H3 **strain-hardened and stabilized.** Applies to products that are strain-hardened and whose mechanical properties are stabilized either by a low temperature thermal treatment or as a result of heat introduced during fabrication. Stabilization usually improves ductility. This designation is applicable only to those alloys that, unless stabilized, gradually age-soften at room temperature. The number following this designation indicates the degree of strain-hardening remaining after the stabilization treatment.

H4 **strain-hardened and lacquered or painted.** Applies to products which are strain-hardened and which are subjected to some thermal operation during the subsequent painting or lacquering operation. The number following this designation indicates the degree of strain-hardening remaining after the product has been thermally treated, as part of painting/lacquering cure operation. The corresponding H2X or H3X mechanical property limits apply.

(b) The digit following the designation H1, H2, H3, and H4 indicates the degree of strain-hardening as identified by the minimum value of the ultimate tensile strength. Numeral 8 has been assigned to the hardest tempers normally produced. The minimum tensile strength of tempers HX8 may be determined from Table 1 and is based on the minimum tensile strength of the alloy in the annealed temper. However, temper registrations prior to 1992 that do not conform to the requirements of Table 1 shall not be revised and registrations of intermediate or modified tempers for such alloy/temper systems shall conform to the registration requirements that existed prior to 1992.

Table 1

US Customary Units

Minimum tensile strength in annealed temper *ksi*	*Increase in tensile strength to HX8 temper* *ksi*
up to 6	8
7 to 9	9
10 to 12	10
13 to 15	11
16 to 18	12
19 to 24	13
25 to 30	14
31 to 36	15
37 to 42	16
43 and over	17

Metric Units

Minimum tensile strength in annealed temper *MPa*	*Increase in tensile strength to HX8 temper* *MPa*
up to 40	55
45 to 60	65
65 to 80	75
85 to 100	85
105 to 120	90
125 to 160	95
165 to 200	100
205 to 240	105
245 to 280	110
285 to 320	115
325 and over	120

Tempers between O (annealed) and HX8 are designated by numerals 1 through 7.

(a) Numeral 4 designates tempers whose ultimate tensile strength is approximately midway between that of the O temper and that of the HX8 tempers;

(b) Numeral 2 designates tempers whose ultimate tensile strength is approximately midway between that of the O temper and that of the HX4 tempers;

(c) Numeral 6 designates tempers whose ultimate tensile strength is approximately midway between that of the HX4 tempers and that of the HX8 tempers;

(d) Numerals 1, 3, 5 and 7 designate, similarly, tempers intermediate between those defined above.

(e) Numeral 9 designates tempers whose minimum ultimate tensile strength exceeds that of the HX8 tempers by 2 ksi or more. (For Metric Units by 10 MPa or more).

The ultimate tensile strength of the odd numbered intermediate (-HX1, -HX3, -HX5, and HX7) tempers, determined as described above, shall be rounded to the nearest multiple of 0.5 ksi. (For Metric Units when not ending in 0 or 5 shall be rounded to the next higher 0 or 5 MPa.)

(c) The third digit,[7] 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. (See Appendix for assigned three-digit H tempers.) NOTE: The minimum ultimate tensile strength of a three-digit H temper must be at least as close to that of the corresponding two-digit H temper as it is to the adjacent two-digit H tempers. Products in the H temper whose mechanical properties are below H__1 shall be variations of H__1.

4.2.2 Subdivision of T Temper: Thermally Treated

(a) Numerals 1 through 10 following the T indicate specific sequences of basic treatments, as follows:[8]

T1 **cooled from an elevated temperature shaping process and naturally aged to a substantially stable condition.** Applies to products that are not cold worked after cooling from an elevated temperature shaping process, or in which the effect of cold work in flattening or straightening may not be recognized in mechanical property limits.

T2 **cooled from an elevated temperature shaping process, cold worked, and naturally aged to a substantially stable condition.** Applies to products that 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 is recognized in mechanical property limits.

[7] Numerals 1 through 9 may be arbitrarily assigned as the third digit and registered with the Aluminum Association for an alloy and product to indicate a variation of a two-digit H temper (see note [6]).

[8] A period of natural aging at room temperature may occur between or after the operations listed for the T tempers. Control of this period is exercised when it is metallurgically important.

T3 solution heat-treated,[9] cold worked, and naturally aged to a substantially stable condition. Applies to products that are cold worked to improve strength after solution heat-treatment, or in which the effect of cold work in flattening or straightening is recognized in mechanical property limits.

T4 solution heat-treated [9] and naturally aged to a substantially stable condition. Applies to products that 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.

T5 cooled from an elevated temperature shaping process and then artificially aged. Applies to products that are not cold worked after cooling from an elevated temperature shaping process, or in which the effect of cold work in flattening or straightening may not be recognized in mechanical property limits.

T6 solution heat-treated [9] and then artificially aged. Applies to products that 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.

T7 solution heat-treated[9] and overaged/stabilized. Applies to wrought products that are artificially aged after solution heat-treatment to carry them beyond a point of maximum strength to provide control of some significant characteristic[10]. Applies to cast products that are artificially aged after solution heat-treatment to provide dimensional and strength stability.

T8 solution heat-treated,[9] cold worked, and then artificially aged. Applies to products that are cold worked to improve strength, or in which the effect of cold work in flattening or straightening is recognized in mechanical property limits.

T9 solution heat-treated,[9] artificially aged, and then cold worked. Applies to products that are cold worked to improve strength.

T10 cooled from an elevated temperature shaping process, cold worked, and then artificially aged. Applies to products that are cold worked to improve strength, or in which the effect of cold work in flattening or straightening is recognized in mechanical property limits.

(b) Additional digits,[11] the first of which shall not be zero, may be added to designations T1 through T10 to indicate a variation in treatment that significantly alters the product characteristics that are or would be obtained using the basic treatment. (See Appendix for specific additional digits for T tempers.)

[9] Solution heat treatment is achieved by heating cast or wrought products to a suitable temperature, holding at that temperature long enough to allow constituents to enter into solid solution and cooling rapidly enough to hold the constituents in solution. Some 6xxx and some 7xxx series alloys attain the same specified mechanical properties whether furnace solution heat treated or cooled from an elevated temperature shaping process at a rate rapid enough to hold constituents in solution. In such cases the temper designations T3, T4, T6, T7, T8, and T9 are used to apply to either process and are appropriate designations.

[10] For this purpose, *characteristic* is something other than mechanical properties. The test method and limit used to evaluate material for this characteristic are specified at the time of the temper registration.

[11] Additional digits may be arbitrarily assigned and registered with The Aluminum Association for an alloy and product to indicate a variation of tempers T1 through T10 even though the temper representing the basic treatment has not been registered (see note [6]). Variations in treatment that do not alter the characteristics of the product are considered alternate treatments for which additional digits are not assigned.

APPENDIX

4.3 Variations of O Temper: Annealed

A digit following the O, when used, indicates a product in the annealed condition having special characteristics. NOTE: As the O temper is not part of the strain-hardened (H) series, variations of O temper shall not apply to products that are strain-hardened after annealing and in which the effect of strain-hardening is recognized in the mechanical properties or other characteristics.

A1 Three-Digit H Tempers

(a) The following three-digit H temper designations have been assigned for wrought products in all alloys:

H_11 Applies to products that incur sufficient strain hardening after the final anneal that they fail to qualify as annealed but not so much or so consistent an amount of strain hardening that they qualify as H_1.

H112 Applies to products that may acquire some temper from working at an elevated temperature and for which there are mechanical property limits.

(b) The following three-digit H temper designations have been assigned for

pattern or embossed sheet	fabricated from
H114	O temper
H124, H224, H324	H11, H21, H31 temper, respectively
H134, H234, H334	H12, H22, H32 temper, respectively
H144, H244, H344	H13, H23, H33 temper, respectively
H154, H254, H354	H14, H24, H34 temper, respectively
H164, H264, H364	H15, H25, H35 temper, respectively
H174, H274, H374	H16, H26, H36 temper, respectively
H184, H284, H384	H17, H27, H37 temper, respectively
H194, H294, H394	H18, H28, H38 temper, respectively
H195, H295, H395	H19, H29, H39 temper, respectively

(c) The following three-digit H temper designations have been assigned only for wrought products in the 5xxx series, or which the magnesium content is 3% nominal or more:

H116 Applies to products manufactured from alloys in the 5xxx series, for which the magnesium content is 3% nominal or more. Products are normally strain hardened at the last operation to specified stable tensile property limits and meet specified levels of corrosion resistance in accelerated type corrosion tests. They are suitable for continuous service at temperature no greater than 150^0 F (66^0C). Corrosion tests include inter-granular and exfoliation.

H321 Applies to products from alloys in the 5xxx series, for which the magnesium content is 3% nominal or more. Products are normally thermally stablized at the last operation to specified stable tensile property limits and meet specified levels of corrosion resistance in accelerated type corrosion tests. They are suitable for continuous service at temperatures no greater than 150^0 F (66^0C). Corrosion tests include inter-granular and exfoliation.

A2 Additional Digits for T Tempers

A2.1 Assigned Additional Digits for Stress-Relieved Tempers

The following specific additional digits have been assigned for stress-relieved tempers of wrought products: