



Designation: A681 – 08 (Reapproved 2022)

Standard Specification for Tool Steels Alloy¹

This standard is issued under the fixed designation A681; 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 alloy tool steel products.

1.2 These products, which include hot or cold finished bar, plate, sheet, strip, 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
- A561 Practice for Macroetch Testing of Tool Steel Bars
- A600 Specification for Tool Steel High Speed
- A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment
- E3 Guide for Preparation of Metallographic Specimens

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.

Current edition approved Sept. 1, 2022. Published September 2022. Originally approved in 1973. Last previous edition approved in 2015 as A681 – 08 (2015). DOI: 10.1520/A0681-08R22.

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.

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

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

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 and Shipment (Civil Agencies)

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

2.4 Other Standard:⁵

SAE J1086 Recommended Practice for Numbering Metals and Alloys (UNS)

3. Classification

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

3.1.1 Hot Work Tool Steels, Identification H:

3.1.1.1 Types H10 to H19 are characterized by a controlled chromium content along with other alloying elements. The first four, containing molybdenum, offer excellent toughness and high hardenability and are frequently used in cold work applications requiring toughness at relatively high hardness levels.

3.1.1.2 Types H21 to H26 are characterized by a controlled tungsten content along with other alloying elements. These steels offer greater resistance to the softening effect of elevated service temperatures but exhibit a lower degree of toughness.

3.1.1.3 Types H41 to H43 are low-carbon modifications of molybdenum high speed tool steels (**Note 1**) and have characteristics similar to the tungsten types.

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>.

⁵ Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.

NOTE 1—High-speed tool steels are covered in Specification A600.

3.1.2 *Cold Work Tool Steels, Identification A*—Types A2 to A10 cover a wide range of carbon and alloy contents but all have high hardenability and may be hardened in air. The low carbon Types A8 and A9 have less wear resistance but offer greater toughness than others in this group. Type A7, with high carbon and vanadium, offers exceptional wear resistance but at a very low level of toughness.

3.1.3 *Cold Work Tool Steels, Identification D*—Types D2 to D7 are characterized by high carbon and high chromium contents and exhibit high resistance to abrasion. The types containing molybdenum may be hardened in air and offer a high degree of dimensional stability in heat treatment.

3.1.4 *Cold Work Tool Steels, Identification O*—Types O1 to O7 are low-alloy types that must be hardened by quenching in oil. Sizes over about 2 in. (50 mm) in cross section usually exhibit lower interior hardness.

3.1.5 *Shock-Resisting Steels, Identification S*—Types S1 to S7 vary in alloy content but are intended for shock-resisting applications.

3.1.6 *Special-Purpose Tool Steels, Identification L*—Types L2 to L6 are low-alloy steels with a wide range of carbon content. The low-carbon types are generally used for structural applications requiring good levels of toughness, while the high-carbon types may be used for short-run tools.

3.1.7 *Special-Purpose Tool Steels, Identification F*—Types F1 to F2 are high-carbon steels with varying tungsten content used primarily for relatively short-run fine edge cutting tools.

3.1.8 *Mold Steels, Identification P*:

3.1.8.1 Types P2 to P6 are very low-carbon steels and must be carburized after machining or hubbing.

3.1.8.2 Types P20 and P21 are usually supplied in the prehardened condition and can be placed in service directly after machining.

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 (hot work tool steel, etc.),
- 4.1.2 Type (H11, D2, etc.),
- 4.1.3 Shape (sheet, strip, plate, flat bar, round bar, square bar, hexagon bar, octagon, special shapes),
- 4.1.4 Dimensions (thickness, width, diameter, length),
- 4.1.5 Finish (hot rolled, forged, blasted or pickled, cold drawn, machined, ground, precision ground and polished),
- 4.1.6 Condition (annealed, hardened and tempered, etc.),
- 4.1.7 ASTM designation and year of issue, and
- 4.1.8 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 or slabs that have been reduced in cross section in such a manner and to such a degree as to ensure proper refinement of the solidification 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 requirements for 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 Requirements

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. 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 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 the seller and the purchaser. The hardness value shall be obtained in accordance with the latest issue of Test Methods and Definitions A370, and shall be the average of at least five readings taken in an area midway between the center and surface of the largest dimension of the cross-sectional specimen or along the parallel surfaces of the longitudinal specimen.

8. Macrostructure

8.1 Specimens for the determination of the macrostructure shall represent the entire cross-sectional area in the annealed condition and be prepared in accordance with the latest issue of Practice A561. Material supplied to this specification shall be capable of exhibiting a structure free of excessive porosity, segregation, slag, dirt or other nonmetallic inclusions, pipe, checks, cracks, and other injurious defects.