

Aluminum Tempers

Aluminum is a lightweight structural material that can be strengthened through alloying and, depending upon composition, further strengthened by heat treatment and/or cold working. Among its advantages for specific applications are:

Low density, high strength-to-weight ratio, good corrosion resistance, ease of fabrication and diversity of form.

Wrought and cast alloys are identified by a four-digit number, the first digit of which generally identifies the major alloying element as shown in the table below. For casting alloys, the fourth digit is separated from the first three digits by a decimal point and indicates the form i.e., cast or ingot.

Number Element

IXXX	997. Mn. Aluminum
IXX.X	997. Mm. Aluminum
2XXX	Copper
2XX.X	Copper
3XXX	Manganese 3SS.S Silicon with added copper and/or magnesium
4XXX	Silicon
4XX.X	Silicon
5XXX	Magnesium
5XX.X	Magnesium
6XXX	Magnesium and Silicon
7XXX	Zinc
7XX.X	Zinc
8XXX	Other Elements
8XX.X	Tin
9XXX	Unused Series
9XX.X	Other Elements

Basic Aluminum Temper Designations

The temper designation appears as a hyphenated suffix to the basic alloy number. An example would be 7075-T73 where T73 is the temper designation. Four basic temper designations are used for aluminum alloys. They are -F: as fabricated; -O: annealed; -H: strain hardened and -T: thermally treated. A fifth designation, -W, is used to describe an as - quenched condition between solution heat treatment and artificial or room temperature aging. Following is a list of tempers which define aluminum alloys.

-H111: Applies to products which are strain hardened less than the amount required for a controlled H11 temper.

-H212: Applies to products which acquire some temper from shaping processes not having special control over the amount of strain-hardening or thermal treatment, but for which there are mechanical property limits.

The following H temper designations have been assigned for wrought products in alloys containing over a nominal 4 percent magnesium.

-H311: Applies to products which are strain-hardened less than the amount for a controlled H31 temper.

-H321: Applies to products which are strain-hardened less than the amount for a controlled H32 temper.

-H323: Applies to products which are specially fabricated to have acceptable resistance to stress corrosion cracking.

Products which are thermally treated with or without supplementary strain-hardening are designated with a –T temper. The T is followed by a digit or digits which designate the specific thermal treatment. Temper designations for aluminum alloys are as follows:

-T1: Cooled from an elevated temperature shaping process and naturally aged to a substantially stable condition.

-T2: Annealed (cast products only).

-T3: Solution heat treated and then cold worked. Applies to products which are cold worked to improve strength or in which the effect of cold work in flattening or straightening is recognized in mechanical property limits.

-T31: Solution heat treated and then cold worked by flattening or stretching. Applies to 2219 and 2024 sheet and plate per MIL-A-8920. Also applies to rivets driven cold immediately after solution heat treatment or cold storage. 2024 rivets are an example.

-T351: Solution heat treatment and stress relieved by stretching. This is equivalent to –T4 condition. It applies to 2024 plate and rolled bar and 2219 plate per MIL-A-8920.

-T3511: Solution heat treated and stress relieved by stretching with minor stretching allowed. This is equivalent to –T4 condition and applies to 2024 extrusions.

-T36: Solution heat treated and then cold worked by a reduction of 6 percent. Applies to 2024 sheet and plate.

-T37: Solution heat treated and then cold worked by a reduction of 7 percent. Applies to 2219 sheet and plate.

-T4: Solution heat treated and naturally aged to a substantially stable condition. Applies to products which are not cold worked after solution heat treatment, or in which the effect of cold work in flattening or straightening may not be recognized in mechanical property limits.

-T42: Solution heat treated and naturally aged by the user to a substantially stable condition. Applies to 2014-0 and 2024-0 plate and extrusions which are heat treated by the user from the annealed condition.

-T451: Solution heat treated and stress relieved by stretching with minor straightening allowed. Equivalent to –T4 and applies to all extrusions except 2024 and 2219.

-T5: Cooled from an elevated temperature shaping process and then artificially aged.

-T51: Cooled from an elevated temperature shaping process, stress-relieved by stretching and then artificially aged.

-T52: Cooled from an elevated temperature shaping process, stress-relieved by compressing and then artificially aged.

-T54: Cooled from an elevated temperature shaping process, stress-relieved by stretching and compressing and then artificially aged. Applies to die forgings which are stress-relieved by striking cold in the finish die.

-T6: Solution heat treated and then artificially aged. Mechanical property limits not affected by cold working. Most alloys in the –w and –T4 conditions artificially aged to –T6.

-T61: Solution heat treated and then artificially aged. Applies to forgings which receive a boiling water quench to avoid internal quenching stress. Applies to solution heat treated and artificially aged castings when more than one aging cycle is available for that alloy.

-T611: Solution heat treated and artificially aged. Applies only to 7079 forgings which are quenched in 1750 to 185°F water.

-T62: Solution heat treated and then artificially aged by the user. Applies to any temper which has been heat treated and aged by user which attains mechanical properties different from those of the –T6 condition.

-T651: Solution heat treated, stress-relieved by stretching and artificially aged. Equivalent to –T6 and applies to plate and rolled bar except 2219.

-T6510: Solution heat treated, stress-relieved by stretching and artificially aged with no hard straightening. Equivalent to –T6 and applies to extruded rod, bar and shapes except 2024.

-T6511: Solution heat treated, stress-relieved by stretching and artificially aged with minor straightening. Equivalent to –T5 and applies to extruded rod, bar and shapes except 2024.

-T652: Solution heat treated, stress-relieved by compressive deformation and artificially aged. Equivalent to –T6 and applies to hard forged squares, rectangles and simple shaped die forgings except 2219.

-T7: Solution heat treated and then stabilized. Applies to products which are stabilized to carry them beyond the point of maximum strength to provide control of growth and residual stress.

-T73: Solution heat treated and then specially artificially aged. Applies to 7075 alloys which have been specially aged to make the material resistant to stress-corrosion.

-T7352: Solution heat treated and specially artificially aged. Applies to 7075 alloy forgings which have both compression-stress relief and special aging to make the material resistant to stress-corrosion.

-T8: Solution heat treated, cold worked and then artificially aged. Applies to products which are cold worked to improve strength, or in which the effect of cold work in flattening or straightening is recognized in the mechanical property limits.

-T81: Solution heat treated, cold worked and then artificially aged. Applies to 2024T3 artificially aged to T-81.

-T-851: Solution heat treated, stress-relieved by stretching and artificially aged. Applicable to plate, rolled bar and rod.

-T8511: Solution heat treated, stress-relieved by stretching and artificially aged. Applies to 2024 extrusions and 2219.

-T86: Solution heat treated, cold worked by a thickness reduction of 10 percent and then artificially aged. Applies to 2219 sheet and plate.

T9: Solution heat treated, artificially aged and then cold worked. Applies to products which are cold worked to improve strength.

-T10: Cooled from an elevated temperature shaping process, artificially aged and then cold worked. Applies to products which are artificially aged after cooling from an elevated temperature shaping process, such as casting or extrusion and then cold worked to further improve strength.