4 or T-6 = solution heat treated and naturally aged or solution heat treated and artifically aged. Weldiing the T-4-6 parts effects the mechanical properties. Typically an anneal and overage effect reducing tensile strength especially in HAZ. To minimize erffects low preheats and low interpass temp	Tensile 62 ksi Yield 42 ksi

2024	UNS A92024 AMS 4007 SAE J454 Germany AlCuMg2 Ittaly PAlCu4.5Mn UNI 3583	93.5 Aluminum - Cu4.4 Mg 1.5 - Mn 0.6 Melts 935F 500C Higher strength than 1XXX Used for Aircraft component, hardware, rivets, wheels etc. NOTE NOT WELDABLE if weld susceptable to stress corrosion cracking after welding that can cause delayed failures.
2024-T4 - T351		Tensile 68 ksi Yield 47 ksi
2024 - O		Tensile 27 ksi Yield 11 ksi As this alloy contains a small amount of Mg the hot cracking potential in the grain boundary area is increased. Use lowest heat input avoid mult-pass welds.
2036	UNS A92036	96.7 Aluminum Cu 2.6 - Mg 0.45 - Mn 0.25 Melts 1030F
2036 - T4		Tensile 49 ksi Yield 28 ksi
2048		94.8 Alum - Cu 3.3 - Mn 0.4 Mg 1.5 Tensile 66 ksi 455 MPa Yield 60 ksi
2090		Li 1.9 - 2.6 - Cu 2.4 - 30 Zr 0.08 - 0.15
2219		93 Aluminum Cu 6.3 - Mn 0.3 Ti-V-Zr Melt range 1010 - 1190F 543 - 620C. With the Cu above 4.5% hot cracking snsitivity decreased
2219-T81		Tensile 66 ksi Yield 51 ksi
2219-O		Tensile 25 ksi Yield 11 ksi
2219-31-351		Tensile 52 ksi Yield 36 ksi
3XXX Aluminum Series Aluminum - Manganese. Non Heat Treatable Ultimate Tensile 16 to 41 ksi. Moderate strength, good corrosion resistance, good for high temp use. Typically welded with 1xxx - 4xxx - 5xxx		
3003	Germany AlMnCu UNI 7788 Italy P-AlMn1.2Cu	98.6 Alum - Cu 0.12 - Mn 1.2 Good Forming Good Weldability Used For Food Handling Air conditioning or heat exchangers. Melt 1190F
3003-O		Tensile 16 ksi Yield 6 ksi
3003-H14		Tensile 22 ksi Yield 21 ksi
3003-H18		Tensile 29 ksi Yield 27 ksi

3004	Germany AlMn1Mg1 Italy PAlMn1.2Mg	97.8 Aluminum Mn 1.2 - Mg 1 Melt Range 1165 - 1205F 630 - 650C
3004-O		Tensile 26 ksi Yield 10 ksi
3004 - H34		Tensile 35 ksi Yield 29 ksi
Weld Note: potential for excess porosity on components > 6 mm consider 60 helium 40 argon		
4XXX Aluminum Series Aluminum - Silicon, Heat Treatable and Non Heat Treatable. Ultimate tensile strength 25 - 55 ksi. Silicon reduces lower melting temp, improves fluidity, often used for weld electrodes. If the 4xxx contains magnesium or copper instead of silicon these alloy are usually heat treatable and used when the welds will be subject to post weld heat treat.		
4032		85% Aluminum Si 12.2 - Cu 0.9 Mg 1.0 Ni 0.9
4032-T6	UNS A994032	Tensile 55 ksi 380 MPa Yield 46 ksi 315 MPa
5XXX Aluminum Aluminum - Magnesium range 0.2 to 6.2%. None Heat Treatable. Ultimate tensile strength 18-51 ksi. These readily weldable alloys have the highest strength of the none heat treatable alum alloys.		
5005	Italy PAlMg0.8 UNI 5764 - 66	99.2 Aluminum - Mg 0.8 Melt 1170F Similar to 3003
5005-H16		Tensile 26 ksi Yield 25 ksi
5005-O		Tensile 18 ksi Yield 6 ksi
5050		98.6 Aluminum - Mg 1.4 Used for Appliance Trim, Auto oil and gas lines Melt Temp 1155 - 1205F 620 - 650C
5050-H34		Tensile 28 ksi Yield 24 ksi
5050-O		Tensile 21 ksi Yield 8 ksi

5052	Germany AlMg2.5 Italy P AlMg2.5	97.2 Aluminum - Mg 2.5-Cr 0.25 Melt Range 1125 - 1200F 605 - 650C Air Conditioners, Heat Exchangers, Aircraft Fuel Lines, Fuel Tanks Street Lights, Appliances
5052-O		Tensile 28 ksi Yield 13 ksi
5052 - H34		Tensile 38 ksi Yield 31 ksi
5056	UNS A95056 Germany AlMg5 Italy P-AlMg5 UNI 3576	95.5 Aluminum - Mg 5 Mn 0.12 - Cr 0.12 Wire products, Screens
5056 - H18		Tensile 28 ksi Yield 13 ksi
5056 -O		Tensile 42 ksi Yield 22 ksi
5083- 5 Mgis the highest strength non-heat-treatable alloy in commercial use. 5083 provides good formability and weldability. 5083 has excellent tensile strength in the weld zone as a result of its as-rolled properties. 5083 is used for ships hulls and the construction of tactical military vehicles. 5083 is also used in highly stressed welded assemblies, cryogenic vessels, dump truck boxes and storage tanks. 5083 has excellent resistance to corrosion.		
5086	UNS A95086 Germany AlMg4Mn Italy P AlMg4.4 UNI 5452-64	95.4 Aluminum - Mg 4.0 Mn 0.4 - Cr 0.15 Melt 1085F. Used for medium strength applications, marine tanks, trucks. This alloy has good weldability and is more formable than alloy 5083. As this alloy is resistant to stress corrosion cracking and exfoliation, it also has wide application in the marine industry. Corrosion resistance is excellent.
5086-O		Tensile 38 ksi Yield 17 ksi
5086 - H32- 116 0 117		Tensile 42 ksi Yield 30 ksi
5154	Germany AlMg3.5	96.2 Aluminum Mg 3.5-Cr 0.25 Melt 1100 Tanks, trailers, trucks, pressure vessels
5154-O		Tensile 35 ksi Yield 17 ksi
5154-H36		Tensile 45 ksi Yield 36 ksi
5454	Germany AlMg2.7Mn Italy P-AlMg2.7Mn	96.3 Aluminum Mg 2.7 Mn 0.8 Cr 0.12 Car wheels Suitable for temperature applications due to limit on Mg
5454-O		Tensile 36 ksi Yield 17 ksi

5454-H36		Tensile 49 ksi Yield 40 ksi Melt Range 1115F - 1195F 600 - 650C
5456	UNS A95456	93.9 Aluminum Mn 0.8 Cr 0.12 - Mg 5.1 Medium strength truck, structural and marine. Melt 1055F
5456 - O		Tensile 45 ksi Yield 23 ksi
5456-H321-116		Tensile 51 ksi Yield 27 ksi
5456-H321-116		Tensile 51 ksi Yield 27 ksi
5457		98.7 Aluminum Mg 0.3 Mn 0.3 Melt range 1165- 1210F 630 - 655 C
5457-O		Tensile 19 ksi Yield 6 ksi
5457 -H25		Tensile 19 ksi Yield 7 ksi
5457-H28		Tensile 30 ksi Yield 27 ksi

Metric Conversion of Filler Strength. ksi x 6.894 = MPa

Aluminum Alloy	Designation	Alloy Content / Description
5652		97.2 Mg 2.5 - Cr 0.25 Melt range 1125 1200F 605 - 650C
5652 - O		Tensile 28 ksi Yield 13 ksi
5652 -H32		Tensile 33 ksi Yield 28 ksi
5652 - H34		Tensile 38 ksi Yield 31 ksi
5657		99.2 Aluminum Mg 0.8 Melt 1175F
5657 - H-28-38		Tensile 28 ksi Yield 24 ksi
5657 - H25		Tensile 23 ksi Yield 20 ksi
6XXX Aluminum Series Aluminum Magnesium Silicon, (magnesium silicides for heat treatment). Ultimate tensile 18 - 58 ksi. Fabrication, Extrusions. These alloys are solidification crack sensitive, dont weld without filler metal. Typically welded with 4xxx and 5xxx		
6005	Germany AlMgSi0.7	98.7 Aluminum Si 0.8 Mg 0.5
6005-T1		Tensile 25 ksi Yield 15 ksi

6005-T5		Tensile 38 ksi Yield 35 ksi
6351		97.8 Aluminum Si 1.0 Mn 0.6 Mg 0.6
6351 - T4		Tensile 36 ksi Yield 22 ksi
6351 -T6		Tensile 45 ksi Yield 41 ksi
6061	Germany AlMgSiCu UNI 6170-68 Italy P - AlMg1SiCu	98.5 Aluminum Si 0.7 Mg 0.8 6061 is a heat-treatable grade widely used in light to medium strength structural applications. such as aircraft, marine, furniture, air conditioning and heat exchanger components.These alloys have good corrosion resistance and weldability and possesses good formability in the 0 to T4 tempers. 6061 loses appreciable strength when welded and it is replaced by the 5000 series alloys where afterweld strength is a prime consideration.
6XXX IS OFTEN MANUFACTURED AS EXTRUDED COMPONENTS		
6061-O		Tensile 18 ksi Yield 8 ksi
6061-T6-651		Tensile 45 ksi Yield 40 ksi
6061-T4-451	UNS A96061	Tensile 35 ksi Yield 21 ksi
6063		98.9 Aluminum Si 0.4 Mg 0.7 Tube, pipe, hardware
6063-O		Tensile 13 ksi Yield 7 ksi
6063-T6		Tensile 35 ksi Yield 31 ksi
6066		95.7 Aluminum Si1.4 Cu 1 - Mn0.8 Mg 1.1
6066-O		Tensile 22 ksi Yield 12 ksi
6066-T4-451		Tensile 52 ksi Yield 30 ksi
6070		96.8 Aluminum Si 1.4 Cu 0.28 Mn 0.7 Mg 0.8
6070-O		Tensile 21 ksi Yield 10 ksi
6070-T4		Tensile 46 ksi Yield 20 ksi
6151		98.2 Aluminum Si 0.9 Mg0.6 - Cr 0.25 Forgings auto parts
6151-T6		Tensile 32 ksi

		Yield 28 ksi
6205		98.4 Aluminum Si 0.8 Mn 0.1 Mg 0.5 - Cr 0.1 Zr 0.1
6205-T1		Tensile 38 ksi Yield 20 ksi
6205-T5		Tensile 45 ksi Yield 42 ksi
6262		96.8 Aluminum Si 0.6 Cu 0.28 Mg 1- Cr 0.09 - Bi 0.6 - Pb 0.6
6262 - T9		Tensile 58 ksi Yield 55 ksi
6351		97.8 Aluminum Si 1.0 Mn Mg 0.6
6351-T4		Tensile 36 ksi Yield 22 ksi
6463		98.9 Aluminum Si 0.4 Mg 0.7
6463-T1		Tensile 22 ksi Yield 13 ksi
7XXX Aluminum Aluminum Zinc. Heat Treatable. Ultimate tensile strength 32 - 88 ksi. Provide the highest strength aluminum alloys aircraft, auto, sports equipment. Some weldable some unweldable. Often welded with 5xxx alloys.		
7005	Al - Zn - Mg alloys	93.5 Aluminum Mn 0.45- Mg1.4 Cr 0.13- Zn 4.5 - Ti 0.04- Zr0.14. Resists hot cracking better than Al - Zn - Mg - Cu alloys such as 7075. Usually welded with 5356 enough magnesium to prevent cracking. Avoid 4043 as the Si can make the welds brittle.
7005-O		Tensile 28 ksi Yield 12 ksi
7005-T53		Tensile 57 ksi Yield 50 ksi
7075	Germany AlZnMgCu1.5 Italy P - AlZn5.8MgCu UNI 3735	90 Aluminum Cu 1.6 Mg 2.5 Cr 0.23 Zn 5.6 High sttrength Aircraft and structural Melt 890 - 1175F Unweldable, if welded stress corrosion cracks can occur, (delayed cracking potential)
7075-O		Tensile 38 ksi Yield 15 ksi
7075-T6 T651		Tensile 83 ksi Yield 73 ksi
7178		welding not recommended on this wrought alloy
7475		90.3 Aluminum Si 1.5 Mg 2.3 Cr 0.22 Zn 5.7
7475-T61		Tensile 76 ksi Yield 67 ksi

Warning: To avoid cracks. Mixing alloys as typically occurs in welding disimiler aluminum alloys can increase the crack sensitivity. When selecting the aluminum filler metal, examine the base alloy and filler alloy combination and avoid a final mix of alloys high in both Mg and Cu content.

Aluminum Filler Metal Selection	
ALUMINUM ALLOY	FILLER METAL SELECTION AWS A5-10. Use first choice. Confirm choice with wire manufacturer
Aluminum 2011 / 7075/ 7178 Wrought Alloys	Welding not recommended
Aluminum Casts - 242 / 520 / 535 / 705 / 707 / 710 / 711 / 713 / 771	Welding not recommended
Aluminum 1060 to 319- 333 - 354 -355 - 380	Use 4145 or 4043
Aluminum 1060 to 413 - 443 - 444 - 356 - 357 - 359 -	Use 4043 or 4047
Aluminum 1060 to 514 / 5454 / 5154 / 5254 /	Use 4043 - 5183 - 5356
Aluminum 1060 to 7005/7939/712/6070/ 5052/5652	Use 4043 - 4047
Aluminum 1060 to 6061 / 6063 / 6101 /6151 6201/ 6951/	Use 4043 - 4047
Aluminum 1060 to 5456 5086 / 5083	Use 5356 - 4043
Aluminum 1060 to 5005 5050 / 1100 / 3003	Use 1100 - 4043
Aluminum 1060 to 3004	Use 4043
Aluminum 1060 to 1060	Use 1260 - 1060
Aluminum 1060 to 2014 / 2024	Use 4145
Aluminum 1100 and 3003 to 319 - 333 354 - 355 - 380	Use 4145 - 4043
Aluminum 1100 and 3003 to 413 - 443 - 44 - 356 - 357 - 359 - 6067	Use 4043 - 4047
Aluminum 1100 and 3003 to 514 - 5545 - 5154- 5254 - 5052 - 5652	Use 4043 - 5183
Aluminum 1100 and 3003 to 6951	Use 4043 4047
Aluminum 1100 and 3003 to 1060	Use 1260 - 4043
Aluminum 1100 and 3003 to 5456 - 5086 - 5083	Use 5356 - 4043
Aluminum 1100 and 3003 to 2014 - 2024 - 2219	Use 4145
Aluminum 1100 and 3003 to 5005 - 5050 - 3004	Use 4043 - 5183
Aluminum 1100 and 3003 to 1100 - 3003	Use 1100 - 4043
Aluminum 2014 and 2024 to 319 - 33 -354 - 355 - 380	Use 4145 - 2319
Aluminum 2014 and 2024 to 413 - 443 - 444 - 356 - 357 - 359	Use 4145
Aluminum 2014 and 2024 to 6067- 6061 -	Use 4145

6063 -6101 - 6151 -6201 -6951	
Aluminum 2014 and 2024 to 2219 - 2014 - 2024 -	Use 4145 - 2319
Aluminum 2090	Use 2319 - 4047- 4145 Note limited crack sensitivity
Aluminum 2219 to 319 - 333- 354 - 355 - 380	Use 4145 - 2319
Aluminum 2219 to 413 - 443 - 444 - 356 - 357 - 359 -	Use 4145 - 4043
Aluminum 2219 to 514 7005 - 7939 - 712	Use 4043 - 4047
Aluminum 2219 to 6070 - 6063 - 6101 - 6151 - 6201 - 6951	Use 4043 - 4145
Aluminum 2219 to 5456 - 5086 -5083 5005 - 5050 3004	Use 4043
Aluminum 2219 to 5154 - 5254 - 5052 5652	Use 4043 - 4047
Aluminum 2219 to 2219	Use 2319
Aluminum 2519 - T87 to 2519 - T87	Use 2319
Aluminum 2519- T87 to 5083 H131	Use 4043
Aluminum 5005 - 5050 - 3004 to 319 333 - 354 - 355 - 380	Use 4043 - 4047
Aluminum 5005 - 5050 3004 to 413 -443 - 444 - 356 - 357 - 359 -	Use 4043 - 4047
Aluminum 5005 - 5050 3004 to 514 - 5154 - 5254	Use 5654 - 5183
Aluminum 5005 - 5050 3004 to 7005 - 7939 - 712 - 5083	Use 5356 - 5183
Aluminum 5005 - 5050 3004 to 6070 - 5052 - 5652 - 5005 - 3004 -	Use 4043 - 5183
Aluminum 5005 - 5050 - 3004 to 6061 - 6101 - 6063 - 6151 - 6201 -6951-	Use 4043 - 5183
Aluminum 5005 - 5050 - 3004 to 5456 - 5086 - 5083 -	Use 5356 - 5183
Aluminum 5005 - 5050 - 3004 to 5454 - 5154 - 5254 -	Use 5654 - 5183
Aluminum 5005 - 5050 - 3004 to 3004	Use 4043 - 5183
Aluminum 5052 - 5652 to 319 - 333 - 354 - 355 - 380	Use 4043 - 4047
Aluminum 5052 - 5652 to 413 443 - 444 - 456 - 357 - 359	Use 4043 - 5183
Aluminum 5052 - 5652 to 514 - 5454 - 5154 - 5254 -	Use 5654 - 5183
Aluminum 5052 - 5652 to 7005 - 7039 - 712 - 5086 - 5083	Use 5356 - 5183
Aluminum 5052 - 5652 to 6070 5456	Use 5366 - 5188
Aluminum 5052 - 5652 to 6061 - 6063 - 6101 - 6151 - 6201 - 6951	Use 5356 - 5183
Aluminum 5083 to 413 - 443 - 440 - 356 - 357 - 359 - 514 - 6070 - 5454	Use 5356 - 5183
Aluminum 5083 to 7005 - 7939 - 712 - 5456 - 5083	Use 5183 - 5356
Aluminum 5083 to 6061 - 6063 - 6101 -6151	Use 5356 - 5183

- 6201 -6951	
Aluminum 5083 to 5154 - 5254 - 5086	Use 5356 - 5183
Aluminum 5083 to 5083	Use 5183 - 5356
Aluminum 5083 to 6070	Use 5356 - 5183
Aluminum 5086 to 413 - 443 - 440 -356 - 357 - 359	Use 5356 - 4043
Aluminum 5086 to 514 - 7005 - 7939 - 712 - 6070 - 6061 - 6063 - 6101	Use 5356 - 5183
Aluminum 5086 to 6151 - 6201 - 6951- 5456 - 5086	Use 5356 - 5183
Aluminum 5086 to 5454 - 5154 - 5254 -	Use 5356 - 5183
Aluminum 5154 5254 5454 to 413 - 443 - 444 - 356 - 357 - 359 -	Use 4043 - 5183
Aluminum 5154 5254 to 514 - 5454 -	Use 5654 - 5183
Aluminum 5154 -5254 - 5454 to 700 - 7939 - 712 - 6070 - 6061 -6063	Use 5356 - 5183
Aluminum 5154 -5254 - 5454 to 6101 - 6151 - 6201 - 6951 - 5456 -	Use 5356 - 5183
Aluminum 5454 to 5454	Use 5554 - 4043
Aluminum 6061 - 6063 - 6101 - 6201 -6151 - 6951 to 319 - 333 - 354 - 355 - 380 -	Use 4145 - 4043
Aluminum 6061 - 6063 - 6101 - 6201 -6151 - 6951 to 514 - 7005 - 7939 - 712	Use 5356 - 5183
Aluminum 6061 to 60XX	Use 4043 - 5183
Aluminum 7004 to 1060 - 1100 1350 - 3003 -5052 - 5083 - 5086	Use 5356
Aluminum 7004 to 5454 - 6061 - 6063 - 6351 -7004	Use 5356
Aluminum 7005 - 7039 - 712 - to 319 - 333 - 3544 - 355 - 380 - 413 - 443 - 444 - 356-79 -	Use 4043
Aluminum 7005 - 7039 - 712 to 514	Use 5356
Aluminum 7005 - 7039 - 712 to 7005 7939 - 712	Use 5039
Aluminum 514 to 413- 443- 444 - 356 - 357 - 359	Use 4043 5183
Aluminum 514 to 514	Use 5654 - 5183
Aluminum 413 - 443 - 444 - 356 - to 319 - 333 - 354 - 355 - 380	Use 4145 - 4043
Aluminum 413 - 443 - 444 - 356 to 413 443 - 4444 - 356 - 357 - 359	Use 4043 or same as base
Aluminum 356 - 357 - 359 - to 319 - 333 - 354 - 355 - 380	Use 4145 or same as base

TABLE H :

Printable Form:

Heat Treatable Alloys					
Alloy AA Old (ISS) New (ISS)	Temper	Ultimate Tensile Strength kg/mm^2		0.2 %Proof Stress Kg / mm2	Elongation on 50 mm OL
		Minimum	Maximum		

2014 [H15] [24345]	T 4[W] T6[WP]	39 49	- -	24.0 43.0	10 6
2017 [H14] [24534]	T4[W]	39	-	24.0	10
2024 [H9]	T4	40.5	-	26.5	12
6063 [H9] [63400]	T 4[W] T6[WP]	14 19	- -	8.0 15.5	14 7
6061 [H20] [65032]	M T 4[W] T6[WP]	11.2 19 28.5	- - -	5.1 11.5 24.0	12 14 7
6351 [H30] [64430]	M T 4[W] T6[WP]	11.2 19 31.5	- - -	8.2 12.0 27.5	12 14 7
6066	M T 4[W] T6[WP]	11.0 28 35	- - -	- 17.5 31.5	12 14 7
6101 [91 E] [63401]	T 4[W] T6[WP]	14 20.5	- -	8.0 17.0	12 10
6201 [64401]	T 4[W] T8[WDP]	16 32	- -	7.0 -	14 3
7039 [74530]	T 4[W] T6[WP]	28 31.5	- -	23.5 26.5	9 7
7018	T6[WP]	40	-	34.4	6

The properties given here are for information only.However properties in specific alloy shall be as per I.S.Specification.

Aluminum alloys difficult to weld :

Alloys that may be sensitive to hot cracking are found in the 2xxx series, alum-copper and in the 7xxx series alum-zinc.

With the 2xxx series hot cracking sensitivity increases with Cu < 3% and decreases with Cu > 4.5%. Avoid weld practices that promote high heat input as grain boundary segregation cracking potential.

7xxx alloys that contain Al-Zn-Mg like 7005 resist hot cracking and have better mechanical weld properties than Al-Zn-Mg-Cu alloys like 7075 that contain small amounts of Mg and Cu which extend the coherance range increasing the crack sensitivity. Zirconium is added to refine grain size and reduce crack potential. Electrode 5356 is often recommended for this group as the magnesium helps prevent cracking. The 4043 electrode would provide excess Si promoting brittle Mg2Si particles in the welds.

Be careful when welding dissimiler alum alloys as extending the coherance range increases the crack sensitivity. When welding alloys that do have good weldability like welding a 5xxx alloy to a 2xxx base alloy or a 2xxx filler on a 5xxx alloy and vice a versa you can end up with high Mg and Cu and increase the coherence range increasing the crack sensitivity.

Wrought alloys: Typical tensile properties at various temperatures (Kg/mm^2)

TABLE – I

Alloy & Temper	Tensile Strength	Temp °C Below zero			Temp °C Above zero						
		-200	-80	-25	25	100	150	200	250	300	350
1100M (19000)	Ultimate Yield	17.5 4.2	10.5 3.9	10.0 3.5	9.0 3.5	7.0 3.2	5.5 3.0	4.0 2.4	3.0 2.0	2.0 1.4	1.5 1.1
2014 T6* (24345)	Ultimate Yield	59.0 50.0	52.0 45.5	50.54 43.5	49 42	44.0 40.0	28.0 24.5	11.0 9.0	6.0 5.0	4.5 3.5	3.0 2.5
2017 T4	Ultimate	56.0	45.5	45.0	43.5	40.0	28.0	11.0	6.5	4.0	3.0

(24534)	Yield	37.0	29.5	29.0	28.0	27.5	21.0	9.0	5.0	3.5	2.5
3003 M (31000)	Ultimate Yield	23.0 6.0	14.0 5.0	12.0 4.5	11.0 4.0	9.0 4.0	7.5 3.5	6.0 3.0	4.0 2.5	3.0 1.7	2.0 1.3
5052 M (52000)	Ultimate Yield	31.0 11.0	20.5 9.0	19.5 9.0	19.5 9.0	19.0 9.0	16.0 9.0	12.0 7.5	8.5 5.0	5.0 4.0	3.5 2.0
5086 M (53000)	Ultimate Yield	38.5 17.0	27.5 15.0	26.5 15.0	26.5 5.0	26.5 15.0	20.5 13.5	15.5 12.0	12.0 7.5	7.5 5.0	4.0 3.0
6061 T4 (65032)	Ultimate Yield	35.0 19.5	26.5 15.5	25.0 15.5	24.5 14.5	- -	21.0 14.5	13.5 10.5	5.0 3.8	3.0 1.8	2.0 1.5
6061 T6	Ultimate Yield	49.0 33.0	34.5 29.5	33.0 28.5	31.5 28.0	29.5 26.5	24.0 21.5	13.5 10.5	5.0 3.5	3.2 1.9	2.1 1.3
6063 T4 (63400)	Ultimate Yield	26.0 12.0	20.5 12.0	19.5 10.5	15.5 9.0	- -	15.5 9.0	6.5 4.5	3.5 2.8	2.1 1.8	1.8 1.4
6063 T6	Ultimate Yield	33.0 25.0	26.5 23.0	25.0 22.5	24.5 21.5	21.5 19.5	14.5 14.0	6.5 4.5	3.0 2.5	2.5 1.8	1.6 1.4

*Subject to special enquiry

TABLE – J

Printable Form:

Wrought Aluminium & Aluminium Alloys: Mechanical and Electical Properties

Alloy		Temper Designation	Tensile Strength Min.	0.2 Percent Proof Stress Min	Percent Elongation on 5.65 √Sa Min.	Electrical Conductivity at 20°C	Maximum Electrical Resistivity at 20°C	Thickness	Inside bendradius Min.	Coeff. Off termal expansion	Thermal Conductivity
AA	IS		Mpa	Mpa		%IACS	Ohm mm/ mm^2	mm		Per °C at 20°C typical	CGS at 25°C typical
1050	19501	M	60	-	25	60.00	0.02874	Upto 12	1 x thicknes s	23.8 x 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	1 x thicknes s	23.4 x 10^{-6}	0.52
6101	63401	WP (range 2)	200	170	10	55.00	0.03135	3.00 to 9.50	2 x thicknes s	23.4 x 10^{-6}	0.52
6201	-	T81	-	-		52.50	0.03283			2.5 x 10^{-6}	0.50

Notes:

1Mpa=1N/mm^2 = 0.102 kg/ mm^2

Properties in M temper are only typical values and are given for information only.
If required the cross-section shall be calculated form the mass and length of a straight test piece taking density 2.705 for grade 19501 and 2.700 for grade 63401

Table K.Some common aluminium alloys, their characteristics and common uses.

Abbr : * = most commonly used alloys, S = sheet, P = plate and E = extrusions

Alloy	Characteristics	Common Uses	Form
1050/1200	Good ductility, weldability and corrosion resistance	Food and chemical industry.	S,P
2014A	Heat treatable. High strength. Non-weldable. Poor corrosion reistance.	Airframes.	E,P
3103/3003	Non-heat treatable. Medium strength work hardening alloy. Good weldability, formability and corrosion resistance.	Vehicle panelling, structures exposed to marine atmospsheres, mine cages.	S,P,E
5251/5052	Non-heat treatable. Medium strength work hardening alloy. Good weldability, formability and corrosion resistance.	Vehicle panelling, structures exposed to marine atmospsheres, mine cages.	S,P
5454*	Non-heat treatable. Used at temperatures from 65-200°C. Good weldability and corrosion resistance.	Pressure vessels and road tankers. Transport of ammonium nitrate, petroleum. Chemical plants.	S,P
5083*/5182	Non-heat treatable. Good weldability and corrosion resistance. Very resistant to sea water, industrial atmospheres. A superior alloy for cryogenic use (in annealed condition)	Pressure vessels and road transport applications below 65°C. Ship building structure in general.	S,P,E
6063*	Heat treatable. Medium strength alloy. Good weldability and corrosion resistance. Used for intricate profiles.	Architectural extrusions (internal and external), window frames, irrigation pipes.	E
6061*/6082*	Heat treatable. Medium strength alloy. Good weldability and corrosion resistance.	Stressed structural members, bridges, cranes, roof trusses, beer barrels.	S,P,E
6005A	Heat treatable. Properties very similar to 6082. Preferable as air quenchable, therefore has less distortion problems. Not notch sensitive.	Thin walled wide extrusions.	E

7020	Heat treatable. Age hardens naturally therefore will recover properties in heat affected zone after welding. Susceptible to stress corrosion. Good ballistic deterrent properties.	Armoured vehicles, military bridges, motor cycle and bicycle frames.	P,E
7075	Heat treatable. Very high strength. Non-weldable. Poor corrosion resistance.	Airframes.	E,P

Wrought alloys: Available For
&
Area Of Usage:

TABLE – L

Alloy	T	R	Wo	M	Br	We	available forms	Area of usage
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	Packing lightly stresses and decorative asemblies in architecture and transport, equipment for chemical, food and berwing 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 engineeing.
2017 (H 14) (24534)	T4	C	C	B	D	C	Rods & Bars	Highly stressed parts in aircraft and oher 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 atractive 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 sructures, 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.
6101 (91 E) (63401)	T4 T6	A A	B B	C C	A A	A A	Rods, Flats, Tubes & other sections	High strength electircal 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	Flat, Tubes, Rods & other sections	Defence structures like mobile bridges etc. Tread and chequered plates. Excellent weling property with no loss of strength in welded zone.
7075 (DTD) 5124)	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 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

ABBREVIATIONS FOR ABOVE 'L' TABULAR :
T – Temper
R – Resistance to Corrosion
Wo – Workability (Cold)
M – Machinability
Br – Brazeability
We– Weldability

Aluminium Designations : Aluminum alloys can be classified by a temper designation.

O = Annealed,
T = Thermally treated,
F = As fabricated,
H = Strain hardened;
W = Solution heat-treated which can designated both heat treatment, or cold working aging.

Designations for Wrought Alloys

These alloys fall into two distinct categories
1. Those which derive their properties from work hardening.
2. Those which depend upon solution heat treatment and age hardening.

Work Hardened Aluminium Alloys :

The 1000, 3000 and 5000 series alloys have their properties adjusted by cold work, usually by cold rolling.
The properties of these alloys depend upon the degree of cold work and whether any annealing or stabilising thermal treatment follows the cold work. A standardised nomenclature is used to describe these conditions.
It uses a letter, O, F or H followed by one or more numbers. It is presented in summary form in Table 4 and defined in Table 6.

Printable Form:

Table 4. Standard nomenclature for work hardened aluminium alloys.

New Symbol	Description	Old BS Symbol
O	Annealed, soft	O
F	As fabricated	M
H12	Strain-hardened, quarter hard	H2
H14	Strain-hardened, half hard	H4
H16	Strain-hardened, three quarter hard	H6
H18	Strain-hardened, fully hard	H8
H22	Strain-hardened, partially annealed quarter hard	H2
H24	Strain-hardened, partially annealed half hard	H4
H26	Strain-hardened, partially annealed three quarter hard	H6
H28	Strain-hardened, partially annealed fully hard	H8

H32	Strain-hardened and stabilised, quarter hard	H2
H34	Strain-hardened and stabilised, half hard	H4
H36	Strain-hardened and stabilised, three quarter hard	H6
H38	Strain-hardened and stabilised, fully hard	H8

Table 5. Explanations of symbols used in table 4.

Term	Description
Cold Work	The nomenclature denotes the degree of cold work imposed on the metal by using the letter H followed by numbers. The first number indicates how the temper is achieved.
H1x	Strain-hardened only to obtain the desired strength without supplementary thermal treatment.
H2x	Strain-hardened and partially annealed. These designations apply to products which are strain-hardened more than the desired final amount and then reduced in strength to the desired level by partial annealing. For alloys that age-soften at room temperature, the H2x tempers have the same minimum ultimate tensile strength as the corresponding H3x tempers. For other alloys, the H2x tempers have the same minimum ultimate tensile strength as the corresponding H1x tempers and slightly higher elongation.
H3x	Strain-hardened and stabilised. These designations apply to products which are strain-hardened and whose mechanical properties are stabilised either by a low temperature thermal treatment or as a result of heat introduced during fabrication. Stabilisation usually improves ductility. This designation is applicable only to those alloys which, unless stabilised , gradually age soften at room temperature.
H4x	H4x Strain-hardened and lacquered or painted. These designations apply to products which are strain-hardened and which may be subjected to some partial annealing during the thermal curing which follows the painting or lacquering operation. The second number after H indicates the final degree of strain-hardening, number 8 being the hardest normally indicated. The third digit after H, when used, indicates a variation of a two digit temper. It is used when the degree of control of temper or the mechanical properties or both differ from, but are close to, that (or those) for the two digit H temper designation to which it is added, or when some other characteristic is significantly affected. The fully soft annealed condition is indicated by the letter O and the `as fabricated' ie material that has received no subsequent treatment is indicated as F. To illustrate; it can be seen that 3103-0 denotes a particular aluminium manganese alloy in the annealed, soft condition, whilst 3103-H16 denotes the same alloy strain-hardened to three quarters hard.

To illustrate this, by reference to Tables 2 and 4, we can see that 3103-0 is an aluminium manganese alloy in the soft annealed condition and 3103-H16 is the same alloy three quarters hard.
With the flexibility of compositions, degree of cold work and variation of annealing and temperature a wide range of mechanical properties can be achieved especially in sheet products.

Solution Heat Treated and Age Hardened Aluminium Alloys

The 2000, 4000, 6000, 7000 and 8000 series alloys respond in this way.
The wide choice of alloy compositions, solution heat treatment temperatures and times, quench rates from temperature, choice of artificial ageing treatment and degree to which the final product has been deformed permit a wide range of properties to be achieved. A system of standard designations is used, based upon the letter T followed a number after the alloy designation, to describe the various conditions. These are defined in Table 6.

Table 6. Definition of heat treatment designations for aluminium and aluminium alloys.

Term	Description
T1	Cooled from an elevated temperature shaping process and naturally aged to a substantially stable condition. This designation applies to products which are not cold worked after cooling from an elevated temperature shaping process, or in which the effect of cold work in flattening or straightening has no effect on mechanical properties

T2	Cooled from an elevated temperature shaping process, cold worked and naturally aged to a substantially stable condition. This designation applies to products which are cold worked to improve strength after cooling from an elevated temperature shaping process, or in which the effect of cold work in flattening or straightening does have an effect on mechanical properties.
T3	Solution heat-treated, cold worked and naturally aged to a substantially stable condition. This designation applies to products which are cold worked to improve strength after solution heat-treatment, or in which the effect of cold work in flattening or straightening does have an effect on mechanical properties.
T4	Solution heat-treated and naturally aged to a substantially stable condition. This designation applies to products which are not cold worked after solution heat-treatment, or in which the effect of cold work in flattening or straightening does not effect mechanical properties.
T5	Cooled from an elevated temperature shaping process and then artificially aged. This designation applies to products which are not cold worked after cooling from an elevated temperature shaping process, or in which the effect of cold work in flattening or straightening does not effect mechanical properties.
T6	Solution heat-treated and then artificially aged. This designation applies to products which are not cold worked after solution heat-treatment, or in which the effect of cold work in flattening or straightening does not effect mechanical properties.
T7	T7 Solution heat-treated and overaged/stabilised This designation applies to products which are artificially aged after solution heat-treatment to carry them beyond a point of maximum strength to provide control of some significant characteristic other than mechanical properties.

The 2000, 4000, 6000, 7000 and 8000 series alloys respond in this way.
The wide choice of alloy compositions, solution heat treatment temperatures and times, quench rates from temperature, choice of artificial ageing treatment and degree to which the final product has been deformed permit a wide range of properties to be achieved. A system of standard designations is used, based upon the letter T followed a number after the alloy designation, to describe the various conditions. These are defined in Table 6.