BS EN 515:2017

BSI Standards Publication

Aluminium and aluminium alloys — Wrought products — Temper designations

National foreword

This British Standard is the UK implementation of EN 515:2017. It supersedes BS EN 515:1993 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee NFE/35, Light metals and their alloys.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2017

ISBN 978 0 580 91764 6

ICS 01.040.77; 77.120.10; 77.150.01

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2017.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 515

March 2017

ICS 01.040.77; 77.120.10; 77.150.01

Supersedes EN 515:1993

English Version

Aluminium and aluminium alloys - Wrought products - Temper designations

Aluminium et alliages d'aluminium - Produits corroyés - Désignation des états métallurgiques

Aluminium und Aluminiumlegierungen - Halbzeug - Bezeichnungen der Werkstoffzustände

This European Standard was approved by CEN on 6 February 2017.

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CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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European foreword

This document (EN 515:2017) has been prepared by Technical Committee CEN/TC 132 “Aluminium and aluminium alloys”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2017, and conflicting national standards shall be withdrawn at the latest by September 2017.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 515:1993.

The following modifications were implemented in this new version of EN 515:

— Addition of Clause 2 “Normative references”;

— new definitions and sources in Clause 3;

— new precision in Subclauses 6.1, 7 and 7.3;

— new Table 1 and modification of Table 2;

— improvement of the content of Clause 8.4;

— modification of Figure 1;

— inclusion of new tempers in Table 3: T552, T554, T72, T72510, T72511, T74511, T7452, T7454, T7752, T7754, T7852, T7854, T7952 and T7954;

— modification of new tempers in Table 3: H131, T3510;

— updating Annex A.

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1 Scope

This European Standard establishes temper designations for all forms of wrought aluminium and aluminium alloys and for continuously cast aluminium and aluminium alloys drawing stock and strip intended to be wrought.

NOTE Some of these temper designations may be subject of patent or patent applications and their listing herein is not to be construed in any way as the granting of a license under such patent right.

Additional temper designations, conforming to this standard, may be standardized with CEN/TC 132 and AECMA/5 provided:

— the temper is used or is available for use by more than one user;

— mechanical property limits are defined;

— the characteristics of the temper are significantly different from those of all other tempers which have the same sequence of basic treatments and for which designations already have been assigned for the same alloy and product;

— the following are also defined if characteristics other than mechanical properties are considered significant:

  a) test methods and limits for the characteristics; or

  b) the specific practices used to produce the temper.

2 Normative references

Not applicable.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
temper
condition of the metal produced by mechanical and/or thermal processing, typically characterized by a certain structure and specified properties

[SOURCE: EN 12258-1:2012, 3.6.5]

3.2
hot working
forming of a solid metal after preheating

Note 1 to entry: Strain hardening may or may not occur during hot working.

[SOURCE: EN 12258-1:2012, 3.2.3]

3.3
cold working
forming of a solid metal without preheating

Note 1 to entry: Plastic deformation of metal at such temperature and strain-rate that strain-hardening occurs.

[SOURCE: EN 12258-1:2012, 3.2.4]

3.4
strain hardening
modification of a metal structure by cold working resulting in an increase in strength and hardness with loss of ductility

[SOURCE: EN 12258-1:2012, 3.2.11]

3.5
solution heat treatment
heating an alloy to a suitable temperature for sufficient time to allow one or more soluble constituents to enter into solid solution, where they are retained in a supersaturated state after quenching

[SOURCE: EN 12258-1:2012, 3.7.1]

3.6
ageing
treatment of a metal aiming at a change in its properties by precipitation of intermetallic phases from supersaturated solid solution

Note 1 to entry: Ageing can be a treatment at room temperature (natural ageing) or a thermal treatment (artificial ageing).

Note 2 to entry: In North America the term “aging” is used.

[SOURCE: EN 12258-1:2012, 3.7.15]

3.7
annealing
thermal treatment to soften metal by reduction or removal of strain hardening resulting from cold working and/or by coalescing precipitates from the solid solution

[SOURCE: EN 12258-1:2012, 3.6.6]

3.8
heat-treatable alloy
alloy capable of being strengthened by suitable thermal treatment

Note 1 to entry: In addition to cold working, heat-treatable alloys are typically strengthened by precipitation hardening.

[SOURCE: EN 12258-1:2012, 2.2.8]

3.9
non heat-treatable alloy
alloy which is not strengthened by thermal treatment

Note 1 to entry: Non-heat-treatable alloys are only strengthened by hot or cold working.

[SOURCE: EN 12258-1:2012, 2.2.9]

3.10
stress relieving
reduction of internal residual stresses by thermal or mechanical means

[SOURCE: EN 12258-1:2012, 3.2.8]

4 Basis of codification

4.1 The temper designations are based on the sequences of basic treatments used to produce the various tempers. Property (mechanical or physical) limits apply to individual alloy-temper-product combinations.

4.2 The temper designation follows the alloy designation; these are separated by a hyphen.

4.3 Basic temper designations consists of letters. If subdivisions of the basic tempers are required, these are indicated by one or more digits following the letter of the basic temper. These digits relate to a specific sequence of basic treatments, but only those treatments or operations recognized as significantly influencing the products characteristics are indicated.

Should some other variation of the same sequence of basic operations be applied to the same alloy, resulting in different characteristics, then additional digits are added to the designation.

5 Basic temper designations

5.1 F – as fabricated

This designation applies to the products of shaping processes in which no special control over thermal conditions or strain hardening is applied. For this temper, there are no mechanical property limits specified.

5.2 O - Annealed

This designation applies to products which are annealed to obtain the lowest strength temper. The O may be followed by a digit other than zero[1].

5.3 H – Strain-hardened

This designation applies to products subjected to the application of cold work after annealing (or after hot forming), or to a combination of cold work and partial annealing or stabilizing, in order to secure the specified mechanical properties. The letter H is always followed by at least two digits, the first indicating the specific combination of basic operations and the second indicating the degree of strain hardening. A third digit indicates the variation of a two digits temper and it is used when mechanical properties, or others characteristics, differ from those of the two digits H temper to which it is added.

[1] Products achieving the required annealed properties after hot forming processes may be designated as O temper.

5.4 W – Solution heat-treated

This designation describes an unstable temper. It applies only to alloys which spontaneously age at room temperature after solution heat-treatment. This designation is specific only when the period of natural ageing is indicated; for example W 1/2 h.

5.5 T - Thermally treated to produce stable tempers other than F, O or H (for heat-treatable alloys only)

This designation applies to products which are thermally treated, with or without supplementary strain-hardening, to produce stable tempers. The T is always followed by one or more digits indicating the specific sequence of treatments.

6 Subdivision of O (annealed) temper designations

6.1 O1 – High temperature annealed and slow cooled[2]

This designation applies to wrought products which are thermally treated at approximately the same time and temperature required for solution heat-treatment and slow cooled to room temperature, in order to generate the correct ultrasonic response and / or provide dimensional stability. It is applicable to products which are to be machined prior to solution heat treatment by the user. Mechanical property limits are not specified.

6.2 O_2 – Thermo-mechanically processed

This designation applies to wrought products subjected to a special thermo-mechanical treatment. It is applicable to products which are to be super-plastically formed prior to solution heat treatment by the user.

6.3 O3 – Homogenized

This designation applies to continuously cast drawing stock or strip, which are subjected to a high temperature soaking treatment to eliminate or reduce segregations, thus improving subsequent formability and or response to solution heat-treatment.

7 Subdivision of H (strain-hardened) temper designations

Subdivisions are made according to the basic operations described in 5.3 and the final degree of strain hardening, as follows:

7.1 First digit after H:

The first digit following the letter H indicates the specific combination of basic operations as follows:

— H1x Strain hardened only

These designations apply to products which are strain-hardened to obtain the desired strength without supplementary thermal treatment.

[2] Formerly designated as T41.

— H2x Strain-hardened and partially annealed

These designations apply to products which are strain-hardened more than the desired final amount and then reduced in strength to the desired final level by partial annealing. For alloys that age-soften at room temperature, the H2x tempers have the same minimum ultimate tensile strength as the corresponding H3x tempers. For other alloys, the H2x tempers have the same minimum ultimate tensile strength as the corresponding H1x tempers and slightly higher elongation.

— H3x Strain-hardened and stabilized

These designations apply to products which 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 which, unless stabilized, gradually age-soften at room temperature.

— H4x Strain-hardened and lacquered or painted.

These designations apply to products which are strain-hardened and which may be subjected to some partial annealing during the thermal curing which follows the painting or lacquering operation.

7.2 Second digit after H:

The second digit following the letter H indicates the final 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.

— Tempers between O (annealed) and Hx8 are designated by numerals 1 to 7.

a) Numeral 2 designates tempers whose ultimate tensile strength is approximately midway between that of the O temper and that of the Hx4 temper.

b) Numeral 4 designates tempers whose ultimate tensile strength is approximately midway between that of the O temper and that of the Hx8 temper.

c) Numeral 6 designates tempers whose ultimate tensile strength is approximately midway between that of the Hx4 temper and that of the Hx8 temper.

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

— Numeral 9 designates tempers whose ultimate tensile strength exceeds that of the Hx8 temper by 10 MPa or more.

— The ultimate tensile strength of intermediate tempers, determined as described above, when not ending in 0 or 5, shall be rounded to the next higher 0 or 5.

Table 1 — Determination of Hx8 minimum tensile strength

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

7.3 Third digit after H:

The third digit, 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.

The following three digit H temper designations have been assigned:

— Hx11: applies to products which 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 Hx1.

— H112: Applies to products which may acquire some strain hardening from working at an elevated temperature or from a limited amount of cold work, and for which there are mechanical property limits.

— H116: applies to products, made of those alloys of the 5xxx group in which the magnesium content is 3 % nominal or more. These products are strain hardened at the last operation to specified stable tensile property limits, and to meet specified levels of corrosion resistance in accelerated-type corrosion test. Corrosion tests include inter-granular and exfoliation test. This temper is suitable for continuous service at temperatures not greater than 65 °C.

— H321: applies to products, made of those alloys of the 5xxx group in which the magnesium content is 3 % nominal or more. These products are thermally stabilized at the last operation to specified stable tensile property limits, and to meet specified levels of corrosion resistance in accelerated-type corrosion test. Corrosion tests include inter-granular and exfoliation test. This temper is suitable for continuous service at temperatures not greater than 65 °C.

— H1x8: Applies to products manufactured from alloys in the 5xxx series group, for which the magnesium content is 3 % nominal or more. These products are strain hardened at the last operation to specified stable tensile property limits, and are capable of meeting specified levels of corrosion resistance in accelerated type corrosion tests after a thermal treatment that is intended to demonstrate improved

corrosion performance in ambient conditions. This temper is suitable for continuous service at temperatures no greater than 65 °C". Corrosion tests include inter-granular and exfoliation test.

— H131: applies to products, made of those alloys of the 5xxx group in which the magnesium content is 3 % nominal or more. These products are strain hardened to specified tensile property limits, and to meet specified levels of corrosion resistance and ballistic performance.

— Hxx4: apply to patterned or embossed sheet and strip fabricated from the corresponding Hxx temper. The mechanical properties of the specified temper may deviate (after embossing or engraving) from those of the original temper. H114 applies to products fabricated from O, Hx1, H111 or H112 tempers.

EXAMPLE an embossed sheet fabricated from an H42 temper is designated H424;

— Hxx5: apply to welded tube. Depending on alloy and geometry of the tube, the mechanical property limits may differ from those of the corresponding Hxx temper for strip.

7.4 Other digits after H:

If necessary, other or additional digits may be used to identify other variations of a subdivision of basic temper H. Such additional identification will be allocated to specific alloys as a need arises.

8 Subdivision of T (thermally treated to produce stable tempers other than F, O or H) temper designations

8.1 First digit after T

The first digit following the letter T is used to identify the specific sequences of basic treatments. Numerals 1 to 10 have been assigned as follows[3]:

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

This designation applies to products which 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.

This designation applies to products which 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.

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

— T3: Solution heat-treated[4], cold worked and naturally aged to a stable condition.

This designation applies to products which 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[4] and naturally aged to a substantially stable condition.

This designation 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.

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

This designation applies to products which 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[4] and then artificially aged.

This designation 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.

— T7: Solution heat treated[4] and over-aged/stabilized.

This designation applies to products which are artificially aged after solution heat-treatment to carry them beyond a point of maximum strength to provide control of some significant characteristic other than mechanical properties[5].

— T8: Solution heat-treated[4], cold worked and then artificially aged.

This designation 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.

— T9: Solution heat-treated[4], artificially aged which are then cold worked.

This designation applies to products which are cold worked to improve strength.

— T10: Cooled from an elevated temperature shaping process, cold worked and artificially aged.

This designation applies to products which are cold worked after cooling from an elevated temperature shaping process, or in which effect of cold work, in flattening or straightening, is recognized in mechanical property limits.

The above definitions are summarized in Table 2.

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[4] Some 6000 or 7000 series alloys attain the same specified mechanical properties whether furnace solution heat treated or cooled from an elevated temperature shaping process with a cooling rate rapid enough to hold constituents in supersaturated solution. In such cases, when allowed by material specifications or purchaser, the temper designations T3, T4, T6, T7, T8 and T9 are used to apply to either process and are appropriate designations, provided the process is controlled to ensure that the product needs specified mechanical properties and, if specified, any other properties (eg: corrosion resistance).

[5] The test method and limit used to evaluate material to this characteristic are specified at the time of the temper definition.

Table 2 — Summary of processing for achieving T tempers

Ageing	Cold worked	Cooled from shaping process	Furnace solution heat-treated[a]
Natural	No	T1	T4
	Yes	T2	T3
artificial	No	T5	T6, T7
	Yes - before ageing	T10	T8
	Yes - after ageing	-	T9
[a] See footnote 4 to text in 8.1			

8.2 Additional digits added to designations T1 to T10

Additional digits, the first of which shall not be zero, may be added to designations T1 to T10 to indicate a variation in treatment which significantly alters the characteristics of the product with respect to the basic treatment. These digits may relate to one or more of the following:

— The solution heat treatment and/or the precipitation heat treatment;

— The amount of cold work after solution heat treatment;

— The stress relieving operation.

These additional digits may be assigned and standardized as described in Clause 1 and in accordance with 8.3 and 8.4.

Variations in treatment that do not alter the characteristics of the product are considered alternative treatments for which additional digits are not assigned.

8.3 Assigned additional digits for stress-relieved T tempers

8.3.1 Stress-relieved by stretching

— Tx51 or Txx51 applies to plate, sheet and rolled or cold finished rod and bar, hand or ring forgings and rolled rings when stretched the indicated amounts after solution heat-treatment or after cooling from an elevated temperature shaping process. The products receive no further straightening after stretching.

a) Plate: 1,5 % to 3 % permanent set (deformation);

b) Sheet: 0,5 % to 3 % permanent set;

c) Rolled or cold finished rod and bar: 1 % to 3 % permanent set;

d) Hand or ring forgings, rolled rings: 1 % to 5 % permanent set.

— Tx510 or Txx510 applies to extruded rod, bar, profiles and tube and to draw tube when stretched the indicated amounts after solution heat-treatment or after cooling from an elevated temperature shaping process. The products receive no further straightening after stretching.

  a) Extruded rod, bar, profiles and tube: 1 % to 3 % permanent set;

  b) Drawn tube: 0,5 % to 3 % permanent set.

— Tx511 or Txx511 applies to extruded rod, bar, profiles and tube and to draw tube when stretched the indicated amounts after solution heat-treatment or after cooling from an elevated temperature shaping process. These products may receive minor straightening to comply standard tolerances.

  a) Extruded rod, bar, profiles and tube: 1 % to 3 % permanent set;

  b) Drawn tube: 0,5 % to 3 % permanent set.

8.3.2 Stress-relieved by compressing

— Tx52 or Txx52 applies to products which are stress-relieved by compressing after solution heat treatment or cooling from an elevated temperature shaping process to produce a permanent set of 1 % to 5 %.

8.3.3 Stress-relieved by combined stretching and compressing

— Tx54 or Txx54 applies to die forgings which are stress-relieved by restriking cold in the finish die.

8.3.4 Assigned additional digits for stress-relieved W tempers

The same digits as those defined in 8.3.1, 8.3.2 and 8.3.3 may be added to the designation W (e.g.: W51; W510; W511; W52; W54) to indicate unstable solution heat-treated and stress-relieved tempers.

8.4 Assigned additional digits for variations of T7 type tempers

These designations apply to products which are artificially overaged in order to:

— improve a property such as stress corrosion resistance, fracture toughness, exfoliation corrosion resistance;

— or to obtain a good compromise between the above properties and the tensile strength.

lt is recommended that the following guidelines be applied when standardizing new alloy-temper-product combinations:

— T79 very limited overaging to achieve improved corrosion resistance compared to the T6 temper and limited strength reduction compared to the T6 temper

— T78: overageing to achieve optimum intercrystalline corrosion resistance. This temper specifically applies to 6000 series alloys

— T77: aged condition to provide strengths at or near to the T6 temper and corrosion resistance similar to the T76 temper

— T76 limited overaging to achieve moderate corrosion resistance with some reduction in strength. The T76 temper has lower strength and better corrosion resistance than the T79 temper

— T74 moderately overaged to achieve good corrosion resistance with a greater reduction in strength compared to the T76 temper. T74 temper strength and corrosion resistance properties are between those of the T73 and T76 tempers

— T73 fully overaged to achieve the best corrosion resistance of the T7x tempers, with a greater reduction in strength compared to the T74 temper

The evolution of material properties from temper T79 to T73, is summarized in Figure 1.

8.5 Demonstration of response to heat treatment

8.5.1 Temper designations for producer/supplier — Laboratory demonstration of response to heat treatment

The following temper designations have been assigned for wrought product test material, furnace heat treated from annealed (O, O1, etc.) or F temper, to demonstrate the response to heat treatment.

a) T42: solution heat-treated from annealed or F temper and naturally aged to a substantially stable condition;

b) T62: solution heat-treated from annealed or F temper and artificially aged;

c) T7x2: solution heat-treated from annealed or F temper and artificially overaged to meet the mechanical properties and corrosion resistance limits of the applicable T7x temper.

8.5.2 Temper designations for producer/supplier — Demonstration of response to temper conversion

Temper designation Tx2 or Txx2 shall be used to indicate wrought product test material, which has undergone furnace heat treatment for capability demonstration of temper conversion. When the purchaser requires capability demonstrations from T temper, the seller shall note “Capability Demonstration” adjacent to the specified and ending tempers. Some examples are:

— T3 to -T82 capability demonstration for response to ageing”;

— T4 to -T62 capability demonstration for response to ageing”;

— T4 to -T762 capability demonstration for response to overageing”;

— T6 to -T732 capability demonstration for response to overageing”;

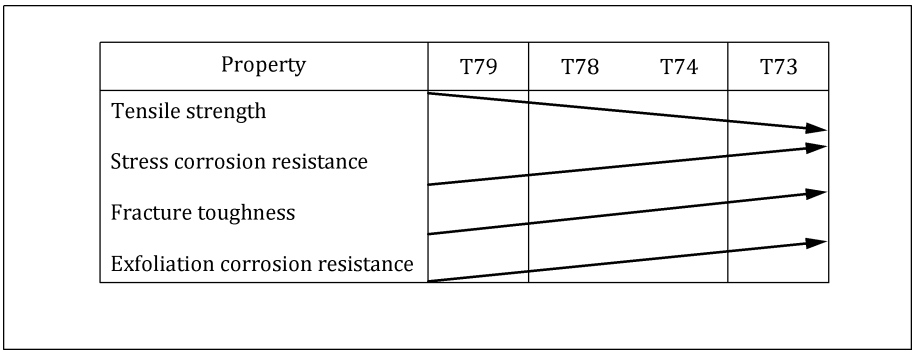
— T351 to -T42 capability demonstration for response to re-solution heat-treating”.

8.5.3 Temper designations for purchaser/user heat treatment

Temper designation Tx2 or Txx2 should also be applied to wrought products heat treated by the purchaser/user, in accordance with the applicable heat treatment specification, in order to achieve the properties applicable to the final temper.

9 Summary

A summary of tempers used in the European Standards is shown in Table 3.



NOTE This is a generalized representation. Actual magnitude and combination of properties vary for individual alloys.

Figure 1 — Summary of generalized relationships for some T7X temper properties

Table 3 — Summary of used tempers in European Standards

Temper	Definition
F	as fabricated (no mechanical property limits specified)
O	annealed - products achieving the required annealed properties after hot forming processes may be designated as 0 temper
O1	thermally treated at approximately the same time and temperature required for solution treatment and slow cooled to room temperature (formerly designated as T41)
O_2	thermomechanically processed to enhance formability, such as required for super-plastic forming (SPF)
O3	Homogenized
H12	strain-hardened - 1/4 hard
H14	strain-hardened - 1/2 hard
H16	strain-hardened - 3/4 hard
H18	strain-hardened- 4/4 hard (fully hardened)
H19	strain-hardened- extra hard
Hxx4	apply to embossed or patterned sheet or strip, fabricated from the corresponding Hxx temper
Hxx5	strain-hardened- apply to welded tubes
H111	annealed and slightly strain-hardened during subsequent operations such as stretching or levelling
H112	slightly strain-hardened from working at an elevated temperature or from a limited amount of cold work (mechanical property limits specified)
H116	applies to aluminium-magnesium alloys with a magnesium content of 3 % nominal or more. These products are strain hardened at the last operation to specified stable tensile property limits, and to meet specified levels of corrosion resistance in accelerated type corrosion test. Corrosion tests include inter-granular and exfoliation test. This temper is suitable for continuous service at temperatures not greater than 65 °C.

Temper	Definition
H1X8	Applies to products manufactured from alloys in the 5xxx series group, for which the magnesium content is 3 % nominal or more. These products are strain hardened at the last operation to specified stable tensile property limits, and are capable of meeting specified levels of corrosion resistance in accelerated type corrosion tests after a thermal treatment that is intended to demonstrate improved corrosion performance in ambient conditions. This temper is suitable for continuous service at temperatures no greater than 65 °C". Corrosion tests include inter-granular and exfoliation test.
H131	applies to products, made of those alloys of the 5xxx group in which the magnesium content is 3 % nominal or more. These products are strain hardened to specified tensile property limits, and to meet specified levels of corrosion resistance and ballistic performance.
H22	strain-hardened and partially annealed - 1/4 hard
H24	strain-hardened and partially annealed - 1/2 hard
H26	strain-hardened and partially annealed - 3/4 hard
H28	strain-hardened and partially annealed - 4/4 hard (fully hardened)
H32	strain-hardened and stabilized - 1/4 hard
H34	strain-hardened and stabilized - 1/2 hard
H36	strain-hardened and stabilized - 3/4 hard
H321	applies to products, made of those alloys of the 5xxx group in which the magnesium content is 3 % nominal or more. These products are thermally stabilized at the last operation to specified stable tensile property limits, and to meet specified levels of corrosion resistance in accelerated-type corrosion test. Corrosion tests include inter-granular and exfoliation test. This temper is suitable for continuous service at temperatures not greater than 65 °C.
H38	strain-hardened and stabilized - 4/4 hard (fully hardened)
H42	strain-hardened and painted or lacquered - 1/4 hard
H44	strain-hardened and painted or lacquered - 1/2 hard
H46	strain-hardened and painted or lacquered - 3/4 hard
H48	strain-hardened and painted or lacquered - 4/4 hard (fully hardened)
W	solution heat-treated (unstable temper). The period of natural ageing (W2h,..) may also be specified
W51	solution heat-treated (unstable temper) and stress-relieved by stretching a controlled amount (permanent set 0,5 % to 3 % for sheet, 1,5 % to 3 % for plate, 1 % to 3 % for rolled or cold-finished rod and bar, 1 % to 5 % for hand or ring forging and rolled ring). The products receive no further straightening after stretching
W510	solution heat-treated (unstable temper) and stress-relieved by stretching a controlled amount (permanent set 1 % to 3 % for extruded rod, bar, shapes and tube, 0,5 % to 3 for drawn tube). The products receive no further straightening after stretching
W511	same as W510 except that minor straightening is allowed after stretching to comply with standard tolerances
W52	solution heat-treated (unstable temper) and stress-relieved by compressing to produce a permanent set of 1 % to 5 %

Temper	Definition
W54	solution heat-treated (unstable temper) and stress-relieved by restriking cold in the finish die (die forging)
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
T31	solution heat-treated, cold worked approximately 1 % and naturally aged
T34	Solution heat-treated, cold worked (permanent set 3,0 to 4,5 %) and naturally aged
T351	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 0,5 % to 3 % for sheet, 1,5 % to 3 % for plate, 1 % to 3 % for rolled or cold-finished rod and bar, 1 % to 5 % for hand or ring forging and rolled ring) and naturally aged. The products receive no further straightening after stretching
T3510	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 1 %, to 3 % for extruded rod, bar, shapes and tube, 0,5 % to 3 % for drawn tube) and naturally aged. The products receive no further straightening after stretching
T3511	same as T3510 except that minor straightening is allowed after stretching to comply with dimensional tolerances
T352	solution heat-treated, stress-relieved by compressing to produce a permanent set of 1 % to 5 % and naturally aged
T354	solution heat-treated, stress-relieved by restriking cold in the finish die and naturally aged
T36	solution heat-treated, cold worked approximately 6 %, and naturally aged
T37	solution heat-treated, cold worked approximately 7 % and naturally aged
T39	solution heat-treated and cold worked an appropriate amount to achieve the specified mechanical properties. Cold work may be carried out before or after natural ageing
T4	solution heat-treated and naturally aged
T42	solution heat-treated and naturally aged. Applies to test material heat-treated from annealed or F temper or to products heat-treated from any temper by the user
T451	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 0,5 % to 3.% for sheet, 1,5 % to 3 % for plate, 1 % to 3 % for rolled or cold-finished rod and bar, 1 % to 5 % for hand or ring forging and rolled ring) and naturally aged. The products receive no further straightening after stretching
T4510	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 1 % to 3 % for extruded rod, bar, shapes and tube, 0,5 % to 3 % for drawn tube) and naturally aged. The products receive no further straightening after stretching
T4511	same as T4510 except that minor straightening is allowed after stretching to comply with dimensional tolerances
T452	solution heat-treated, stress-relieved by compressing to produce a permanent set of 1 % to 5 % and naturally aged
T454	solution heat-treated, stress-relieved by restriking cold in the finish die and naturally aged

Temper	Definition
T5	cooled from an elevated temperature shaping process and then artificially aged
T51	cooled from an elevated temperature shaping process and then artificially aged in underageing conditions to improve formability
T551	Cooled from an elevated temperature shaping process, stress-relieved by stretching a controlled amount (permanent set 0,5 % to 3 % for sheet, 1,5 % to 3 % for plate, 1 % to 3 % for rolled or cold-finished rod and bar, 1 % to 5 % for hand or ring forging and rolled ring) and then artificially aged. The products receive no further straightening after stretching
T5510	Cooled from an elevated temperature shaping process, stress-relieved by stretching a controlled amount (permanent set 1 % to 3 % for extruded rod, bar, shapes and tube, 0,5 % to 3 % for drawn tube) and then artificially aged. The products receive no further straightening after stretching
T5511	Same as T5510 except that minor straightening is allowed after stretching to comply with dimensional tolerances
T552	Cooled from an elevated temperature shaping process, stress-relieved by compressing to produce a permanent set of 1 % to 5 % and then artificially aged
T554	Cooled from an elevated temperature shaping process, stress-relieved by restriking cold in the finish die and then artificially aged
T56	cooled from an elevated temperature shaping process and then artificially aged - mechanical property level higher than T5 achieved through special control of the process (6000 series alloys)
T6	solution heat-treated and then artificially aged
T61	solution heat-treated and then artificially aged in underageing conditions to improve formability
T6151	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 0,5 % to 3 % for sheet, 1,5 % to 3 % for plate) and then artificially aged in underageing conditions to improve formability. The products receive no further straightening after stretching
T62	solution heat-treated and then artificially aged. Applies to test material heat-treated from annealed or F temper or to products heat-treated from any temper by the user
T64	solution heat-treated and then artificially aged in underageing conditions (between T6 and T61) to improve formability
T651	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 0,5 % to 3 % for sheet, 1,5 % to 3 % for plate, 1 % to 3 % for rolled or cold-finished rod and bar, 1 % to 5 % for hand or ring forging and rolled ring) and then artificially aged. The products receive no further straightening after stretching
T6510	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 1 % to 3 % for extruded rod, bar, shapes and tube, 0,5 % to 3 % for drawn tube) and then artificially aged. The products receive no further straightening after stretching
T6511	same as T6510 except that minor straightening is allowed after stretching to comply with standard tolerances
T652	solution heat-treated, stress-relieved by compressing to produce a permanent set of 1 % to 5 % and then artificially aged.

Temper	Definition
T654	solution heat-treated, stress-relieved by restriking cold in the finish die and then artificially aged
T66	solution heat-treated and then artificially aged - mechanical property level higher than T6 achieved through special control of the process 6000 series alloys)
T7	solution heat-treated and then artificially overaged
T72	Solution heat-treated and then artificially aged in order to achieve optimal intercrystalline corrosion resistance (this temper specifically applies to 6000 series alloys).
T72510	Solution heat-treated and then artificially aged in order to achieve optimal intercrystalline corrosion resistance (this temper specifically applies to 6000 series alloys). The products receive no further straightening after stretching' (this temper specifically applies to 6000 series alloys).
T72511	same as T72510 except that minor straightening is allowed after stretching to comply with standard tolerances
T73	solution heat-treated and then fully artificially overaged to achieve the best corrosion resistance of the T7x tempers, with a greater reduction in strength compared to the T74 temper.'
T732	solution heat-treated and then artificially overaged to the T73 condition. Applies to test material heat-treated from annealed or F temper or to products heat-treated from any temper by the user'
T7351	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 0,5 % to 3 % for sheet, 1,5 % to 3 % for plate, 1 % to 3 % for rolled or cold-finished rod and bar, 1 % to 5 % for hand or ring forging and rolled ring) and then artificially overaged to the T73 condition. The products receive no further straightening after stretching.
T73510	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 1 % to 3 % for extruded rod, bar, shapes and tube, 0,5 % to 3 % for drawn tube) and then artificially overaged to the T73 condition. The products receive no further straightening after stretching'
T73511	same as T73510 except that minor straightening is allowed after stretching to comply with standard tolerances
T7352	solution heat-treated, stress-relieved by compressing to produce a permanent set of 1 % to 5 % and then artificially overaged to the T73 condition'
T7354	solution heat-treated, stress-relieved by restriking cold in the finish die and then artificially overaged to the T73 condition'
T74	solution heat-treated and then moderately artificially overaged to achieve good corrosion resistance with a greater reduction in strength compared to the T76 temper. T74 temper strength and corrosion resistance properties are between those of the T73 and T76 tempers.'
T742	solution heat-treated and then artificially overaged to the T74 condition. Applies to test material heat-treated from annealed or F temper or to products heat-treated from any temper by the user'

Temper	Definition
T7451	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 0,5 % to 3 % for sheet, 1,5 % to 3 % for plate, 1 % to 3 % for rolled or cold-finished rod and bar, 1 % to 5 % for hand or ring forging and rolled ring) and then artificially overaged to the T74 condition. The products receive no further straightening after stretching'
T74510	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 1 % to 3 % for extruded rod, bar, shapes and tube, 0,5 % to 3 % for drawn tube) and then artificially overaged to the T74 condition. The products receive no further straightening after stretching'
T74511	same as T74510 except that minor straightening is allowed after stretching to comply with dimensional tolerances.
T7452	solution heat-treated, stress-relieved by compressing to produce a permanent set of 1 % to 5 % and then artificially aged to the T74 condition.
T7454	solution heat-treated, stress-relieved by restriking cold in the finish die and then artificially aged to the T74 condition.
T76	solution heat-treated and then given limited artificial overaging to achieve moderate corrosion resistance with some reduction in strength. The T76 temper has lower strength and better corrosion resistance than the T79 temper.
T761	solution heat-treated and then artificially overaged in order to achieve a good exfoliation corrosion resistance (applies to 7475 sheet and strip)
T762	solution heat-treated and then artificially overaged to the T76 condition. Applies to test material heat-treated from annealed or F temper or to products heat-treated from any temper by the user'
T7651	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 0,5 % to 3 % for sheet, 1,5 % to 3 % for plate, 1 % to 3 % for rolled or cold-finished rod and bar, 1 % to 5 % for hand or ring forging and rolled ring) and then artificially overaged to the T76 condition'
T76510	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 1 % to 3 % for extruded rod, bar, shapes and tube, 0,5 % to 3 % for drawn tube) and then artificially overaged to the T76 condition'
T76511	same as T76510 except that minor straightening is allowed after stretching to comply with standard tolerances
T7652	solution heat-treated, stress-relieved by compressing to produce a permanent set of 1 % to 5 % and then artificially overaged to the T76 condition'
T7654	solution heat-treated, stress-relieved by restriking cold in the finish die and then artificially overaged to the T76 condition'
T77	Solution heat-treated, and then artificially overaged to provide strengths at or near to the T6 temper and corrosion resistance similar to the T76 temper'
T7751	Solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 0,5 % to 3 % for sheet, 1,5 % to 3 % for plate, 1 % to 3 % for rolled or cold-finished rod and bar, 1 % to 5 % for hand or ring forging and rolled ring) and then artificially overaged to the T77 condition. The products receive no further straightening after stretching'

Temper	Definition
T77510	Solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 1 % to 3 % for extruded rod, bar, shapes and tube, 0,5 % to 3 % for drawn tube) and then artificially overaged to the T77 condition. The products receive no further straightening after stretching'
T77511	Same as T77510 except that minor straightening is allowed after stretching to comply with dimensional tolerances
T7752	solution heat-treated, stress-relieved by compressing to produce a permanent set of 1 % to 5 % and then artificially aged to the T77 condition.
T7754	solution heat-treated, stress-relieved by restriking cold in the finish die and then artificially aged to the T77 condition.
T78	Solution heat-treated and then artificially overaged in order to achieve optimal intercrystalline corrosion resistance (this temper specifically applies to 6000 series alloys).
T7851	Solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 0,5 % to 3 % for sheet, 1,5 % to 3 % for plate, 1 % to 3 % for rolled or cold-finished rod and bar, 1 % to 5 % for hand or ring forging and rolled ring) and then artificially overaged to the T78 condition (6000 series alloys). The products receive no further straightening after stretching
T78510	Solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 1 % to 3 % for extruded rod, bar, shapes and tube, 0,5 % to 3 % for drawn tube) and then artificially overaged to the T78 condition (6000 series alloys). The products receive no further straightening after stretching'
T78511	Same as T78510 except that minor straightening is allowed after stretching to comply with dimensional tolerances
T7852	solution heat-treated, stress-relieved by compressing to produce a permanent set of 1 % to 5 % and then artificially aged to the T78 condition (6000 series alloys).
T7854	solution heat-treated, stress-relieved by restriking cold in the finish die and then artificially aged to the T78 condition (6000 series alloys).
T79	solution heat-treated and then given very limited artificial overaging to achieve improved corrosion resistance compared to the T6 temper and limited strength reduction compared to the T6 temper
T7951	Solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 0,5 % to 3 % for sheet, 1,5 % to 3 % for plate, 1 % to 3 % for rolled or cold-finished rod and bar, 1 % to 5 % for hand or ring forging and rolled ring) and then artificially overaged to the T79 condition. The products receive no further straightening after stretching'
T79510	Solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 1 % to 3 % for extruded rod, bar, shapes and tube, 0,5 % to 3 % for drawn tube) and then artificially overaged to the T79 condition. The products receive no further straightening after stretching
T79511	Same as T79510 except that minor straightening is allowed after stretching to comply with dimensional tolerances
T7952	solution heat-treated, stress-relieved by compressing to produce a permanent set of 1 % to 5 % and then artificially aged to the T79 condition.

Temper	Definition
T7954	solution heat-treated, stress-relieved by restriking cold in the finish die and then artificially aged to the T79 condition.
T8	solution heat-treated, cold worked and then artificially aged
T81	solution heat-treated, cold worked approximately 1 % and then artificially aged
T82	solution heat-treated by the user, controlled stretched with a minimum permanent set of 2 % and then artificially aged
T832	solution heat-treated, cold worked a controlled specific amount and then artificially aged (applies to 6063 drawn tube)
T84	solution heat-treated by the user, cold worked (permanent set 3,0 to 4,5 %) and then artificially aged
T84511	solution heat-treated by the user, cold worked (permanent set 3,0 to 4,5 %) and then artificially aged; minor straightening is allowed after stretching to comply with dimensional tolerances
T841	solution heat-treated, cold worked and then artificially underaged
T84151	solution heat-treated, stress-relieved by stretching with a permanent set of 1,5 % to 3 % and then artificially underaged
T851	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 0,5 % to 3 % for sheet, 1,5 % to 3 % for plate, 1 % to 3 % for rolled or cold-finished rod and bar, 1 % to 5 % for hand or ring forging and rolled ring) and then artificially aged. The products receive no further straightening after stretching
T8510	solution heat-treated, stress-relieved by stretching a controlled amount (permanent set 1 % to 3 % for extruded rod, bar, shapes and tube, 0,5 % to 3 % for drawn tube) and then artificially aged. The products receive no further straightening after stretching
T8511	same as T8510 except that minor straightening is allowed after stretching to comply with standard tolerances
T852	solution heat-treated, stress-relieved by compressing to produce a permanent set of 1 % to 5 % and then artificially aged
T854	solution heat-treated, stress-relieved by restriking cold in the finish die and then artificially aged
T86	solution heat-treated, cold worked approximately 6 % and then artificially aged
T87	solution heat-treated, cold worked approximately 7 % and then artificially aged
T89	solution heat-treated, cold worked an appropriate amount to achieve the specified mechanical properties and then artificially aged
T9	solution heat-treated, artificially aged and then cold worked
T10	Cooled from an elevated temperature shaping process, cold worked and artificially aged.

Annex A
(informative)

Recommendations for further T tempers extensions

A.1 Numeral 1 as a second digit after T

Numeral 1 may be used to indicate a solution heat-treatment at lower than standard temperature or a limited rate of quenching or a limited and controlled amount of cold work or an artificial ageing in underageing conditions.

It applies to wrought products, when one or more of the following properties is required: improved ductility, improved forrnability, lower deformation, improved fracture toughness, etc. than in the corresponding Tx conditions.

A.2 Numerals 1 and 3 to 9 as a second digit after T3, T8 or T9

This digit may be used to indicate increasing amounts of cold work after solution heat-treatment or after artificial ageing as applicable.

NOTE For some particular T8 type tempers, the second digit may be used to indicate different degrees of underageing.

A.3 Numerals 1 and 3 to 5 as a second digit after T5 or T6

This digit may be used to indicate different degrees of underageing.

A.4 Numeral 6 as a second digit after T5 or T6

This digit may be used to indicate a level of mechanical properties, respectively higher than T5 or T6, obtained through special control of the process.

A.5 Summary of possible uses of a second digit after T

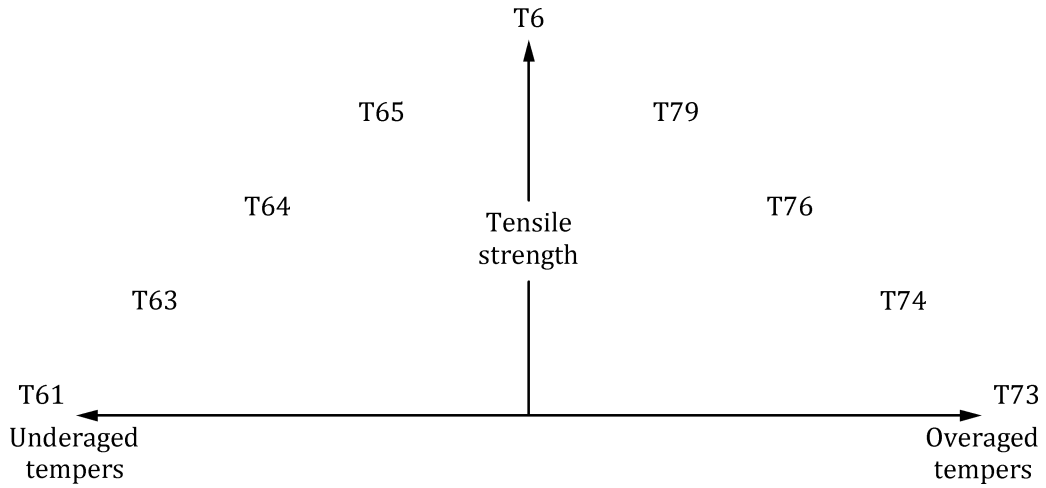
Table A.1 summarizes the various uses (recommended or assigned) of the second digit after the letter T.

Table A.1 — Various uses of the second digit after letter T

Second digit	Relevant process and subclause				
	Test material 8.5.1	Overageing 7.4	Cold work A.2	Underageing A.3	Special process A.4
1	X	-	T31, T81	T51, T61	-
2	T42, T62	X	X	X	X
3	X	T73	T83	T63	-
4	X	T74	T34, T84	T64	-
5	X	-	-	T65	-
6	X	T76	T36, T86	X	T56, T66
7	X	T77	T37, T87	X	-
8	X	T78	-	X	-
9	X	T79	T39, T89	X	-
X: shall not be used -: possible future utilization					

As a further example, the relative positions of the variations of T6 and T7 tempers for 7000 series alloys are shown in Figure A.1 (tensile strength versus ageing conditions diagram). Temper T77 has not been included for readability purposes.

Temper T78 only applies to 6000 series alloys.



Key

A underaged tempers

B tensile strength

C overaged tempers

Figure A.1 — Relative positions of the variations of T6 and T7 tempers

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