



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

This standard is issued under the fixed designation B 601; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon (ε) indicates an editorial change since the last revision or reappraisal.

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

1. Scope*

1.1 This classification establishes temper designations for copper and copper alloys—wrought and cast. The temper designations are classified by the process or processes used in manufacturing the product involved and its resulting properties. It is not a specification of copper and copper alloys.

1.2 The property requirements for the tempers are given in the applicable product specification.

2. Referenced Documents

2.1 *ASTM Standards:*²

B 846 Terminology for Copper and Copper Alloys

3. Terminology

3.1 For terminology related to copper and copper alloys, refer to Terminology **B 846**.

4. Significance and Use

4.1 *Significance*—This classification establishes an alphanumeric code of the tempers of copper and copper alloy products.

4.2 *Use*—An alphanumeric code establishes a system by which product tempers in specifications and published data are designated.

4.2.1 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.

NOTE 1—These letters are frequently the same as those used in temper systems of other metal products.

¹ This classification is under the jurisdiction of ASTM Committee B05 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.91 on Editorial and Publications.

Current edition approved April 1, 2007. Published May 2007. Originally approved in 1974. Last previous edition approved in 2002 as B 601 – 02.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

NOTE 2—Undefined letters, used in prior temper systems and included in this system for reference, are defined in **Appendix X1**.

5. Classification of Tempers

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

5.2 *Annealed Tempers, with Grain Size Prescribed, OS*—Tempers produced by annealing to meet standard or special grain size requirements.

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

5.4 *Cold-Worked Tempers, H*—Tempers produced by controlled amounts of cold work, by manufacturing process, or by use.

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

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

5.5.2 *End Annealed Temper, HE*—Temper produced by cold work followed by anneal of the ends of the product.

5.6 *Heat-Treated Tempers, T*—Tempers that are based on solution heat treatments followed by rapid cooling, with or without subsequent cold working or thermal treatments.

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

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

5.6.3 *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.

5.6.4 *Precipitation Heat-Treated Temper, TF*—Tempers produced by Solution Heat-Treatment and precipitation heat treatment of precipitation-hardenable alloys.

*A Summary of Changes section appears at the end of this standard.

5.6.5 *Spinodal Heat Treated Temper, TX*—Tempers produced by Solution Heat-Treatment and spinodal heat treatment of spinodal hardenable alloys.

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

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

5.6.8 *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.

5.6.9 *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.

5.6.10 *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.

5.7 *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.)

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

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

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

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

5.7.5 *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.

O80	Annealed to Temper— $\frac{1}{8}$ Hard
O81	Annealed to Temper— $\frac{1}{4}$ Hard
O82	Annealed to Temper— $\frac{1}{2}$ Hard

6.1.2 Annealed Tempers, with Grain Size Prescribed—OS

Temper Codes	Temper Designations Nominal Avg Grain Size, mm
OS005	0.005
OS010	0.010
OS015	0.015
OS025	0.025
OS035	0.035
OS045	0.045
OS050	0.050
OS060	0.060
OS065	0.065
OS070	0.070
OS100	0.100
OS120	0.120
OS150	0.150
OS200	0.200

6.2 Cold-Worked Tempers, H:

6.2.1 Cold-Worked Tempers to Meet Standard Requirements Based on Cold Rolling or Cold Drawing, H:

Temper Codes	Temper Names
H00	$\frac{1}{8}$ Hard
H01	$\frac{1}{4}$ Hard
H02	$\frac{1}{2}$ Hard
H03	$\frac{3}{4}$ Hard
H04	Hard
H06	Extra Hard
H08	Spring
H10	Extra Spring
H12	Special Spring
H13	Ultra Spring
H14	Super Spring

6.2.2 Cold-Worked Tempers to Meet Standard Requirements Based on Temper Names Applicable to Particular Products, H:

Temper Codes	Temper Names
H50	Hot Extruded and Drawn
H52	Hot Pierced and Drawn
H55	Light Drawn, Light Cold-Worked
H58	Drawn General Purpose
H60	Cold Heading, Forming
H63	Rivet
H64	Screw
H66	Bolt
H70	Bending
H80	Hard Drawn
H85	Medium Hard-Drawn Electrical Wire
H86	Hard-Drawn Electrical Wire
H90	As-finned

6.3 Cold-Worked Tempers with Added Treatments:

6.3.1 Cold Worked and Stress Relieved, HR:

6. Temper Designation Codes and Names

6.1 Annealed Tempers, O:

6.1.1 Annealed to Meet Mechanical Properties, O:

Temper Codes	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	Hot Extruded and Precipitation Heat Treated
O32	Hot Extruded and Temper Annealed
O40	Hot Pierced and Annealed
O50	Light Anneal
O60	Soft Anneal
O61	Annealed
O65	Drawing Anneal
O68	Deep Drawing Anneal
O70	Dead Soft Anneal



Temper Codes	Temper Names	TD00	Solution Heat Treated and Cold Worked: $\frac{1}{8}$ Hard
HR01	$\frac{1}{4}$ Hard and Stress Relieved		
HR02	$\frac{1}{2}$ Hard and Stress Relieved		
HR04	Hard and Stress Relieved		
HR06	Extra Hard and Stress Relieved	TD01	Solution Heat Treated and Cold Worked: $\frac{1}{4}$ Hard ($\frac{1}{4}$ H)
HR08	Spring and Stress Relieved		
HR10	Extra Spring and Stress Relieved		
HR12	Special Spring and Stress Relieved		
HR20	As-finned and Stress Relieved	TD02	Solution Heat Treated and Cold Worked: $\frac{1}{2}$ Hard ($\frac{1}{2}$ H)
HR50	Drawn and Stress Relieved		

6.3.2 Cold Rolled and Order Strengthened, HT:

Temper Codes	Temper Names	TD03	Solution Heat Treated and Cold Worked: $\frac{3}{4}$ Hard ($\frac{3}{4}$ H)
HT04	Hard Temper and Treated		
HT08	Spring Temper and Treated	TD04	Solution Heat Treated and Cold Worked: Hard (H)

6.3.3 Hard Drawn End Annealed, HE:

Temper Codes	Temper Name
HE80	Hard Drawn and End Annealed

6.5.4 Solution Heat Treated and Precipitation Heat Treated, TF:

6.4 As-Manufactured Tempers, M:

Temper Codes	Temper Names	TF00	Precipitation Hardened (AT)
M01	As Sand Cast	TF01	Precipitation Heat-Treated Plate—Low Hardness (ATLH)
M02	As Centrifugal Cast	TF02	Precipitation Heat-Treated Plate—High Hardness (ATHH)
M03	As Plaster Cast		
M04	As Pressure Die Cast		
M05	As Permanent Mold Cast		
M06	As Investment Cast		
M07	As Continuous Cast		
M10	As Hot Forged—Air Cooled		
M11	As Hot Forged—Quenched		
M20	As Hot Rolled		
M25	As Hot Rolled and Rerolled		
M30	As Hot Extruded		
M40	As Hot Pierced		
M45	As Hot Pierced and Rerolled		

6.5.5 Solution Heat Treated and Spinodal Heat Treated, TX:

Temper Codes	Temper Name
TX00	Spinodal Hardened (AT)

6.5.6 Solution Heat Treated, Cold Worked, and Precipitation Heat Treated, TH:

6.5 Heat-Treated Tempers, T:

6.5.1 Quench Hardened, TQ:

Temper Codes	Temper Names
TQ00	Quench Hardened
TQ30	Quench Hardened and Tempered
TQ50	Quenched Hardened and Temper Annealed
TQ55	Quench Hardened and Temper Annealed, Cold Drawn and Stress Relieved
TQ75	Interrupted Quench

Temper Codes	Temper Names
TH01	$\frac{1}{4}$ Hard and Precipitation Heat Treated ($\frac{1}{4}$ HT)
TH02	$\frac{1}{2}$ Hard and Precipitation Heat Treated ($\frac{1}{2}$ HT)
TH03	$\frac{3}{4}$ Hard and Precipitation Heat Treated ($\frac{3}{4}$ HT)
TH04	Hard and Precipitation Heat Treated (HT)

6.5.7 Cold-Worked Tempers and Spinodal Heat Treated to Meet Standard Requirements Based on Cold Rolling or Cold Drawing, TS:

6.5.2 Solution Heat Treated, TB:

Temper Codes	Temper Name
TB00	Solution Heat Treated (A)

6.5.3 Solution Heat Treated and Cold Worked, TD:

Temper Codes	Temper Names

Temper Codes	Temper Names
TS00	$\frac{1}{8}$ Hard and Spinodal Hardened ($\frac{1}{8}$ TS)
TS01	$\frac{1}{4}$ Hard and Spinodal Hardened ($\frac{1}{4}$ TS)
TS02	$\frac{1}{2}$ Hard and Spinodal Hardened ($\frac{1}{2}$ TS)
TS03	$\frac{3}{4}$ Hard and Spinodal Hardened ($\frac{3}{4}$ TS)
TS04	Hard and Spinodal Hardened
TS06	Extra Hard and Spinodal Hardened
TS08	Spring and Spinodal Hardened
TS10	Extra Spring and Spinodal Hardened



TS12	Special Spring and Spinodal Hardened
TS13	Ultra Spring and Spinodal Hardened
TS14	Super Spring and Spinodal Hardened

6.5.8 Mill Hardened, TM:

Temper Codes	Manufacturing Designations
TM00	AM
TM01	1/4 HM
TM02	1/2 HM
TM03	3/4 HM
TM04	HM
TM05	SHM
TM06	XHM
TM08	XHMS

6.5.9 Precipitation Heat Treated or Spinodal Heat Treated and Cold Worked, TL:

Temper Codes	Temper Names
TL00	Precipitation Heat Treated or Spinodal Heat Treated and 1/8 Hard
TL01	Precipitation Heat Treated or Spinodal Heat Treated and 1/4 Hard
TL02	Precipitation Heat Treated or Spinodal Heat Treated and 1/2 Hard
TL04	Precipitation Heat Treated or Spinodal Heat Treated and Hard
TL08	Precipitation Heat Treated or Spinodal Heat Treated and Spring
TL10	Precipitation Heat Treated or Spinodal Heat Treated and Extra Spring

6.5.10 Precipitation Heat Treated or Spinodal Heat Treated, Cold Worked, and Thermal Stress Relieved, TR:

Temper Codes	Temper Names
TR01	Precipitation Heat Treated or Spinodal Heat Treated, 1/4 Hard and Stress Relieved
TR02	Precipitation Heat Treated or Spinodal Heat Treated, 1/2 Hard and Stress Relieved
TR04	Precipitation Heat Treated or Spinodal Heat Treated, Hard and Stress Relieved

6.6 Tempers of Welded Tube, W:

6.6.1 As-Welded, WM:

Temper Codes	Temper Names
WM50	As-Welded from Annealed Strip
WM00	As-Welded from 1/8 Hard Strip
WM01	As-Welded from 1/4 Hard Strip
WM02	As-Welded from 1/2 Hard Strip
WM03	As-Welded from 3/4 Hard Strip
WM04	As-Welded from Hard Strip
WM06	As-Welded from Extra Hard Strip
WM08	As-Welded from Spring Strip
WM10	As-Welded from Extra Spring Strip
WM15	As-Welded from Annealed Strip, Thermal Stress Relieved
WM20	As-Welded from 1/8 Hard Strip, Thermal Stress Relieved
WM21	As-Welded from 1/4 Hard Strip, Thermal Stress Relieved
WM22	As-Welded from 1/2 Hard Strip, Thermal Stress Relieved
WM24	As-Welded from 3/4 Hard Strip, Thermal Stress Relieved

6.6.2 Welded Tube and Annealed, WO:

Temper Codes	Temper Names
WO50	Welded and Light Annealed
WO60	Welded and Soft Annealed
WO61	Welded and Annealed

6.6.3 Welded Tube and Light Cold-Worked, WC:

	Temper Name
WC55	Welded and Light Cold-Worked

6.6.4 Welded Tube and Cold Drawn, WH:

Temper Codes	Temper Names
WH00	Welded and Drawn: Eighth Hard
WH01	Welded and Drawn: Quarter Hard
WH02	Welded and Drawn: Half Hard
WH03	Welded and Drawn: Three Quarter Hard
WH04	Welded and Drawn: Hard
WH06	Welded and Drawn: Extra Hard
WH55	Welded and Cold Reduced or Light Drawn
WH58	Welded and Cold Reduced or Drawn, General Purpose
WH80	Welded and Reduced or Hard Drawn

6.6.5 Welded Tube, Cold Drawn, and Stress Relieved, WR:

Temper Codes	Temper Names
WR00	Welded, Drawn, and Stress Relieved from: Eighth Hard
WR01	Welded, Drawn, and Stress Relieved from: Quarter Hard
WR02	Welded, Drawn, and Stress Relieved from: Half Hard
WR03	Welded, Drawn, and Stress Relieved from: Three Quarter Hard
WR04	Welded, Drawn, and Stress Relieved from: Hard
WR06	Welded, Drawn, and Stress Relieved from: Extra Hard

6.6.6 Welded Tube, Fully Finished, O, OS, H:

6.6.6.1 Fully Finished Tube, Annealed to Meet Property Requirements:

Temper Codes	Temper Names
O— & OS—	Use appropriate designation for property or grain size requirements. See 6.1.1 or 6.1.2

6.6.6.2 Fully Finished Tube, Drawn to Meet Property Requirements:

Temper Codes	Temper Names
H—	Use appropriate designation for property requirement. See 6.2.1.

7. Keywords

7.1 copper and copper alloys; temper designation; temper codes; temper names



APPENDIX

(Nonmandatory Information)

X1. DATA (See Section 4, Note 2.)

X1.1 For information associated with B 601 tempers, see Table X1.1.

TABLE X1.1 Information on B 601 Tempers

Letter	Name	Used with B 601 Tempers
A	Annealed (Mill Hardened)	TB
1/4H,	Solution Heat Treated and Cold Worked 1/4 Hard	TD
1/2H,	Solution Heat Treated and Cold Worked 1/2 Hard	
3/4H,	Solution Heat Treated and Cold Worked 3/4 Hard	
H	Solution Heat Treated and Cold Worked Hard	
AT	Precipitation Hardened	TF and TX
ATLH	Precipitation Hardened-Low Hardness	TF
ATHH	Precipitation Hardened-High Hardness	TF
1/4 HT	1/4 Hard and Precipitation Heat Treated	TH
1/2 HT	1/2 Hard and Precipitation Heat Treated	
3/4 HT	3/4 Hard and Precipitation Heat Treated	
HT	Hard and Precipitation Heat Treated	
1/8 TS,	1/8 Hard and Spinodal Hardened	TS
1/4 TS	1/4 Hard and Spinodal Hardened	
1/2 TS	1/2 Hard and Spinodal Hardened	
3/4 TS	3/4 Hard and Spinodal Hardened	
AM	Solution Heat Treated (Mill Hardened)	TM
1/4 HM	1/4 Hard (Mill Hardened)	TM
1/2 HM	1/2 Hard (Mill Hardened)	TM
3/4 HM	3/4 Hard (Mill Hardened)	
HM	Hard (Mill Hardened)	
SHM	Spring Hard (Mill Hardened)	TM
XHM	Extra Hard (Mill Hardened)	TM
XHMS	Extra Spring Hard (Mill Hardened)	TM

SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue (B 601 - 02) that may impact the use of this standard:

- (1) Temper WM24 was added to 6.6.1
- (2) Temper HR20 name was corrected to include “and Stress Relieved” in 6.3.1.
- (3) Temper codes and temper names (in Section 6) were coordinated with classification definitions (in Section 5).
- (4) Added Appendix X1.

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).