Designation: A686 – 92 (Reapproved 2024)

Standard Specification for Tool Steel, Carbon[1]

This standard is issued under the fixed designation A686; 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 (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope

1.1 This specification covers the chemical, mechanical, and physical requirements for available wrought carbon tool steel products.

1.2 These products, which include hot- or cold-finished bar, plate, sheet, rod, wire, or forgings, are normally fabricated into tools, dies, or fixtures. The selection of a material for a particular application will depend upon design, service conditions, and desired properties.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A388/A388M Practice for Ultrasonic Examination of Steel Forgings

A561 Practice for Macroetch Testing of Tool Steel Bars

A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment

E3 Guide for Preparation of Metallographic Specimens

E30 Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron (Withdrawn 1995)[3]

E45 Test Methods for Determining the Inclusion Content of Steel

E59 Practice for Sampling Steel and Iron for Determination of Chemical Composition (Withdrawn 1996)[3]

2.2 *Military Standard:*[4]

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage

2.3 *Federal Standards:*[4]

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products

3. Classification

3.1 Material in accordance with this specification is classified by chemical composition. Types correspond to respective AISI designations.

3.1.1 *Carbon Tool Steels, Identification W*—Types W1, W2, and W5 are often referred to as water hardening tool steels since they require rapid quenching rates to attain the necessary hardness. Except in very small sizes they will harden with a hard case and a soft core.

3.1.1.1 Type W1 is an unalloyed carbon steel available in several carbon ranges.

3.1.1.2 Type W2 is characterized by a nominal vanadium content of 0.25 % and is also available in several carbon ranges.

3.1.1.3 Type W5 is characterized by a nominal chromium content of 0.50 %.

3.1.1.4 A suffix following the type designation is added to denote the minimum carbon content of the carbon range to be specified.

3.1.2 Types W1 and W2 are further classified by quality levels, namely, Grade A and Grade C.

3.1.2.1 Grade A is sometimes referred to as *Extra* or *Special*. It is controlled for hardenability; the chemical composition is held to closest limits; and it is subject to rigid tests to ensure

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.29 on Tool Steels.

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[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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

uniformity. Grade A is available with three degrees of hardenability, namely, shallow hardening, regular hardening, and deep hardening.

3.1.2.2 Grade C is sometimes referred to as *Regular* or *Standard*. It is intended for applications that do not require controlled hardenability and where some latitude in uniformity is permissible.

4. Ordering Information

4.1 Orders for material under this specification shall include the following information, as required to describe adequately the desired material:

4.1.1 Class of material (carbon tool steel),

4.1.2 Type (W1, W2, W5),

4.1.3 Suffix denoting carbon range (where applicable, such as W1–9, W2–10, etc.),

4.1.4 Grade and hardenability (where applicable, for example, Grade A deep hardening, and so forth),

4.1.5 Shape (sheet, plate, flat bar, round bar, square bar, hexagon bar, octagon, special shapes),

4.1.6 Dimensions (thickness, width, diameter, length),

4.1.7 Finish (hot rolled, forged, blasted or pickled, cold drawn, machined, ground, precision ground and polished),

4.1.8 Condition (annealed, unannealed, hardened and tempered, and so forth),

4.1.9 ASTM specification number and date of issue, and

4.1.10 Special requirements.

5. Materials and Manufacture

5.1 Unless otherwise specified, material covered by this specification shall be made by an electric melting process. It shall be made from ingots that have been reduced in cross section in such a manner and to such a degree as to ensure proper refinement of the ingot structure.

6. Chemical Composition

6.1 An analysis of each heat of steel shall be made by the manufacturer to determine the percentage of the elements specified and these values shall conform to the chemical composition specified in Table 1. If requested or required, the chemical composition shall be reported to the purchaser or his representative.

6.2 Analysis may be made by the purchaser from finished bars and forgings by machining off the entire cross section and drilling parallel to the axis of the bar or forging at any point midway between the center and surface in accordance with the latest issue of Practice E59. The chemical analysis of the drilling chips shall be made in accordance with the latest issue of Test Methods E30. The chemical composition thus determined shall not vary from the limits specified in Table 1.

7. Hardness Properties

7.1 Annealed hardness values shall be obtained in accordance with the latest issue of Test Methods and Definitions A370, and shall not exceed the Brinell hardness values (or equivalent Rockwell hardness values) specified in Table 2.

7.2 Specimens for determination of minimum response to hardening shall be ¼ in. (6.4 mm) thick disks cut so as to represent either the full cross-sectional area or that midway between the center and outer surface of the material. If the material form or size does not lend itself to accurate hardness determination on ¼ in. (6.4 mm) thick cross-sectional disks, then longitudinal specimens may be used for hardness testing. Examples are round bars less than ½ in. (12.7 mm) in diameter or sheet. In this case, the specimen shall be a minimum of 3 in. (76.2 mm) in length and parallel flats shall be ground on the original mill surfaces. The specimens shall be heat treated as prescribed in Table 3.

7.2.1 The hardness of the specimen after the specified heat treatment shall meet the minimum hardness value for the particular type of steel shown in Table 3. Rockwell C tests should be used where possible but light load tests may be necessary on thin specimens. These tests should be specified by agreement between seller and purchaser. The hardness value shall be obtained in accordance with the latest issue of Test

TABLE 1 Chemical Composition, %[A]

UNS Designation	Type	Grade	Carbon		Manganese		Silicon		Phosphorus, max	Sulfur, max	Chromium		Vanadium		Tungsten, max	Molybdenum, max	Copper, max	Nickel, max
			min	max	min	max	min	max			min	max	min	max				
T72301	W1	A	[B]	[B]	0.10	0.40	0.10	0.40	0.030	0.030	...	0.15	...	0.10	0.15	0.10	0.20	0.20
T72301	W1	C	[B]	[B]	0.10	0.40	0.10	0.40	0.030	0.030	...	0.30	...	0.10	0.15	0.10	0.20	0.20
T72302	W2	A	[C]	[C]	0.10	0.40	0.10	0.40	0.030	0.030	...	0.15	0.15	0.35	0.15	0.10	0.20	0.20
T72302	W2	C	[C]	[C]	0.10	0.40	0.10	0.40	0.030	0.030	...	0.30	0.15	0.35	0.15	0.10	0.20	0.20
T72305	W5	...	1.05	1.15	0.10	0.40	0.10	0.40	0.030	0.030	0.40	0.60	...	0.10	0.15	0.10	0.20	0.20

[A] Chemistry limits include product analysis tolerances.

[B] The carbon ranges for W1 and their respective suffix identification, sometimes referred to as tempers, are as follows:

Suffix	Carbon Range, %	Suffix	Carbon Range, %
8	0.80–0.90	10	1.00–1.10
8½	0.85–0.95	10½	1.05–1.15
9	0.90–1.00	11	1.10–1.20
9½	0.95–1.05	11½	1.15–1.25

[C] The carbon ranges for W2 and their respective suffix identification are as follows:

Suffix	Carbon Range, %
8½	0.85–0.95
9	0.90–1.00
9½	0.95–1.10
13	1.30–1.50