



## Designation: **A600 – 92a (Reapproved 2010) A600 – 92a (Reapproved 2016)**

# Standard Specification for Tool Steel High Speed<sup>1</sup>

This standard is issued under the fixed designation A600; 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 U.S. Department of Defense.*

## 1. Scope

1.1 This specification covers tungsten-type and molybdenum-type high-speed steels available as annealed, hot-rolled bars, forgings, plate, sheet, or strip, and annealed, cold-finished bars or forgings used primarily in the fabrication of tools.

1.2 Seven types of tungsten high-speed tool steels designated T1, T2, etc., seventeen types of molybdenum high-speed tool steels designated M1, M2, etc., and two intermediate high speed steels designated as M50 and M52 are covered. Selection will depend upon design, service conditions, and mechanical properties.

1.3 The term “high-speed steel” is described and its minimum requirements are covered in the Annex.

1.4 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.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

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[E30 Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron](#) (Withdrawn 1995)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

[E45 Test Methods for Determining the Inclusion Content of Steel](#)

[E59 Practice for Sampling Steel and Iron for Determination of Chemical Composition](#) (Withdrawn 1996)<sup>3</sup>

### 2.2 Military Standard:

[MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage](#)<sup>4</sup>

### 2.3 Federal Standards:

[Fed. Std. No. 123 Marking for Shipment \(Civil Agencies\)](#)<sup>4</sup>

[Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products](#)<sup>4</sup>

## 3. Classification

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

3.1.1 Types T1, T2, T4, T5, T6, T8, and T15 are characterized by a controlled high tungsten content along with other alloying elements.

3.1.2 Types M1, M2, M3, M4, M6, M7, M10, M30, M33, M34, M36, M41, M42, M43, M44, M46, M47, M48, and M62 are characterized by a controlled high molybdenum content along with other alloying elements.

<sup>1</sup> 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>4</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://dodssp.daps.dla.mil/DLA> Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, <http://quicksearch.dla.mil>.

3.1.3 Types M2, M3, and M10 are further classified according to carbon range. Type M3 is further classified according to vanadium range.

3.1.4 Types M50 and M52 are considered intermediate high speed steels in view of their lower total alloy content than the standard types. These leaner alloy grades normally are limited to less severe service conditions.

#### 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 Name of material (high-speed tool steel),

4.1.2 Type,

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). (For coils, include the minimum inside diameter or inside diameter range, the maximum outside diameter, and maximum or minimum coil weight if required. (Minimum coil weights are subject to negotiation.)),

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

4.1.6 Condition (annealed),

4.1.7 ASTM designation and date of issue, and

4.1.8 Special or supplementary requirements.

#### 5. Materials and Manufacture

5.1 Unless otherwise specified, material covered by this specification shall be made by an electric melting process.

#### 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 as to 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 **Method 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 when obtained in accordance with the latest issue of Test Methods and Definitions **A370** 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; sheet; and strip. In this case, the specimen shall be a minimum of ~~3-in.~~ 3 in. (76.2 mm) in length, and parallel flats shall be ground on the original mill surfaces. The specimens shall be heat treated in two furnaces, one operating as a preheat furnace and the other as a high-heat furnace. The furnaces may be either controlled atmosphere or molten-salt bath. The austenitizing temperature ranges stipulated in **Table 3** cover both furnace types.

7.2.1 After being austenitized for the proper time, the samples may be oil quenched or quenched in molten salt plus air cooling. When a salt quench is employed, its temperature shall be 1050 to 1175°F (566 to 635°C) except for M3, M4, M41, ~~M42, M43~~ ~~M42, M43~~, M46, M47, M48, M62, and T15, when it shall be 1000 to 1075°F (538 to 579°C). All samples shall be double tempered at 1025°F (552°C) for 2 h each cycle except for M0 and M52 which shall be given two tempering cycles of 2 h each at 1000°F and M41, M42, M43, M44, M46, M47, M48, M62, and T15, which shall be given three tempering cycles of 2 h each at 1000°F.

7.2.2 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 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. The surface to be tested shall be ground sufficiently to remove any surface condition, scale, carburization, or decarburization which might affect readings.



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### TABLE 1 Chemical Requirements, %<sup>A</sup>

| UNS Designation <sup>B</sup>      | Type          | Carbon |      | Manganese |      | Phosphorus | Sulfur <sup>C</sup> |      | Silicon |      | Chromium |      | Vanadium |       | Tungsten |       | Molybdenum |       | Cobalt |     |
|-----------------------------------|---------------|--------|------|-----------|------|------------|---------------------|------|---------|------|----------|------|----------|-------|----------|-------|------------|-------|--------|-----|
|                                   |               | min    | max  | min       | max  | max        | max                 | min  | max     | min  | max      | min  | max      | min   | max      | min   | max        | min   | max    | min |
| Tungsten-Type High-Speed Steels   |               |        |      |           |      |            |                     |      |         |      |          |      |          |       |          |       |            |       |        |     |
| T12001                            | T1            | 0.65   | 0.80 | 0.10      | 0.40 | 0.03       | 0.03                | 0.20 | 0.40    | 3.75 | 4.50     | 0.90 | 1.30     | 17.25 | 18.75    | ...   | ...        | ...   | ...    |     |
| T12002                            | T2            | 0.80   | 0.90 | 0.20      | 0.40 | 0.03       | 0.03                | 0.20 | 0.40    | 3.75 | 4.50     | 1.80 | 2.40     | 17.50 | 19.00    | ...   | 1.00       | ...   | ...    |     |
| T12004                            | T4            | 0.70   | 0.80 | 0.10      | 0.40 | 0.03       | 0.03                | 0.20 | 0.40    | 3.75 | 4.50     | 0.80 | 1.20     | 17.50 | 19.00    | 0.40  | 1.00       | 4.25  | 5.75   |     |
| T12005                            | T5            | 0.75   | 0.85 | 0.20      | 0.40 | 0.03       | 0.03                | 0.20 | 0.40    | 3.75 | 5.00     | 1.80 | 2.40     | 17.50 | 19.00    | 0.50  | 1.25       | 7.00  | 9.50   |     |
| T12006                            | T6            | 0.75   | 0.85 | 0.20      | 0.40 | 0.03       | 0.03                | 0.20 | 0.40    | 4.00 | 4.75     | 1.50 | 2.10     | 18.50 | 21.00    | 0.40  | 1.00       | 11.00 | 13.00  |     |
| T12008                            | T8            | 0.75   | 0.85 | 0.20      | 0.40 | 0.03       | 0.03                | 0.20 | 0.40    | 3.75 | 4.50     | 1.80 | 2.40     | 13.25 | 14.75    | 0.40  | 1.00       | 4.25  | 5.75   |     |
| T12015                            | T15           | 1.50   | 1.60 | 0.15      | 0.40 | 0.03       | 0.03                | 0.15 | 0.40    | 3.75 | 5.00     | 4.50 | 5.25     | 11.75 | 13.00    | ...   | 1.00       | 4.75  | 5.25   |     |
| Molybdenum-Type High-Speed Steels |               |        |      |           |      |            |                     |      |         |      |          |      |          |       |          |       |            |       |        |     |
| T11301                            | M1            | 0.78   | 0.88 | 0.15      | 0.40 | 0.03       | 0.03                | 0.20 | 0.50    | 3.50 | 4.00     | 1.00 | 1.35     | 1.40  | 2.10     | 8.20  | 9.20       | ...   | ...    |     |
| T11302                            | M2 regular C  | 0.78   | 0.88 | 0.15      | 0.40 | 0.03       | 0.03                | 0.20 | 0.45    | 3.75 | 4.50     | 1.75 | 2.20     | 5.50  | 6.75     | 4.50  | 5.50       | ...   | ...    |     |
| T11303                            | M2 high C     | 0.95   | 1.05 | 0.15      | 0.40 | 0.03       | 0.03                | 0.20 | 0.45    | 3.75 | 4.50     | 1.75 | 2.20     | 5.50  | 6.75     | 4.50  | 5.50       | ...   | ...    |     |
| T11304                            | M4            | 1.25   | 1.40 | 0.15      | 0.40 | 0.03       | 0.03                | 0.20 | 0.45    | 3.75 | 4.75     | 3.75 | 4.50     | 5.25  | 6.50     | 4.25  | 5.50       | ...   | ...    |     |
| T11306                            | M6            | 0.75   | 0.85 | 0.15      | 0.40 | 0.03       | 0.03                | 0.20 | 0.45    | 3.75 | 4.50     | 1.30 | 1.70     | 3.75  | 4.75     | 4.50  | 5.50       | 11.00 | 13.00  |     |
| T11307                            | M7            | 0.97   | 1.05 | 0.15      | 0.40 | 0.03       | 0.03                | 0.20 | 0.55    | 3.50 | 4.00     | 1.75 | 2.25     | 1.40  | 2.10     | 8.20  | 9.20       | ...   | ...    |     |
| T11310                            | M10 regular C | 0.84   | 0.94 | 0.10      | 0.40 | 0.03       | 0.03                | 0.20 | 0.45    | 3.75 | 4.50     | 1.80 | 2.20     | ...   | ...      | 7.75  | 8.50       | ...   | ...    |     |
| T11310                            | M10 high C    | 0.95   | 1.05 | 0.10      | 0.40 | 0.03       | 0.03                | 0.20 | 0.45    | 3.75 | 4.50     | 1.80 | 2.20     | ...   | ...      | 7.75  | 8.50       | ...   | ...    |     |
| T11330                            | M30           | 0.75   | 0.85 | 0.15      | 0.40 | 0.03       | 0.03                | 0.20 | 0.45    | 3.50 | 4.25     | 1.00 | 1.40     | 1.30  | 2.30     | 7.75  | 9.00       | 4.50  | 5.50   |     |
| T11333                            | M33           | 0.85   | 0.92 | 0.15      | 0.40 | 0.03       | 0.03                | 0.15 | 0.50    | 3.50 | 4.00     | 1.00 | 1.35     | 1.30  | 2.10     | 9.00  | 10.00      | 7.75  | 8.75   |     |
| T11334                            | M34           | 0.85   | 0.92 | 0.15      | 0.40 | 0.03       | 0.03                | 0.20 | 0.45    | 3.50 | 4.00     | 1.90 | 2.30     | 1.40  | 2.10     | 7.75  | 9.20       | 7.75  | 8.75   |     |
| T11336                            | M36           | 0.80   | 0.90 | 0.15      | 0.40 | 0.03       | 0.03                | 0.20 | 0.45    | 3.75 | 4.50     | 1.75 | 2.25     | 5.50  | 6.50     | 4.50  | 5.50       | 7.75  | 8.75   |     |
| T11341                            | M41           | 1.05   | 1.15 | 0.20      | 0.60 | 0.03       | 0.03                | 0.15 | 0.50    | 3.75 | 4.50     | 1.75 | 2.25     | 6.25  | 7.00     | 3.25  | 4.25       | 4.75  | 5.75   |     |
| T11342                            | M42           | 1.05   | 1.15 | 0.15      | 0.40 | 0.03       | 0.03                | 0.15 | 0.65    | 3.50 | 4.25     | 0.95 | 1.35     | 1.15  | 1.85     | 9.00  | 10.00      | 7.75  | 8.75   |     |
| T11343                            | M43           | 1.15   | 1.25 | 0.20      | 0.40 | 0.03       | 0.03                | 0.15 | 0.65    | 3.50 | 4.25     | 1.50 | 1.75     | 2.25  | 3.00     | 7.50  | 8.50       | 7.75  | 8.75   |     |
| T11344                            | M44           | 1.10   | 1.20 | 0.20      | 0.40 | 0.03       | 0.03                | 0.30 | 0.55    | 4.00 | 4.75     | 1.85 | 2.20     | 5.00  | 5.75     | 6.00  | 7.00       | 11.00 | 12.25  |     |
| T11346                            | M46           | 1.22   | 1.30 | 0.20      | 0.40 | 0.03       | 0.03                | 0.40 | 0.65    | 3.70 | 4.20     | 3.00 | 3.30     | 1.90  | 2.20     | 8.00  | 8.50       | 7.80  | 8.80   |     |
| T11347                            | M47           | 1.05   | 1.15 | 0.15      | 0.40 | 0.03       | 0.03                | 0.20 | 0.45    | 3.50 | 4.00     | 1.15 | 1.35     | 1.30  | 1.80     | 9.25  | 10.00      | 4.75  | 5.25   |     |
| T11348                            | M48           | 1.42   | 1.52 | 0.15      | 0.40 | 0.03       | 0.07                | 0.15 | 0.40    | 3.50 | 4.00     | 2.75 | 3.25     | 9.50  | 10.50    | 4.75  | 5.50       | 8.00  | 10.00  |     |
| T11352                            | M52           | 0.85   | 0.95 | 0.15      | 0.40 | 0.03       | 0.03                | 0.15 | 0.40    | 3.50 | 4.00     | 1.80 | 2.10     | 5.75  | 6.50     | 10.00 | 11.00      | ...   | ...    |     |
| T11352                            | M52           | 0.85   | 0.95 | 0.15      | 0.40 | 0.03       | 0.03                | 0.20 | 0.60    | 3.50 | 4.30     | 1.65 | 2.25     | 0.75  | 1.50     | 4.00  | 4.90       | ...   | ...    |     |
| Intermediate High Speed Steels    |               |        |      |           |      |            |                     |      |         |      |          |      |          |       |          |       |            |       |        |     |
| T11350                            | M50           | 0.78   | 0.88 | 0.15      | 0.45 | 0.03       | 0.03                | 0.20 | 0.60    | 3.75 | 4.50     | 0.80 | 1.25     | ...   | ...      | 3.90  | 4.75       | ...   | ...    |     |
| T11350                            | M50           | 0.78   | 0.88 | 0.15      | 0.45 | 0.03       | 0.03                | 0.20 | 0.60    | 3.75 | 4.50     | 0.80 | 1.25     | ...   | ...      | 3.90  | 4.75       | ...   | ...    |     |
| T11352                            | M52           | 0.85   | 0.95 | 0.15      | 0.45 | 0.03       | 0.03                | 0.20 | 0.60    | 3.50 | 4.30     | 1.65 | 2.25     | 0.75  | 1.50     | 4.00  | 4.90       | ...   | ...    |     |
| T11352                            | M52           | 0.85   | 0.95 | 0.15      | 0.45 | 0.03       | 0.03                | 0.20 | 0.60    | 3.50 | 4.30     | 1.65 | 2.25     | 0.75  | 1.50     | 4.00  | 4.90       | ...   | ...    |     |

<sup>A</sup> Chemistry limits include product analysis tolerances. Unless otherwise specified, nickel plus copper equals 0.75 % max for all types.

<sup>B</sup> New designation established in accordance with Practice E527 and SAE J 1086.

<sup>c</sup> Where specified, sulfur may be 0.06 to 0.15 % to improve machinability.

**TABLE 2 Maximum Brinell Hardness in Annealed or Cold Drawn Condition**

| Type                    | Annealed BHN | Cold Drawn Annealed BHN | Cold Drawn BHN |
|-------------------------|--------------|-------------------------|----------------|
| M1                      | 248          | 255                     | 262            |
| M2 (regular C)          | 248          | 255                     | 262            |
| M2 (high C)             | 255          | 262                     | 269            |
| M3, Class 1 and Class 2 | 255          | 262                     | 269            |
| M4                      | 255          | 262                     | 269            |
| M6                      | 277          | 285                     | 293            |
| M7                      | 255          | 262                     | 269            |
| M10 (regular C)         | 248          | 255                     | 262            |
| M10 (high C)            | 255          | 262                     | 269            |
| M30                     | 269          | 277                     | 285            |
| M33                     | 269          | 277                     | 285            |
| M34                     | 269          | 277                     | 285            |
| M36                     | 269          | 277                     | 285            |
| M41                     | 269          | 277                     | 285            |
| M42                     | 269          | 277                     | 285            |
| M43                     | 269          | 297                     | 285            |
| M44                     | 285          | 293                     | 302            |
| M46                     | 269          | 277                     | 285            |
| M47                     | 269          | 277                     | 285            |
| M48                     | 311          | 321                     | 331            |
| M50                     | 248          | 255                     | 262            |
| M52                     | 248          | 255                     | 262            |
| M62                     | 285          | 293                     | 302            |
| T1                      | 255          | 262                     | 269            |
| T2                      | 255          | 262                     | 269            |
| T4                      | 269          | 277                     | 285            |
| T5                      | 285          | 293                     | 302            |
| T6                      | 302          | 311                     | 321            |
| T8                      | 255          | 262                     | 269            |
| T15                     | 277          | 285                     | 293            |

## 8. Macrostructure

8.1 The macrostructure of a specimen representing the entire cross-sectional area in the annealed condition and prepared in accordance with the latest issue of Practice **A561** shall exhibit a structure free of excessive porosity, slag, dirt, or other nonmetallic inclusions, pipes, checks, cracks and other injurious defects.

8.2 Macroetch severity levels for center porosity and ingot pattern, illustrated photographically in Practice **A561**, shall not exceed the ratings specified in **Table 4** for the appropriate material size and composition.

## 9. Decarburization

9.1 Decarburization shall be determined on a specimen representing a cross section of the material and prepared in accordance with the latest issue of **Methods Guide E3**. When examined at 20× or greater magnification, it shall not exceed the values given in **Tables 5-8** for the appropriate size and shape of the material.

9.2 Material ordered as drill rod, ground and polished, centerless ground, ground finished, or machine finished flats and squares shall be free of scale and decarburization.

## 10. Permissible Variations in Dimensions

10.1 Permissible variations in dimensions shall not exceed the applicable limits stated in **Tables 8-22**, incl. Where out-of-round or square requirements are shown, they shall be determined as follows:

10.1.1 *Out-of-Round*—Difference between high and low readings as determined by micrometers or other suitable measuring instruments.

10.1.2 *Out-of-Square*—The amount required to be removed from each edge in order to square the edge with the face as determined with a square and suitable measuring instruments.

## 11. Workmanship, Finish, and Appearance

11.1 High-speed tool steel shall be free of heavy scale, deep pitting, laps, porosity, injurious segregations, excessive nonmetallic inclusions, seams, cracks, checks, slivers, scale marks, dents, soft and hard spots, pipes, or any defects that would detrimentally affect the suitability of the material, after removal of the recommended stock allowance. (See **Tables 5-8**.)

**TABLE 3 Heat-Treating Requirements**

NOTE 1—The austenitizing temperatures are stipulated for the response to hardening test only. Other combinations of austenitizing and tempering temperatures may be used for particular applications.

| Class           | Preheat Temperature<br>°F — (°C) °F (°C) | Austenitizing Temperature, °F (°C) <sup>A</sup> |                                  | Tempering Temperature,<br>°F (°C) <sup>B</sup> | Minimum<br>Hardness,<br>Rockwell C |
|-----------------|------------------------------------------|-------------------------------------------------|----------------------------------|------------------------------------------------|------------------------------------|
|                 |                                          | Salt Bath                                       | Controlled Atmosphere<br>Furnace |                                                |                                    |
| M1              | 1350–1550 (732–843)                      | 2185 (1196)                                     | 2205 (1207)                      | 1025 (552)                                     | 64                                 |
| M2 (regular C)  | 1350–1550 (732–843)                      | 2220 (1216)                                     | 2240 (1227)                      | 1025 (552)                                     | 64                                 |
| M2 (high C)     | 1350–1550 (732–843)                      | 2200 (1204)                                     | 2220 (1216)                      | 1025 (552)                                     | 65                                 |
| M3, Class 1     | 1350–1550 (732–843)                      | 2200 (1204)                                     | 2220 (1216)                      | 1025 (552)                                     | 64                                 |
| M3, Class 2     | 1350–1550 (732–843)                      | 2200 (1204)                                     | 2220 (1216)                      | 1025 (552)                                     | 64                                 |
| M4              | 1350–1550 (732–843)                      | 2200 (1204)                                     | 2220 (1216)                      | 1025 (552)                                     | 64                                 |
| M6              | 1350–1550 (732–843)                      | 2170 (1188)                                     | 2190 (1199)                      | 1025 (552)                                     | 64                                 |
| M7              | 1350–1550 (732–843)                      | 2200 (1204)                                     | 2220 (1216)                      | 1025 (552)                                     | 65                                 |
| M10 (regular C) | 1350–1550 (732–843)                      | 2185 (1196)                                     | 2205 (1207)                      | 1025 (552)                                     | 63                                 |
| M10 (high C)    | 1350–1550 (732–843)                      | 2185 (1196)                                     | 2205 (1207)                      | 1025 (552)                                     | 64                                 |
| M30             | 1350–1550 (732–843)                      | 2200 (1204)                                     | 2220 (1216)                      | 1025 (552)                                     | 64                                 |
| M33             | 1350–1550 (732–843)                      | 2200 (1204)                                     | 2220 (1216)                      | 1025 (552)                                     | 65                                 |
| M34             | 1350–1550 (732–843)                      | 2200 (1204)                                     | 2220 (1216)                      | 1025 (552)                                     | 64                                 |
| M36             | 1350–1550 (732–843)                      | 2200 (1204)                                     | 2220 (1216)                      | 1025 (552)                                     | 64                                 |
| M41             | 1350–1550 (732–843)                      | 2175 (1190)                                     | 2195 (1202)                      | 1000 (538)                                     | 66                                 |
| M42             | 1350–1550 (732–843)                      | 2150 (1177)                                     | 2170 (1188)                      | 1000 (538)                                     | 66                                 |
| M43             | 1350–1550 (732–843)                      | 2150 (1177)                                     | 2170 (1188)                      | 1000 (538)                                     | 66                                 |
| M44             | 1350–1550 (732–843)                      | 2170 (1188)                                     | 2190 (1199)                      | 1000 (538)                                     | 66                                 |
| M46             | 1350–1550 (732–843)                      | 2200 (1204)                                     | 2220 (1216)                      | 1000 (538)                                     | 66                                 |
| M47             | 1350–1550 (732–843)                      | 2175 (1190)                                     | 2195 (1202)                      | 1000 (538)                                     | 66                                 |
| M48             | 1350–1550 (732–843)                      | 2175 (1190)                                     | 2195 (1202)                      | 1000 (538)                                     | 66                                 |
| M50             | 1350–1550 (732–843)                      | 2020 (1104)                                     | 2040 (1116)                      | 1000 (538)                                     | 61                                 |
| M52             | 1350–1550 (732–843)                      | 2125 (1163)                                     | 2145 (1174)                      | 1000 (538)                                     | 63                                 |
| M62             | 1350–1550 (732–843)                      | 2175 (1190)                                     | 2195 (1202)                      | 1000 (538)                                     | 66                                 |
| T1              | 1500–1600 (816–871)                      | 2330 (1277)                                     | 2350 (1288)                      | 1025 (552)                                     | 63                                 |
| T2              | 1500–1600 (816–871)                      | 2330 (1277)                                     | 2350 (1288)                      | 1025 (552)                                     | 63                                 |
| T4              | 1500–1600 (816–871)                      | 2330 (1277)                                     | 2350 (1288)                      | 1025 (552)                                     | 63                                 |
| T5              | 1500–1600 (816–871)                      | 2330 (1277)                                     | 2350 (1288)                      | 1025 (552)                                     | 63                                 |
| T6              | 1500–1600 (816–871)                      | 2330 (1277)                                     | 2350 (1288)                      | 1025 (552)                                     | 63                                 |
| T8              | 1500–1600 (816–871)                      | 2330 (1277)                                     | 2350 (1288)                      | 1025 (552)                                     | 63                                 |
| T15             | 1500–1600 (816–871)                      | 2240 (1227)                                     | 2260 (1238)                      | 1000 (538)                                     | 65                                 |

<sup>A</sup> Temperature limit shall be  $\pm 10^{\circ}\text{F}$  ( $\pm 5^{\circ}\text{C}$ ). If samples are austenitized in salt, the sample shall be immersed in the austenitizing salt bath for 5 min minimum. If austenitized in a controlled atmosphere furnace, the sample shall be at the austenitizing temperature for 5 to 15 min. The time at temperature is the time after the sample reaches the austenitizing temperature. This range in time is given because of the difficulty in determining when the sample reaches the austenitizing temperature in some types of controlled atmosphere furnaces.

Quenching may be done in oil or molten salt.

<sup>B</sup> Tempers at 1025°F (552°C) are for 2 + 2 h. Tempers at 1000°F (538°C) are for 2 + 2 + 2 h.

<https://standards.iteh.ai/catalog/standards/astm/d5c1a38c-f694-4d2d-a90c-0c270a1133bd/astm-a600-92a2016>

**TABLE 4 Macroetch Standards**  
 Maximum Allowable Rating<sup>A</sup>

| Bar Size, in. (mm)                | T Classification Steels <sup>B</sup>         |                  | M Classification Steels <sup>C</sup> |                  |
|-----------------------------------|----------------------------------------------|------------------|--------------------------------------|------------------|
|                                   | Porosity                                     | Ingot<br>Pattern | Porosity                             | Ingot<br>Pattern |
| Up to 2 (50.8), incl              | 3½                                           | 5                | 3                                    | 5                |
| Over 2 to 3 (50.8 to 76),<br>incl | 4                                            | 5                | 3½                                   | 5                |
| Over 3 to 4 (76 to 102),<br>incl  | 4½                                           | 5                | 4                                    | 5                |
| Over 4 to 5 (102 to 127),<br>incl | 5                                            | 5                | 4                                    | 5                |
| Over 5 to 6 (127 to 152),<br>incl | 5                                            | 5                | 4½                                   | 5                |
| Over 6 (152)                      | As negotiated between supplier and purchaser |                  |                                      |                  |

<sup>A</sup> Refer to macroetch photographs in Practice A561.

<sup>B</sup> Types T1, T2, T4, T5, T6, T8, and T15.

<sup>C</sup> Types M1, M2, M3, M4, M6, M7, M10, M30, M33, M34, M36, M41, M42, M43, M44, M46, M47, M48, M50, M52, and M62.

11.2 Visual examination shall be made to ensure compliance with the requirements for workmanship, finish, dimensions and tolerances, identification marking, and packaging.

**TABLE 5 Maximum Decarburization Limits Rounds<sup>A</sup>**

NOTE 1—The recommended minimum allowance for machining prior to heat treatment is 25 % greater than the maximum decarburization allowed.

| Specified Diameter, in. (mm)     | Decarburization Limits per      |
|----------------------------------|---------------------------------|
|                                  | Side, in. (mm),<br>Drawn Finish |
| Up to ½ (12.7), incl             | 0.013 (0.33)                    |
| Over ½ to 1 (12.7 to 25.4), incl | 0.025 (0.64)                    |
| Over 1 to 2 (25.4 to 50.8), incl | 0.038 (0.96)                    |
| Over 2 to 3 (50.8 to 76), incl   | 0.050 (1.27)                    |
| Over 3 to 4 (76 to 102), incl    | 0.070 (1.78)                    |

<sup>A</sup> Rounds to be free of decarburization except drawn finish. Maximum decarburization of drawn finish rounds to be in accordance with the table above.

## 12. Sampling

12.1 Unless otherwise specified, a lot shall consist of all material submitted for inspection at the same time, of the same heat, type, finish, and size, and must conform to the provisions of this specification.

## 13. Inspection

13.1 Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. The supplier may utilize his own facilities or any other acceptable to the purchaser.

13.2 When specified in the purchase order, the inspector representing the purchaser shall have access to the material subject to inspection for the purpose of witnessing the selection of samples, preparation of test pieces, and performance of the tests. For such tests, the inspector shall have the right to indicate the pieces from which samples will be selected. Otherwise the seller shall report to the purchaser, or his representative, the results of the chemical analysis and the physical property tests made in accordance with this specification.

13.3 The purchaser may perform any of the inspections set forth in the specification on the as-received material where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

## 14. Rejection and Rehearing

14.1 Unless otherwise specified, any rejection based on tests made in accordance with this specification should be reported to the seller within 30 days from the date of receipt of the material.

14.2 Material that shows injurious defects subsequent to its acceptance by the purchaser shall be rejected and the seller notified.

## 15. Rehearing

15.1 Samples tested in accordance with this specification that represent rejected material shall be preserved for three weeks from the date of the test report. In case of dissatisfaction with the results of the test, the seller may make claim for a rehearing within that time.

## 16. Packaging, Loading, and Package Marking

### 16.1 Packaging and Loading:

16.1.1 Unless otherwise specified, shipments shall be packaged and loaded in accordance with Practices **A700**.

16.1.2 When specified in the contract or order, and for direct procurement by or direct shipment to the government, when Level A is specified, preservation, packaging, and loading shall be in accordance with the Level A requirements of MIL-STD-163.

### 16.2 Package Marking:

16.2.1 Shipments shall be properly marked with the name or brand of manufacturer, purchaser's name and order number, specification number (ASTM A600), heat number, grade or type, and where appropriate, the size, length, and weight. Unless otherwise specified, method of marking is at the option of the manufacturer.

16.2.2 When specified in the contract or order, and for direct procurement by or direct shipment to the government, marking for shipment, in addition to any requirements specified in the contract or order, shall be in accordance with MIL-STD-163 for military agencies, and in accordance with Fed. Std. No. 123 for civil agencies.

16.2.3 For government procurement by the Defense Supply Agency, steel shall be continuously marked for identification in accordance with Fed. Std. No. 183.

## 17. Keywords

17.1 high speed; tool steel