Aluminum Alloy

Types and overview of aluminum alloy

Alloy system	Classification code	Overview
Al-Cu	A2011 A2014 A2017 A2024	2017 and 2024, known as duralumin and super duralumin, are representative, with high strength comparable with steel materials. Its machinability is good and especially 2011 with addition of Pb and Bi is widely used for machine components as free-cutting alloy. 2014 can be applied to various usages as a high-strength cast material. It contains a relatively high amount of copper, so it is less corrosion-resistant. Sufficient anti-corrosion treatment is required if it is exposed in a corrosive environment.
Al-Mn	A3003 A3004	3003 is the representative alloy, having improved strength without impairing processing properties and corrosion resistance of pure aluminum with the addition of Mn. This can be applied to various usages such as ware, building materials and containers, etc. Further, 3004, which is an alloy equivalent to 3003 with addition of 1% Mg, has higher strength and is widely used for aluminum cans, roof panels and door panel materials, etc.
Al-Si	A4032	4032 has thermal expansion ratio suppressed and abrasion resistance improved by addition of Si and also heat resistance improved by addition of about 1% Cu, Ni and Mn each. For its excellent heat resistance and less thermal expansion, it is a suitable material for cast pistons.
Al-Mg	A5005 A5052 A5083	A representative alloy with less Mg addition is 5005, which is used for vehicle interior ceiling plates, building materials and ware materials, etc. A representative alloy with content of medium amount of Mg is 5052, which is the most typical material among medium strength materials. 5083 having high Mg content is a non-heat-treated alloy and has the highest strength among non-heat-treated alloys, as well as good weldability. Therefore, it is used for marine, automotive and chemical plants as a welding structure material.
Al-Mg-Si	A6061 A6063	This alloy type has excellent strength and corrosion resistance and is used as a structure material. 6061 has strength improved by addition of small amount of Cu. Although its corrosion resistance is a bit lower, it has an excellent casting property, so it is used for rivet materials and small automobile components. If the durability is 254N/mm^2 or above and deflection is not an issue in the design, it has an advantage of the allowable stress equivalent to that of SS400 steel. Strength of 6063 is low but it has an excellent extrusion property. So it is used as a structure material that does not have to be as strong as 6061.
Al-Zn	A7075 A7N01	This can be classified into Al-Zn-Mg-Cu alloys which have the highest strength among aluminum alloys and Al-Zn-Mg alloys for welding structure without Cu content. A representative alloy of Al-Zn-Mg-Cu alloys is 7075, which is used for aircrafts and sporting goods, etc. While having relatively high strength, Al-Zn-Mg alloys can restore its heated section to the strength level close to that of the base material due to natural aging after welding, which results in excellent joint efficiency. 7N01 is the representative alloy and used for train cars, etc. as a material for welding structure.

Chemical components of aluminum alloy

Classification code	Chemical components (%)									
	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al	Others
A2011	0.4 or less	0.7 or less	5.0 - 6.0	–	–	–	0.30 or less	–	Remaining part	Pb : 0.20 - 0.6
A2014	0.50 - 1.2	0.7 or less	3.9 - 5.0	0.40 - 1.2	0.20 - 0.8	0.10 or less	0.25 or less	–	Remaining part	Zr+Ti: 0.20 or less
A2017	0.20 - 0.8	0.7 or less	3.5 - 4.5	0.40 - 1.0	0.40 - 0.8	0.10 or less	0.25 or less	–	Remaining part	Zr+Ti: 0.20 or less
A2024	0.5 or less	0.5 or less	3.8 - 4.9	0.30 - 0.9	1.2 - 1.8	0.10 or less	0.25 or less	–	Remaining part	Zr+Ti: 0.20 or less
A3003	0.6 or less	0.7 or less	0.05 - 0.20	1.0 - 1.5	–	–	0.10 or less	–	Remaining part	–
A3004	0.3 or less	0.7 or less	0.25 or less	1.0 - 1.5	0.8 - 1.3	–	0.25 or less	–	Remaining part	–
A4032	11.0 - 13.5	1.0 or less	0.50 - 1.3	–	0.8 - 1.3	0.10 or less	0.25 or less	–	Remaining part	Ni : 0.50 - 1.3
A5005	0.3 or less	0.7 or less	0.20 or less	0.20 or less	0.50 - 1.1	0.10 or less	0.25 or less	–	Remaining part	–
A5052	0.25 or less	0.4 or less	0.10 or less	0.10 or less	2.2 - 2.8	0.15 - 0.35	0.10 or less	–	Remaining part	–
A5083	0.4 or less	0.4 or less	0.10 or less	0.40 - 1.0	4.0 - 4.9	0.05 - 0.25	0.25 or less	0.15 or less	Remaining part	–
A6061	0.40 - 0.8	0.7 or less	0.15 - 0.40	0.15 or less	0.8 - 1.2	0.04 - 0.35	0.25 or less	0.15 or less	Remaining part	–
A6063	0.20 - 0.6	0.35 or less	0.10 or less	0.10 or less	0.45 - 0.9	0.10 or less	0.10 or less	0.10 or less	Remaining part	–
A7075	0.4 or less	0.5 or less	1.2 - 2.0	0.30 or less	2.1 - 2.9	0.18 - 0.28	5.1 - 6.1	0.20 or less	Remaining part	Zr+Ti : 0.25

Temper symbols of aluminum alloy; excerpt from JIS H 0001-1998

Symbol	Definition	Meaning
F	As is manufactured	What can be achieved from the manufacturing processes without special adjustment for processing hardening or heat treatment.
O	Annealed	For wrought materials, annealed to achieve the softest state. For castings, annealed to increase the extension or stabilize the dimensions.
H	Process-hardened	Alloy with strength improved by processing hardening regardless of presence/absence of additional heat treatment to achieve appropriate softness.
T	Alloy that became stable temper other than F, O and H by heat treatment	Heat-treated alloy that became stable temper regardless of additional processing hardening.

Subordinate symbol	Meaning
H1	Process hardening only: Alloy that is process-hardened only without additional heat treatment to achieve prescribed mechanical properties.
H2	Appropriate softening heat treatment after process hardening: After process hardening to above the prescribed value, the strength is decreased to the prescribed level by appropriate heat treatment. For alloys that is softened by aging at the normal temperature, this temper has the strength equivalent to H3 temper. For other alloys, this temper has the strength equivalent to H1 temper, but its extension is a bit higher.
H3	Stabilization treatment after process hardening: Process-hardened products stabilized by low-temperature heating. This decreases its strength but increases the extension. This stabilization treatment only applies to alloys containing magnesium that is gradually softened due to aging at the normal temperature.
T1	Natural aging after cooling from hot processing: The alloy subject to natural aging to sufficiently stable state without active cold processing after cooling from the hot manufacturing process as performed for extruded materials. Therefore, the effect of cold processing is small even after correction.
T2	Cold processing after cooling from hot processing and then natural aging: The alloy subject to natural aging to sufficiently stable state after active cold processing to reinforce the strength after cooling from the hot manufacturing process as performed for extruded materials.
T3	Cold processing after solution treatment and then natural aging: The alloy subject to natural aging to sufficiently stable state after active cold processing to reinforce the strength after solution treatment.
T4	Solution treatment and then natural aging: The alloy subject to natural aging to sufficiently stable state without cold processing after solution treatment. Therefore, the effect of cold processing is small even after correction.
T5	Artificial age-hardening after cooling from hot processing: The alloy subject to artificial age-hardening treatment without active cold processing after cooling from hot manufacturing processes as performed for castings or extruded materials. Therefore, the effect of cold processing is small even after correction.
T6	Artificial age-hardening treatment after solution treatment: The alloy subject to artificial age-hardening treatment without active cold processing after solution treatment. Therefore, the effect of cold processing is small even after correction.
T7	Stabilization treatment after solution treatment: The alloy subject to excessive aging treatment beyond the artificial age-hardening treatment condition to achieve the maximum strength in order to adjust to special characteristics after solution treatment.
T8	Cold processing after solution treatment and then artificial age-hardening treatment: The alloy subject to artificial age-hardening treatment after active cold processing to reinforce the strength after solution treatment.
T9	Artificial age-hardening treatment after solution treatment and then cold processing: The alloy subject to artificial age-hardening treatment after solution treatment, and then cold processing to reinforce the strength.

Mechanical properties of aluminum alloy

Type (JIS name)	Temper	Tensile strength (N/mm^2)	Durability (N/mm^2)	Extension (%)	Brinell hardness (HBS 10/500)	Fatigue strength* (N/mm^2)
A2014	T6	485	415	13	135	125
A2017	O	180	70	22	45	90
A2024	T4	470	325	20	120	140
A3003	O	110	40	30	28	50
A4032	T6	380	315	9	120	110
A5052	H38	290	255	7	77	140
A5083	H116	315	230	16	–	160
A6061	T6	310	275	12	95	95
A6063	T6	240	215	12	73	70
A7075	T6	570	505	11	150	160
A7N01	T5	345	295	15	100	125

*Indicating fatigue strength of 50 x 10^7 cycles by rotary bending.

● Values in the above table are for reference only. They are not guaranteed values.