

## Aluminium Alloy - Temper Designations

Last Updated 30 January 2020

Aluminium Alloys are supplied in a very wide range of tempers with two principal groups:

**Non-heat treatable alloys** - Alloys whose strength/mechanical properties are achieved by cold working (rolling, extruding, etc.). Sometimes called work hardening alloys, Temper is denoted by letter H.

**Heat treatable alloys** - Alloys whose strength/mechanical properties are achieved by heat treatment followed by cooling and natural or artificial ageing. Temper denoted by letter T.

### HEAT-TREATABLE ALLOYS

**Solution heat treating** - The process of heating aluminium at prescribed temperature for a prescribed time and then cooling rapidly usually by quenching in water.

**Natural ageing (T1, T2, T3, T4)** - The process which occurs spontaneously at ordinary temperature until the metal reaches a stable condition. This hardens the metal after solution heat treatment.

**Artificial ageing (T5, T6, T9)** - The process of heating for a prescribed period (2-30 hours) at a prescribed low temperature (100-200°C) until the metal reaches a stable condition. This hardens/increases strength after solution heat treating quicker than natural ageing and to a greater level.

### NON HEAT-TREATABLE ALLOYS

**Work hardening (H14)** - General term for processes which increase strength of aluminium and reduce the ductility, (e.g. rolling, drawing, pressing, stamping). Sometimes called strain-hardening.

**Partial annealing (H24)** - A heating process which reduces strength and increases ductility of aluminium after work hardening. Sometimes called temper let-down.

**Stabilising (H34)** - A low temperature thermal treatment or heat introduced during manufacture which stabilises the mechanical properties. This process usually improves ductility and is only applied to those alloys which, unless stabilised, gradually age-soften at room temperature, (i.e. non-heat treatable range.) The purpose of stabilising is to relieve the residual internal stress in the metal. Mainly used for 5000 series alloys.

Standard	Scope
H1X	Work hardened.
H2X	Work hardened and partially annealed.
H3X	Work hardened and stabilised by low temperature treatment.
H4X	Work hardened and stoved.
HX2	Quarter-Hard.
HX4	Half-Hard.
HX6	Three-quarter Hard.
HX8	Fully Hardened.

### TEMPER CODES FOR PLATE

Code	Description
H111	Some work hardening imparted by shaping processes but less than required for H11 temper.
H112	Alloys that have some tempering from shaping but no special control over the amount of strain-hardening or thermal treatment. Some strength limits apply.
H321	Strain hardened less than required for a controlled H32 temper.
H323	A version of H32 that has been specially fabricated to provide acceptable resistance to stress corrosion cracking.
H34	Stabilised, Half Hard - A low temperature thermal treatment or heat introduced during manufacture which stabilises the mechanical properties and relieves residual internal stress, usually improves ductility. Only applied to alloys which, unless stabilised, gradually age-soften at room temperature.
H343	H34 specially fabricated to provide acceptable resistance to stress corrosion cracking.
H115	Armour plate.
H116	Special corrosion-resistant temper.

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### FULL LIST OF TEMPER CODES

Code	Description
F	As Fabricated (no property limits specified).
O	Fully Annealed, Soft.
H111	<i>see table on page 1.</i>
H112	<i>see table on page 1.</i>
H115	Armour Plate.
H116	Special corrosion resistant temper.
H12	Work hardened to quarter hard, not annealed after rolling.
H14	Work hardened to half hard, not annealed after rolling.
H16	Work hardened to three-quarter hard, not annealed after rolling.
H18	Work hardened to fully hard, not annealed after rolling.
H19	Work hardened to Extra Hard, not annealed after rolling.
H24	Work hardened then partially annealed to half hard.
H26	Work hardened then partially annealed to three-quarter hard
H28	Work hardened then partially annealed to fully hard.
H32	Work hardened then stabilised by low-temperature heat treatment to quarter hard.
H321	<i>see table on page 1.</i>
H323	<i>see table on page 1.</i>
H34	<i>see table on page 1.</i>
H343	<i>see table on page 1.</i>
H36	Work hardened then stabilised by low-temperature heat treatment to three-quarter hard.
H38	Work hardened then stabilised by low-temperature heat treatment to fully hard.

O	Fully Annealed, Soft.
T1	Cooled from an elevated temperature and naturally aged.
T2	Cooled from an elevated temperature, cold worked and naturally aged.
T3	Solution heat treated, cold worked and naturally aged.
T351	Solution heat treated then stress relieved by stretching - Equivalent to T4 condition.
T352	Solution heat treated, stress relieved by compressing to produce a permanent set of 1% to -5% then naturally aged.
T3510	Solution heat treated and stress relieved by stretching - Equivalent to T4 condition.
T3511	Solution heat treated and stress relieved by stretching - Equivalent to T4 condition.
T36	Solution heat treated then cold worked by a reduction of 6%.
T361	Solution heat treated then stress relieved by stretching.
T4	Solution heat treated and naturally aged to a substantially stable condition.
T42	Solution heat treated and naturally aged to a substantially stable condition.
T451	Solution heat treated then stress relieved by stretching - Equivalent to T4.
T4510	Solution heat treated and stress relieved by stretching - Equivalent to T4 condition.
T4511	Solution heat treated and stress relieved by stretching - Equivalent to T4 condition.
T5	Cooled from an elevated temperature shaping process and artificially aged.
T6	Solution heat treated and artificially aged
T62	Solution heat treated then artificially aged by the user.

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### FULL LIST OF TEMPER CODES (Contiued)

T651	Solution heat treated, stress relieved by stretching then artificially aged.
T6510	Solution heat treated and stress relieved by stretching then artificially aged with no straightening after aging - Equivalent to T4 condition.
T6511	Solution heat treated and stress relieved by stretching then artificially aged with minor straightening after aging - Equivalent to T4 condition.
T7	Solution heat treated then stabilised.
T72	Solution heat treated then specially artificially aged for resistance to stress corrosion.
T73	Solution heat treated then specially artificially aged for resistance to stress corrosion.
T7351	Solution heat treatment then specially artificially aged for resistance to stress corrosion.
T8	Solution heat treated, cold worked then artificially aged.
T81	Solution heat treated, cold worked then artificially aged.
T851	Solution heat treated then stress relieved by stretching then artificially aged.
T8510	Solution heat treated, stress relieved by stretching then artificially aged.
T8511	Solution heat treated, stress relieved by stretching then artificially aged.
T9	Solution heat treated, artificially aged and cold worked.
T10	Cooled from an elevated temperature, artificially aged then cold worked.

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### ALUMINIUM STANDARDS

The old BS1470 standard has been replaced by nine EN standards. The EN standards are given in table 4.

**Table 4.** EN standards for aluminiumTable 2. Typical properties for aluminium.

Standard	Scope
EN485-1	Technical conditions for inspection and delivery
EN485-2	Mechanical properties
EN485-3	Tolerances for hot rolled material
EN485-4	Tolerances for cold rolled material
EN515	Temper designations
EN573-1	Numerical alloy designation system
EN573-2	Chemical symbol designation system
EN573-3	Chemical compositions
EN573-4	Product forms in different alloys

The EN standards differ from the old standard, BS1470 in the following areas:

- Chemical compositions – unchanged.
- Alloy numbering system – unchanged.
- Temper designations for heat treatable alloys now cover a wider range of special tempers. Up to four digits after the T have been introduced for nonstandard applications (e.g. T6151).
- Temper designations for non heat treatable alloys - existing tempers are unchanged but tempers are now more comprehensively defined in terms of how they are created. Soft (O) temper is now H111 and an intermediate temper H112 has been introduced. For alloy 5251 tempers are now shown as H32/H34/H36/H38 (equivalent to H22/H24, etc). H19/H22 & H24 are now shown separately.
- Mechanical properties – remain similar to previous figures. 0.2% Proof Stress must now be quoted on test certificates.

Tolerances have been tightened to various degrees.

### Heat Treatment

A range of heat treatments can be applied to aluminium alloys:

- Homogenisation – the removal of segregation by heating after casting.
- Annealing – used after cold working to soften work-hardening alloys (1XXX, 3XXX and 5XXX).
- Precipitation or age hardening (alloys 2XXX, 6XXX and 7XXX).
- Solution heat treatment before ageing of precipitation hardening alloys.
- Stoving for the curing of coatings

After heat treatment a suffix is added to the designation numbers.

- The suffix F means “as fabricated”.
- O means “annealed wrought products”.
- T means that it has been “heat treated”.
- W means the material has been solution heat treated.
- H refers to non heat treatable alloys that are “cold worked” or “strain hardened”.

The non-heat treatable alloys are those in the 3XXX, 4XXX and 5XXX groups.

**Table 5.** Heat treatment designations for

Term	Description
T1	Cooled from an elevated temperature shaping process and naturally aged.
T2	Cooled from an elevated temperature shaping process cold worked and naturally aged.
T3	Solution heat-treated cold worked and naturally aged to a substantially.
T4	Solution heat-treated and naturally aged to a substantially stable condition.
T5	Cooled from an elevated temperature shaping process and then artificially aged.
T6	Solution heat-treated and then artificially aged.
T7	Solution heat-treated and overaged/stabilised.

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### WORK HARDENING

The non-heat treatable alloys can have their properties adjusted by cold working. Cold rolling is a typical example.

These adjusted properties depend upon the degree of cold work and whether working is followed by any annealing or stabilising thermal treatment.

Nomenclature to describe these treatments uses a letter, O, F or H followed by one or more numbers. As outlined in Table 6, the first number refers to the worked condition and the second number the degree of tempering.

**Table 6.** Non-Heat treatable alloy designations

Term	Description
H1X	Work hardened.
H2X	Work hardened and partially annealed.
H3X	Work hardened and stabilized by low temperature treatment.
H4X	Work hardened and stoved.
HX2	Quarter-hard – degree of working.
HX4	Half-hard – degree of working.
HX6	Three-quarter hard – degree of working.
HX8	Full-hard – degree of working.

**Table 7.** Temper codes for plate

Term	Description
H112	Alloys that have some tempering from shaping but do not have special control over the amount of strain-hardening or thermal treatment. Some strength limits apply.
H321	Strain hardened to an amount less than required for a controlled H32 temper.
H323	A version of H32 that has been specially fabricated to provide acceptable resistance to stress corrosion cracking.
H343	A version of H34 that has been specially fabricated to provide acceptable resistance to stress corrosion cracking.
H115	Armour plate.
H116	Special corrosion-resistant temper.

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