



Designation: B 601 – 04~~2~~

## Standard Classification for Temper Designations for Copper and Copper Alloys— Wrought and Cast<sup>1</sup>

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 reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

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

<sup>1</sup> 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~~ Oct. 10, 2004~~2~~. Published ~~August 2004~~, November 2002. Originally published as B 601 – 74. Last previous edition B 601 – 99~~a~~01.

### 1. Scope \*

1.1 This is a classification of 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 qualities. It is not a specification of copper and copper alloy products.

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

### 2. Referenced Documents

2.1 *ASTM Standards:*

B 846 Terminology for Copper and Copper Alloys<sup>2</sup>

### 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*—The alphanumeric code is used to designate product tempers in specifications and published data.

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.

### 5. Classification of Tempers

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

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

5.3 *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.

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

5.5 *Cold-Worked (Drawn), 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.

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

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.

<sup>2</sup> *Annual Book of ASTM Standards*, Vol 02.01.

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

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

5.6.5 *Spinodal Heat Treated Temper, TX*—Tempers produced by 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.

## 6. Temper Designation Codes

### 6.1 *Annealed Tempers, O:*

#### 6.1.1 *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
<del>O32</del>	
<u>O32</u>	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
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 to Meet Nominal Average Grain Size, OS:*

Annealed Tempers, with Grain Size Prescribed—OS	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:*

Cold-Worked Tempers—H	Temper Names
H00	1/8 Hard
H01	1/4 Hard
H02	1/2 Hard
H03	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:*

Cold-Worked Tempers—H	Temper Names
H50	Extruded and Drawn
H52	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:*

	Temper Names
HR01	1/4 Hard and Stress Relieved
HR02	1/2 Hard and Stress Relieved
HR04	Hard and Stress Relieved
HR06	Extra Hard and Stress Relieved
HR08	Spring and Stress Relieved
HR10	Extra Spring and Stress Relieved
HR12	Special Spring and Stress Relieved
HR20	As-finned

6.3.2 *Drawn and Stress Relieved, HR:*

	Temper Name
HR50	Drawn and Stress Relieved

6.3.3 *Cold Rolled and Order Strengthened, HT:*

	Temper Names
HT04	Hard Temper and Treated
HT08	Spring Temper and Treated
...	...

6.3.4 *Hard Drawn End Annealed, HE:*

	Temper Name
HE80	Hard Drawn and End Annealed

6.4 *As-Manufactured Tempers, M:*

	Temper Names
M01	As Sand Cast
M02	As Centrifugal Cast
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 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 *Heat-Treated Tempers, T:*

6.5.1 *Quench Hardened, TQ:*

	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

6.5.2 *Solution Heat Treated, TB:*

	Temper Name
TB00	Solution Heat Treated (A)

6.5.3 *Solution Heat Treated and Cold Worked, TD:*

	Temper Names
TD00	Solution Heat Treated and Cold Worked: 1/8 Hard
TD01	Solution Heat Treated and Cold Worked: 1/4 Hard (1/4 H)
TD02	Solution Heat Treated and Cold Worked: 1/2 Hard (1/2 H)
TD03	Solution Heat Treated and Cold Worked: 3/4 Hard (3/4 H)
TD04	Solution Heat Treated and Cold Worked: Hard (H)

6.5.4 *Solution Heat Treated and Precipitation Heat Treated, TF:*

Temper Name

TF00	Pre- cipitation Hardened (AT)
TF01	Pre- cipitation Heat-Treated Plate—Low Hardness (ATLH)
TF02	Pre- cipitation Heat-Treated Plate—High Hardness (ATHH)

6.5.5 *Solution Heat Treated and Spinodal Heat Treated, TX:*

	Temper Name
TX00	Spinodal Hardened (AT)

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

	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:*

	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:*

	Manufacturing Designations
TM00	AM
TM01	$\frac{1}{4}$ HM
TM02	$\frac{1}{2}$ HM
TM03	$\frac{3}{4}$ HM
TM04	HM
TM05	SHM
TM06	XHM
TM08	XHMS

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

Temper 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 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 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

6.6.2 *Welded Tube and Annealed, WO:*

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:*

WC55

Temper Name

Welded and Light Cold-Worked

6.6.4 *Welded Tube and Cold Drawn, WH:*

WH00  
WH01  
WH02  
WH03  
WH04  
WH06  
WH55  
WH58  
WH80

Temper Names

Welded and Drawn: Eighth Hard  
Welded and Drawn: Quarter Hard  
Welded and Drawn: Half Hard  
Welded and Drawn: Three Quarter Hard  
Welded and Drawn: Hard  
Welded and Drawn: Extra Hard  
Welded and Cold Reduced or Light Drawn  
Welded and Cold Reduced or Drawn, General Purpose  
Welded and Reduced or Hard Drawn

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

WR00  
WR01  
WR02  
WR03  
WR04  
WR06

Temper Names

Welded, Drawn, and Stress Relieved from: Eighth Hard  
Welded, Drawn, and Stress Relieved from: Quarter Hard  
Welded, Drawn, and Stress Relieved from: Half Hard  
Welded, Drawn, and Stress Relieved from: Three Quarter Hard  
Welded, Drawn, and Stress Relieved from: Hard  
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:*

O— & OS—

Temper Names

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:*

H—

Temper Names

Use appropriate designation for property requirement.  
See 6.2.1.

**7. Keywords**

7.1 copper and copper alloys; temper designation

**SUMMARY OF CHANGES**

Committee B05 has identified the location of selected changes to this standard since the ~~B-601--99a~~ last issue (B 601 - 01) that may impact the use of this standard:

- ~~(1) Document was changed from a “Practice” to a “Classification.”~~
- ~~(2) “Scope” section was revised to clarify intent of the standard as a classification and not as a terminology document.~~
- ~~(3) A “Referenced Document” section was added.~~
- ~~(4) A “Significance and Use” section was added.~~
- ~~(5) The Terminology section O32 temper designation was ~~modified~~ added to reference terms located in Terminology B 846, and these terms were removed: 6.1.1.~~

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