Aluminum Alloys and Temper Designations 101

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Aluminum Classifications for Wrought Alloys

Wrought alloys are classified by composition using a 4 digit number.
The first digit specifies the major alloying element(s), their atomic symbol(s) / Element name(s) are shown below:

Series	Element Names (in order of %)	Atomic Symbols	Treatable Status
1xxx	Super- or commercial-purity aluminum		Non-heat-treatable
2xxx	Aluminum-Copper-Magnesium	Al-Cu(-Mg)	Heat-treatable
3xxx	Aluminum-Manganese-Magnesium	Al-Mn(-Mg)	Non-heat-treatable
4xxx	Aluminum-Silicon	Al-Si	Non-heat-treatable
5xxx	Aluminum-Magnesium	Al-Mg	Non-heat-treatable
6xxx	Aluminum-Magnesium-Silicon	Al-Mg-Si	Heat-treatable
7xxx	Aluminum-Zinc-Magnesium-Copper	Al-Zn-Mg(-Cu)	Heat-treatable
8xxx	Aluminum-Lithium- Etc…	Al-Li-Other Elements	Non-heat-treatable
9xxx	Unused Series		

Each series has it's own unique properties and some of them have been listed below.

"1xxx Series" Super- and commercial-purity aluminum

- Non-heat treatable alloys containing at least 99.0% Al. Other significant elements are Fe and Si.
  General Properties:
  - High thermal and electrical conductivities
  - Poor mechanical properties
  - Good workability
  - Excellent corrosion resistance
  - Examples...
    1050, 1100, 1200, 1350

"2xxx Series" Al-Cu and Al-Cu-Mg alloys

- Heat treatable alloys. The major alloying element is copper.
  General Properties:
  - Mechanical properties similar to mild steel.
  - 2xxx alloys have only limited corrosion resistance and are especially prone to intergranular corrosion.
  - Examples...
    2024, 2219, 2618

"3xxx Series" Al-Mn(-Mg) alloys

- Non heat treatable alloys containing manganese as the major alloying element. Trace elements, such as Cu are common.
  General Properties:
  - Medium strength alloys which are widely used in a range of strain hardened tempers
  - Examples...
    3003, 3104, 3105

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"4xxx Series" Al-Si alloys

- Non heat treatable alloys containing around 12% silicon.
  General Properties:
  - Poor ductility alloys, but this can be improved with the addition of Sr and P
  - Iron impurities decrease the ductility of the materials
  - Examples...
    4045, 4032

"5xxx Series" Al-Mg alloys

- Non heat treatable alloys containing magnesium as the major alloying element.
  General Properties:
  - Moderate to high strength
  - Good corrosion resistance
  - Good weldability
  - Stress corrosion susceptibility at Mg levels > 3%
  - Examples...
    5005, 5454, 5083, 5182

"6xxx Series" Al-Mg-Si alloys

- Heat treatable alloys containing magnesium and silicon.
  General Properties:
  - Less strong than 2xxx and 7xxx alloys
  - Good formability
  - Good corrosion resistance
  - Examples...
    6063, 6151, 6061

"7xxx Series" Al-Zn-Mg(-Cu) alloys

- Heat treatable alloys containing zinc as the major alloying element. Other significant elements are Mg, Cu and Cr.
  General Properties:
  - Very high strength
  - Poor corrosion behavior
  - Moderate fatigue performance
  - Examples...
    7075, 7475

"8xxx Series" Al-Li etc…

- Non-Heat treatable alloys containing lithium.

  - Examples...
    8006, 8011, 8017, 8030, 8079, 8176, 8177

  - Typical uses: aluminum conductors used today in building wire and service cables are more than likely manufactured from an aluminum alloy known as an ACM alloy. ACM stands for Aluminum Conductor Material. ACM alloys are in the Aluminum Association's 8000 series of alloys and are recognized for use in various wire and cable products by standards organizations such as Underwriters Laboratories and the Canadian Standards Association

"9xxx Series" Unused Series

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Aluminum Temper Designations

A descriptive nomenclature providing control to the designation to and the degree of temper applied to wrought aluminum and wrought aluminum alloys for both casted and foundry ingot is provided for by ANSI H35.1-2004. The secretariat to the noted specification is the "American Aluminum Association[1]" Dayco is providing only a synapses of the total data contained there in[2].

The system is based on the sequence of basic treatments used to produce various tempers. The temper designation follows the alloy designation with the two separated by a hyphen.

Basic designations consist of a single letter while subdivisions of those basic tempers, where required, are indicated by one or more numeric digits following those letters. The system is designed to set down specific sequences of fabrication processes, but only those operations that are recognized as significantly influencing the characteristics of the product involved. Should some other variation of the same sequence of basic operations be applied to the same alloy, resulting in different characteristics, the additional digits will be added to the numerical designation. The 5 base designation letters are as follows:

"F"

Basic Temper Designations **F** "As fabricated". Denotes metal that has been fabricated to ordered dimensions without any attempt on the part of the producer to control the results of either strain-hardening operations or thermal treatments. There are no mechanical property limits, and the strength levels may vary form lot to lot and from shipment to shipment.

"O"

Temper Designation **O** "Annealed". Applies to wrought products that have undergone a thermal treatment to reduce their mechanical property levels to their minimums. Often described as "dead soft" metal.

"W"

Temper Designation **W** "Solution heat-treated". An unstable temper applying to certain of the (7XXX) heat-treatable alloys that, after heat treatment, spontaneously age harden at room temperature. Only when the period of natural aging is indicated (W 1hr. for example) is this a specific and complete designation.

"H"

Temper Designation **H** "Strain-hardened". Applies to those wrought products which have had an increase in strength by reduction through strain-hardening or cold working operations.
The "H" is always followed by two or more digits.

"T"

Temper Designation **T** "Thermally treated" to produce tempers other than F, O or H. Applies to those products which have had an increase in strength due to thermal treatments, with or without supplementary strain-hardening operations. The "T" is always followed by one or more digits.

Temper Designations H and T require additional specific detail call-outs, which bring about desired mechanical and physical characteristics to their properties, these can be found on the following pages.

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[1] American Aluminum Association, 900 19th St., NW, Washington, DC 20006

[2] It is recommended that any and all design work should always reference the latest revision of ANSI H35.1

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“H”

- Subdivisions of "H" Temper-Non-Heat-Treatable Alloys
  - H1 Strain-hardened only. Applies to products which are strain-hardened or cold worked to obtain the desired strength level without supplementary thermal treatments. The number following this designation indicates the degree of strain-hardening.
  - H2 Strain-hardened partially annealed. Applies to products strain-hardened or cold worked more than the desired level by partial annealing. The number following this designation indicates the degree of strain hardening remaining after the partial annealing process.
  - H3 Strain-hardened and stabilized. Applies to products in the magnesium-aluminum class which will age-soften at room temperature after strain-hardening. These products are strain-hardened to the desired amount and then subjected to a low temperature thermal operation which results in a improved ductility. The number following this designation indicates the degree of strain-hardening remaining after the stabilization treatment.

- H1x,H2x,H3x The second digit following the designations H1, H2, H3 indicate the final degree of strain hardening. The number 8 has been assigned to tempers having a final degree of strain-hardening equivalent to that resulting from approximately 75 % reduction in area. Tempers between that of the 0 Temper (annealed) and 8 (full hard) are designated by the numbers 1 through 7. A number 4 (which is halfway between 0 and 8) designation is considered half-hard; number 2 is considered quarter-hard; and the number 6 is three-quarter hard. When the number is odd, the limits of ultimate strength are exactly halfway between those of the even numbered tempers.
  - H2 1/4 hard
  - H3 3/8 hard
  - H4 1/2 hard
  - H5 5/8 hard
  - H6 3/4 hard
  - H7 7/8 hard
  - H8 full hard (approximately 75% reduction after a full anneal).
  - H9 extra hard (limited to certain alloys and/or product forms).

- Hxxx The third digit indicates a variation of the two digit H temper. It is used when the degree of temper is close to the 2 digit H temper.
  - H111 Applies to alloys which are strain-hardened less than the amount required for a controlled H11 temper.
  - H112 Applies to alloys that acquire some temper from shaping processes which do not have special control over the amount of strain-hardening or thermal treatment, but for which there are mechanical property limits.
  - H311 Applies to alloys which are strain-hardened less than the amount required for a controlled H31 temper.
  - H321 Applies to alloys which are strain-hardened less than the amount required for a controlled H32 temper.
  - H323 Applies to products which are fabricated to have good resistance to stress corrosion cracking.
- H343 Applies to products which are fabricated to have good resistance to stress corrosion cracking

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“T”

- Subdivisions of "T" Temper-Heat-Treatable Alloys
  - T1 cooled from an elevated temperature shaping process and naturally aged to a substantially stable condition. Usually associated with extruded products and limited to the 6XXX series alloys.
  - T2 cooled from an elevated temperature shaping process, cold worked, and naturally aged to a substantially stable condition. Usually associated with cast products.
  - T3 solution heat-treated, cold worked, and naturally aged to a substantially stable condition. (T4+cold work)
  - T4 solution heat-treated, and naturally aged to a substantially stable condition.
  - T5 cooled from an elevated temperature shaping process and artificially aged. Usually associated with extruded products in the 6XXX series alloys. (T1+artificial age)
  - T6 solution heat-treated, and artificially aged. (T4+artificial age)
  - T7 solution heat-treated, and over-aged/stabilized. Applies to alloy products which are thermally over-aged after solution heat-treatment to carry them beyond the point of maximum strength to provide control of some special characteristic.
  - T8 solution heat-treated, cold worked, and artificially aged. (T3+artificial age)
  - T9 solution heat-treated, artificially aged and cold worked. (T6+artificial age)
  - T10 cooled from an elevated temperature shaping process, cold worked, and artificially aged. Usually associated with cast products.(T2+artificial age)

- The following specific digits have been assigned for stress-relieved tempers of wrought products:
  - T_51 Applies to cold finished rod or bar when stress-relieved by stretching 1 to 3 % permanent set. Stretching is performed after solution heat treatment or after cooling from an elevated temperature shaping process. No straightening takes place after stretching.
  - T_510 Applies to extruded products and to drawn tube when stress-relieved by stretching 1 to 3 % permanent set. Stretching is performed after solution heat treatment or after cooling from an elevated temperature shaping process. No straightening takes place after stretching 1 to 3 % permanent set.
  - T_511 Applies to extruded products and to drawn tube when stress-relieved by stretching 1 to 3 % permanent set. Stretching is performed after solution heat treatment or after cooling from an elevated temperature shaping process. These products may receive minor straightening after stretching to comply with standard tolerances.

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