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Aluminium and aluminium alloys — Wrought products — Temper designations

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

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 2107 was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys*, Subcommittee SC 9, *Symbolization*.

This third edition cancels and replaces the second edition (ISO 2107:2004), which has been technically revised by the addition of a terms and definitions clause and the designation of solution heat-treatment. This edition deals with wrought aluminium products and no longer applies to magnesium alloys.

Aluminium and aluminium alloys — Wrought products — Temper designations

1 Scope

This International Standard establishes temper designations as required for identification for all product forms of wrought aluminium and aluminium alloys.

2 Terms and definitions

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

2.1
temper
condition produced by either mechanical or thermal treatment, or both, and characterized by a certain structure and mechanical properties

2.2
working
deformation of metal, either hot or cold, by shaping processes including rolling, extruding, forging, drawing

2.3
hot working
plastic deformation, i.e., permanent deformation of metal at such temperatures that no strain-hardening occurs

2.4
cold working
plastic deformation, i.e., permanent deformation of metal at such temperatures that strain-hardening occurs

2.5
strain-hardening
modification of a metal structure, by cold working, resulting in an increase in strength and hardness but with loss of ductility

2.6
solution heat-treating
heating an alloy at a suitable temperature for a sufficient time to allow soluble constituents to enter into solid solution where they are retained in a supersaturated state after quenching (rapid cooling)

2.7
ageing
precipitation from supersaturated solid solution resulting in a change in properties of an alloy, usually occurring slowly at room temperature (natural ageing) and more rapidly at elevated temperatures (artificial ageing)

2.8
annealing
thermal treatment to soften metal by removal of stress resulting from cold working or by coalescing precipitates from solid solution

3 Basis of codification

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

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

Basic temper designations consist 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 product 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.

Throughout this International Standard, generalized examples of tempers are shown, as follows:

— “X” denotes an unspecified digit (e.g., H2X is generalized to indicate appropriate temper designations in the series H21 to H29);

— “XX” denotes two unspecified digits (e.g., HXX4 is generalized to indicate appropriate temper designations in the H114 to H194 series, the H224 to H294 series, and the H324 to H394 series);

— “_” denotes one or multiple unspecified digits (e.g., T_51 is generalized to indicate appropriate temper designations such as T351, T651, T6151, T7351, T7651, etc.).

4 Basic temper designations

4.1 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.

4.2 O — annealed

This designation applies to wrought products that are annealed to obtain the lowest strength temper, and to cast products that are annealed to improve ductility and dimensional stability. The O may be followed by a digit other than zero[1] to indicate a product in the annealed condition having special characteristics.

4.3 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 achieve 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 a variation of a two digit temper and is used when the mechanical properties, or other characteristics, differ from those of the two-digit H temper to which it is added.

4.4 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, e.g., W 1/2 h.

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

4.5 T — thermally treated to produce stable tempers other than F, O or H

This designation applies to products that 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.

5 Subdivisions of O temper designations

5.1 O1 — high-temperature annealed and slow cooled

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

5.2 O2 — 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.

5.3 O3 — homogenized

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

6 Subdivisions of H temper designations

6.1 General

Subdivisions are made according to the basic operations described in Clause 4 and the final degree of strain hardening as described in 6.2 to 6.5.

6.2 First digit after H

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

a) H1X Strain-hardened only

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

b) H2X Strain-hardened and partially annealed

These designations apply to products that are strain-hardened more than the desired final amount, and then reduced in strength to the desired 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.

c) H3X Strain-hardened and stabilized

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

d) H4X Strain-hardened and lacquered or painted

These designations apply to products that are strain-hardened and which are subjected to some thermal operation during the subsequent painting or lacquering operation.

6.3 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.

a) 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.

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

b) Tempers between O (annealed) and HX8 are designated by numerals 1 to 7:

1) HX4 designates tempers whose ultimate tensile strength is approximately midway between that of the O temper and that of the HX8 tempers;

2) HX2 designates tempers whose ultimate tensile strength is approximately midway between that of the O temper and that of the HX4 tempers;

3) HX6 designates tempers whose ultimate tensile strength is approximately midway between that of the HX4 tempers and that of the HX8 tempers;

4) HX1, HX3, HX5 and HX7 designate tempers intermediate between those defined above.

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 5 MPa.

c) HX9 designates tempers whose minimum ultimate tensile strength exceeds that of the HX8 tempers by 10 MPa or more.

6.4 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.

a) HX11 applies to products that incur sufficient strain-hardening after the final anneal, such that they fail to qualify as annealed, but not so much or so consistent an amount of strain-hardening that they qualify as HX1.

b) H112 applies to products that 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.

c) 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 tests. Corrosion tests include inter-granular and exfoliation tests. This temper is suitable for continuous service at temperatures not greater than 65° C (150° F).

d) 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 obtain specified stable tensile property limits, and to meet specified levels of corrosion resistance in accelerated-type corrosion tests. Corrosion tests include inter-granular and exfoliation tests. This temper is suitable for continuous service at temperatures not greater than 65° C (150° F).

e) HXX4 applies to patterned or embossed sheet and strip fabricated from the corresponding HXX temper. The mechanical properties of the embossed or engraved product differs from those of the original temper.

f) HXX5 applies to welded tube. Depending on the alloy and geometry of the tube, the mechanical property limits may differ from those of the corresponding HXX temper for strip.

6.5 Other digits after H

If necessary, other or additional digits may be used to identify other variations of a subdivision of basic temper H.

7 Subdivisions of T temper designations

7.1 First digits (numerals 1 to 10) 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[2)].

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

This designation 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.

2) A period of natural ageing 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.