Major Alloying Elements

The following table represents the major aluminum alloy series and their principal constituents. Aluminum alloys are grouped by major alloying elements; each series exhibits a unique set of properties and characteristics.

Wrought Alloy Designation	Major Alloying Elements and Typical Alloy Characteristics
1xxx Series	**Minimum 99% aluminum** High Corrosion resistance. Excellent finishability. Easily joined by all methods. Low strength. Poor machinability. Excellent workability. High electrical and thermal conductivity.
2xxx Series	**Copper** High strength. Relatively low corrosion resistance. Excellent machinability. Heat treatable.
3xxx Series	**Manganese** Low to medium strength. Good corrosion resistance. Poor machinability. Good workability.
4xxx Series	**Silicon** Not available as extruded products.
5xxx Series	**Magnesium** Low to moderate strength. Excellent marine corrosion resistance. Very good weldability.
6xxx Series	**Magnesium & Silicon** Most popular extrusion alloy class. Good strength. Good extrudability. Good strength. Good corrosion resistance. Good machinability. Good weldability. Good formability. Heat treatable.
7xxx Series	**Zinc** Very high strength. Poor corrosion resistance. Good machinability. Heat treatable.

Effects of Alloying Elements

The addition of alloying elements modifies the properties and characteristics of aluminum. Such aspects as density, electrical and thermal conductivity, thermal expansion, mechanical properties, ability to finish and harden, and corrosion resistance are all affected by combining the alloying elements with aluminum.

Manganese, for example, increases the mechanical strength of alloys in the 3xxx group. Zinc, in combination with magnesium and copper, produces a material that can be age-hardened, as in alloys 7075. Hard alloys such as 7075 must be thermally treated away from the extrusion press in a separate furnace. Alloys vary in their relative ease of extrudability. Many extrude easily, others are considered relatively easy, while a few are quite difficult to extrude and require procedures that slow the process. Alloys 6063, 6101, and 6463, for example, are rated as having excellent extrudability, while 7075 and 7178 are categorized as difficult to extrude.

Because of its adaptability to a number of large-volume uses, its many favorable characteristics, and its ease of extrudability, 6063 is used to produce a large percentage of aluminum profiles. New, cutting-edge aluminum alloys are being developed to produce even stronger, lighter extrusions for use in aviation and deep-space vehicles. Aluminum-lithium is one of the new alloy classes. Lithium, one of the lightest metals known, is about one-fifth as dense as aluminum. When combined with aluminum into a new alloy, it is 7– to 10–percent lighter and up to 30–percent stiffer than conventional aircraft alloys.

New alloys are periodically introduced to satisfy the changing needs of the marketplace. Designers and specifiers are encouraged to discuss with extruders the best-suited alloys for any given application.

New, cutting-edge alloys, including aluminum lithium, are being developed for aerospace applications.

Tempers

All aluminum alloys, regardless of product form, are classified as either heat-treatable or nonheat-treatable. Those alloys classified as nonheat-treatable develop maximum strength characteristics through cold work after extruding, if section shape permits. Nonheat-treatable alloys are found in the 1xxx, 3xxx, and 5xxx series.

Heat-treatable alloys attain their maximum strength through controlled heat treatment. This group has the highest strength of all aluminum alloys and includes the 2xxx, 6xxx, and 7xxx series.

The Temper Designation System lists the modification methods applied to heat-treatable and nonheat-treatable alloys:

F As Extruded: No special control over thermal conditions or strain-hardening; no mechanical property limits.

O Annealed: thermally treated to obtain the lowest strength temper.

H Strain-hardened: Cold working used to increase strength and hardness.

T Thermally Treated: Thermally treated to produce stable tempers other than F, O, or H.

A complete alloy-temper designation reads like this: “6063-T5.” This designation indicates a particular alloy of the 6xxx series (Mg and Si) which is thermally treated by being cooled from an elevated temperature and artificially aged.

Typical Tempers for Extrusions

O Fully annealed.

H112 Strain-hardened; used for nonheat-treatable alloys.

T1 Cooled from an elevated temperature and naturally aged.

T4 Solution heat-treated and naturally aged.

T5 Cooled from an elevated temperature and naturally aged.

T6 Solution heat-treated[1.] and naturally aged.

1. For some alloys, this may be accomplished in-line at the extrusion press.

Aluminum is combined with other elements, such as magnesium, silicone or zinc to produce extrusion alloys. Structural and certain physical properties are influenced significantly by the choice of alloy and temper.