



Standard Practice for Temper Designations for Copper and Copper Alloys— Wrought and Cast¹

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This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This practice defines the terminology in general use for indicating the temper of copper and copper alloy products. The designations used in ASTM specifications under the jurisdiction of Committee B-5 will conform to this practice.

1.2 It defines the terminology of the processes that produce the tempers and the observable changes in the product that result from the processes.

1.3 It establishes an alphanumeric code for use in designating the product tempers.

1.3.1 The letters in the code identify the type of process used to produce the product temper. For example, “H” indicates a temper resulting from cold working. These letters are frequently the same as those used in temper systems of other metals, and are applied to copper products in accordance with this practice.

1.3.2 The numbers in the code were chosen subjectively for general tempers, and objectively to indicate grain size for annealed tempers or reductions for cold-worked tempers.

1.4 The use of this code is recommended for all product tempers in specifications and published data. Its use will simplify the presentation of property data when in tabular form.

1.5 The property requirements for the tempers are given in applicable product specifications.

1.6 Where the word “product” is used, it means a copper or copper alloy product.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Terminology

2.1 Definitions:

2.1.1 *temper*—the metallurgical structure and properties of

a product resulting from thermal or mechanical processing treatments.

2.2 *Basic Processes Used to Produce the Different Tempers:*

2.2.1 *anneal (annealing)*—a thermal treatment to change the properties or grain structure of the product.

2.2.1.1 When applied to a cold-worked product having a single phase; to produce softening by recrystallization or recrystallization and grain growth, with the accompanying changes in properties.

2.2.1.2 When applied to a product having two or more phases: to produce softening by changes in phase relationships which may include recrystallization and grain growth.

2.2.2 *cold work*—controlled mechanical operations for changing the form or cross section of a product and for producing a strain-hardened product at temperatures below the recrystallization temperature.

2.2.3 *drawn stress relieved (DSR)*—a thermal treatment of a cold-drawn product to reduce residual stress variations, thus reducing susceptibility of product to stress corrosion or season cracking, without significantly affecting its tensile strength or microstructure.

2.2.4 *hot working*—controlled mechanical operations for shaping a product at temperatures above the recrystallization temperature.

2.2.5 *order strengthening*—a thermal treatment of a cold-worked product at a temperature below its recrystallization temperature causing ordering to occur to obtain an increase in yield strength.

2.2.6 *precipitation heat treatment*—a thermal treatment of a solution heat-treated product to produce property changes such as hardening, strengthening, and conductivity increase by precipitation of constituents from the supersaturated solid solution. This treatment has also been called “age hardened” and “precipitation hardened.”

2.2.7 *quench hardening*—a treatment for copper-aluminum alloy products consisting of heating above the betatizing temperature followed by quenching to produce a hard martensitic structure.

2.2.8 *solution heat treatment*—a thermal treatment of a product to put alloying elements into solution in the base metal by heating into the temperature range of solid solubility,

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followed by cooling at a sufficient rate to retain them in a supersaturated solid solution.

2.2.9 *spinodal heat treatment*—a thermal treatment of a solution heat-treated product to produce property changes such as hardening, strengthening, and conductivity increase by spinodal decomposition of a solid solution. This treatment has also been called “age hardened,” “spinodal hardened,” or “spinodally decomposed.”

2.2.10 *strain hardening*—the increase in strength and hardness and decrease in ductility as a result of permanent deformation of the structure by cold working.

2.2.11 *stress relief*—a treatment of a product to reduce residual stresses.

2.2.11.1 *by thermal treatment*—without causing recrystallization.

2.2.11.2 *by mechanical treatment*—without causing a significant change in size.

2.2.12 *temper annealing*—a thermal treatment above the eutectoid temperature for copper-aluminum alloy products to minimize the presence of the stable eutectoid structure.

2.2.13 *tempering*—a thermal treatment of a quench-hardened product to improve ductility.

2.2.14 *thermal treatment*—a controlled heating; time at maximum temperature-cooling cycle as needed to satisfy the property and grain structure requirements of the temper.

3. Classification of Tempers

NOTE 1—In the following paragraphs, tempers are classified according to terminology used by U.S. manufacturers of copper and copper alloy products and are arranged in alphabetical order with their designated code letters.

3.1 *Annealed Tempers, O*—Tempers produced by annealing to meet mechanical property requirements.

3.2 *Annealed Tempers, OS*—Tempers produced by annealing to meet standard or special grain size requirements.

3.3 *Manufactured Tempers, M*—Tempers produced in the product by the primary manufacturing operations of casting and hot working and controlled by the methods employed in the operations.

3.4 *Cold-Worked Tempers, H*—Tempers produced by controlled amounts of cold work.

3.5 *Cold-Worked (Drawn), Stress-Relieved Tempers, HR*—Tempers produced by controlled amounts of cold work followed by stress relief.

3.5.1 *Order-Strengthening Tempers, HT*—Tempers produced by controlled amounts of cold work followed by a thermal treatment to produce order strengthening.

3.6 *Heat-Treated Tempers, T*—Tempers that are based on heat treatments followed by rapid cooling.

3.6.1 *Quench-Hardened Tempers, TQ*—Tempers produced by quench-hardening treatments.

3.6.2 *Solution Heat-Treated Temper, TB*—Tempers produced by solution heat-treating precipitation hardenable or spinodal hardenable alloys.

3.6.3 *Solution Heat-Treated and Cold-Worked Tempers, TD*—Tempers produced by controlled amounts of cold work of solution heat-treated precipitation hardenable or spinodal hardenable alloys.

3.6.4 *Precipitation Heat-Treated Temper, TF*—Tempers

produced by precipitation heat treatment of precipitation-hardenable alloys.

3.6.5 *Spinodal Heat Treated Temper, TX*—Tempers produced by spinodal heat treatment of spinodal hardenable alloys.

3.6.6 *Cold-Worked and Precipitation Heat-Treated Tempers, TH*—Tempers produced in alloys that have been solution heat treated, cold worked, and precipitation heat treated.

3.6.7 *Cold-Worked and Spinodal Heat-Treated Tempers, TS*—Tempers produced in alloys that have been solution heat treated, cold worked, and spinodal heat treated.

3.6.8 *Mill-Hardened Tempers, TM*—Tempers of heat-treated materials as supplied by the mill resulting from combinations of cold work and precipitation heat treatment or spinodal heat treatment.

3.6.9 *Precipitation Heat-Treated or Spinodal Heat-Treated and Cold-Worked Tempers, TL*—Tempers produced by cold working the precipitation heat-treated or spinodal heat-treated alloys.

3.6.10 *Precipitation Heat-Treated or Spinodal Heat-Treated, Cold-Worked, and Thermal Stress-Relieved Tempers, TR*—Tempers produced in the cold-worked precipitation heat-treated or spinodal heat-treated alloys by thermal stress relief.

3.7 *Tempers of Welded Tubes, W*—(Welded tubes are produced from strip of various tempers and essentially have the temper of the strip except in the heat-affected zone.)

3.7.1 *Tube, As-Welded Tempers, WM*—Tempers that result from forming and welding when producing tube.

3.7.2 *Tube, Welded and Annealed Temper, WO*—Temper that results from forming, welding, and annealing when producing tube.

3.7.3 *Tube, Welded and Cold-Worked Tempers, WH*—Tempers that result from forming, welding, and cold working when producing tube.

3.7.4 *Tube, Welded, Cold-Worked and Stress-Relieved Tempers, WR*—Tempers that result from forming, welding, cold working, and stress relieving when producing tube.

3.7.5 *Tube, Welded, and Fully Finished Tempers, O, OS, H*—Tempers that result from both annealing a welded and cold-worked tube, or cold working, a welded cold-worked and annealed tube. With these treatments, the weld area has been transformed into a wrought structure, and the usual temper designations apply.

4. Temper Designation Codes

NOTE 2—Also shown are regular temper terms that are being retained for an indefinite period.

4.1 *Annealed Tempers, O:*

4.1.1 *Annealed to Meet Mechanical Properties, O:*

Annealed Tempers—O	Temper Names
O10	Cast and Annealed (Homogenized)
O11	As Cast and Precipitation Heat Treated
O20	Hot Forged and Annealed
O25	Hot Rolled and Annealed
O30	Hot Extruded and Annealed
O31	Extruded and Precipitation Heat Treated
O40	Hot Pierced and Annealed
O50	Light Anneal
O60	Soft Anneal