



# Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use<sup>1</sup>

This standard is issued under the fixed designation A668/A668M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

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

## 1. Scope\*

1.1 This specification covers untreated and heat-treated carbon and alloy steel forgings for general industrial use. Other ASTM specifications for forgings are available for specific applications such as pressure vessels, railroad use, turbine generators, gearing, and others involving special temperature requirements.

1.2 Hot-rolled or cold finished bars are not within the scope of this specification.

1.3 Six classes of carbon steel and seven classes of alloy steel forgings are listed (see Section 7), which indicate their required heat treatments, as well as mechanical properties.

1.4 Provision, with the suffix H for certification and marking, for the supply of forgings after hardness testing only.

1.5 Supplementary requirements, including those in Specification A788/A788M, of an optional nature are provided. These shall apply only when specified by the purchaser.

1.6 Appendix X1 lists the current classes corresponding to the various classes of Specifications A235, A237, and A243, which have been superseded by this specification.

1.7 The values stated in either SI units or inch-pound units are to be regarded separately as standard; within the text and tables, the SI units are shown in brackets. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.8 Unless the order specifies the applicable “M” specification, the forgings shall be furnished to the inch-pound units.

<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 A01.06 on Steel Forgings and Billets.

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1.9 *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:<sup>2</sup>

A275/A275M Practice for Magnetic Particle Examination of Steel Forgings

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A388/A388M Practice for Ultrasonic Examination of Steel Forgings

A788/A788M Specification for Steel Forgings, General Requirements

E290 Test Methods for Bend Testing of Material for Ductility

E340 Practice for Macroetching Metals and Alloys

## 3. Terminology

3.1 The terminology section of Specification A788/A788M is applicable to this specification.

### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *class, n*—a description of steel forgings based on heat treatment, mechanical properties and composition.

3.2.2 *controlling cross section thickness ( $T_C$ ), n*—the diameter of the largest theoretical sphere which can be inscribed within the volume of the forging.

3.2.3 *rough machining, n*—machining performed after the heat treatment cycle used to obtain the stated mechanical property requirements of Table 2.

<sup>2</sup> 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.

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

3.2.3.1 *Discussion*—Rough machining is performed by the forging supplier or forging supplier representative. It does not include machining used to create detailed features such as gear teeth, splines, threads, or keyways and typically does not produce the surface finish or dimensional tolerances the part will have when put in service.

3.2.4  $T_p$ ,  $n$ —designates prolongations which have a size other than the controlling cross section thickness ( $T_C$ ).

## 4. Ordering Information and General Requirements

4.1 Material supplied to this specification shall conform to the requirements of Specification **A788/A788M** which outlines additional ordering information, manufacturing requirements, testing and retesting methods and procedures, marking, certification, product analysis variations and additional supplementary requirements.

4.1.1 If the requirements of this specification are in conflict with the requirements of Specification **A788/A788M**, the requirements of this specification shall prevail.

4.2 When this specification is to be applied to an inquiry, contract, or order, the purchaser should furnish the following information:

4.2.1 The ordering information required by Specification **A788/A788M**,

4.2.2 The class of forging desired as listed in **Table 1**,

4.2.3 Location(s) of areas of significant loading if test specimens are to be located in accordance with **7.1.4.5**,

4.2.4 The options which may be selected as found in **5.3.2**, **6.1**, and **7.3**, and

4.2.5 Any applicable supplementary requirements.

## 5. Materials and Manufacture

5.1 *Discard*—Sufficient discard shall be made from each ingot to secure freedom from piping and undue segregation.

### 5.2 Forging Process:

5.2.1 The forging shall be brought as close as practical to finished shape and size by hot mechanical work.

5.2.2 Supplementary Requirements S2, S14, and S15 may be specified by the purchaser to satisfy concerns about the utility of the proposed forging.

### 5.3 Heat Treatment:

5.3.1 All forgings, other than Class A, shall be heat treated. See Section 7.

5.3.2 Where options exist within a class, the choice of heat treatment shall be left to the discretion of the manufacturer, unless the purchaser specifies one of the available options.

## 6. Chemical Composition

6.1 The steel shall conform to the requirements prescribed in **Table 1**.

6.2 The choice of chemical composition is left to the discretion of the manufacturer, unless otherwise specified by the purchaser. See **Appendix X2**.

### 6.3 Heat Analysis:

6.3.1 An analysis of each heat shall be made by the manufacturer.

6.4 *Product Analysis*—An analysis may be made by the purchaser according to the requirements of Specification **A788/A788M**. If a standard grade has been used to manufacture the forging the permissible variations in composition of Specification **A788/A788M** shall apply. If a non-standard grade of steel has been used, and composition limits have not been supplied, the product analysis can be used only to confirm the type of steel supplied.

## 7. Mechanical Properties

### 7.1 Tensile Requirements:

7.1.1 The material shall conform to the tensile and hardness properties prescribed in **Table 2**. See Test Methods and Definitions **A370**.

7.1.2 *All Forgings*—The dimensions of the controlling cross section thickness ( $T_C$ ) of the forging at time of heat treatment determine the mechanical properties to be met within each class (see **Table 2**) except as noted in **7.1.4.2**.

7.1.3 *Number of Tests*—Unless the purchaser specifies that forgings shall be furnished in accordance with the requirements of **7.3**, the number of tension tests performed shall be as follows:

7.1.3.1 For all classes of heat-treated forgings with as-heat treated weights (excluding test prolongations) less than 5000 lb [2250 kg] each, one test shall be made from each controlling cross section thickness ( $T_C$ ) represented in each heat and heat-treating charge. For untreated forgings (Class A) weighing less than 5000 lb [2250 kg] each, one test from each heat shall be made.

7.1.3.2 On all classes, for forgings with as-heat treated weights (excluding test prolongations) of 5000 lb [2250 kg] or more, at least one test from each forging shall be made.

7.1.3.3 On all classes, for forgings with as-heat treated weights (excluding test prolongations) of 7000 lb [3200 kg] or more, two tests will be taken: on ring and disk forgings 180° apart; on shafts and long hollow cylinders (over 80 in. [2.0 m] in length excluding test material), one from each end and offset 180°. Shafts and cylinder forgings 80 in. [2.0 m] or less in length (excluding test material) may have both tests located at one end 180° apart.

7.1.3.4 When forgings are made in multiple as a single forging, that is, forged as one piece and divided after heat treatment, the multiple forging shall be considered as one forging, and the number of tests required shall be as designated in **7.1.3.1**, **7.1.3.2**, and **7.1.3.3**.

### 7.1.4 Prolongations:

7.1.4.1 A sufficient number of the forgings shall have prolongations for extracting specimens for testing. Examples of test locations for various forging configurations are shown in **Figs. 1 and 2**.

NOTE 1—Figures provided demonstrate the concept of controlling cross section thickness ( $T_C$ ) but do not encompass all possible test prolongation configurations which meet the requirements of Section 7.

7.1.4.2 For all forgings of non-uniform cross section in classes A, B, C, D, E, G, H, and J (when class J is provided in the normalized and tempered condition): the prolongation(s) may be extensions of sections other than the controlling cross section thickness ( $T_C$ ), that is  $T_P \neq T_C$ . In this case, the

dimension of  $T_p$  shall determine the mechanical properties to be met within each class. In the case of forgings requiring prolongations on both ends, the prolongations may or may not have the same  $T_p$ . If  $T_p$  is not the same, and the prolongations fall into different size categories, the manufacturer may elect to work to either the larger or smaller set of mechanical properties for both prolongations. It is not necessary for a forging with prolongations falling into two different size classifications to meet the requirements of both size classifications. When  $T_p \neq T_C$ ,  $T_p$  shall not have more reduction than the smallest cross section to be qualified.

(1) For annealed, normalized, or normalized and tempered forgings in classes A, B, C, D, E, G, H, and J, the center of the gage length axis of tension test specimens shall be  $\frac{1}{4}$  the controlling cross section thickness ( $T_C$ ) from one surface except as noted in 7.1.4.2 (2).

(2) If the prolongation thickness ( $T_p$ ) is less than the controlling cross section thickness ( $T_C$ ) the center of the gage length axis of the tension test shall be  $\frac{1}{4}$  of the prolongation thickness ( $T_p$ ) from one surface.

7.1.4.3 For quenched forgings in Classes F, J, K, L, M, and N, the center of the gage length axis of the tension test specimen shall be at a minimum  $\frac{1}{4}$  ( $T_C$ ) from one quenched surface and  $3\frac{1}{2}$  in. [90 mm] from the nearest second surface. For forgings in the aforementioned classes with ( $T_C$ ) of 7 in. [180 mm] or less, the test shall be taken at  $\frac{1}{4}$  ( $T_C$ ) from the nearest quenched surface, and at least ( $T_C/2$ ) from all other quenched surfaces exclusive of the ( $T_C$ ) dimension surfaces.

7.1.4.4 In place of prolongations, the manufacturer may: (1) elect to submit a representative forging(s) to represent each test lot; in this event, the representative forging must be made from the same heat of steel, must not receive more reduction than the forging it represents, must receive the same type of hot working it represents, be of the same controlling cross section thickness ( $T_C$ ), and have been heat treated in the same heat-treating charge as the forging(s) it represents; or (2) obtain the test specimen from the trepanned material of transverse or radial holes, provided the required depth is met.

7.1.4.5 With prior purchaser approval, test specimens may be taken at a depth ( $t$ ) corresponding to the distance from the area of significant stress to the nearest heat-treated surface and at least twice this distance ( $2t$ ) from any second surface. However, the test depth shall not be nearer to one heat-treated surface than  $\frac{3}{4}$  in. [19 mm] and to the second heat-treated surface than  $1\frac{1}{2}$  in. [38 mm]. Sketches showing the exact test locations shall be approved by the purchaser when this method is used.

7.1.5 Tests for acceptance shall be made after final heat treatment of the forgings. Thermal cycling after mechanical testing is complete shall not exceed  $50^\circ\text{F}$  [ $30^\circ\text{C}$ ] less than the temperature used to establish mechanical properties.

7.1.6 Test specimen orientation relative to the axis of major metal flow is to be at the discretion of the manufacturer provided the requirements of Table 2 are met. Test specimen orientation shall be reported.

7.1.7 Yield point shall be determined on carbon steel Grades A through F, and yield strength on alloy steel Grades G through N. For carbon steel grades not showing a yield point, the yield strength at 0.2 % offset shall be reported.

7.2 *Hardness Tests*—Brinell hardness tests shall be performed and reported per Test Methods and Definitions A370. Hardness testing shall be performed after heat treatment (except on Class A forgings) and rough machining on each forging weighing under 7000 lb [3200 kg] at the time of heat treatment and each multiple forging made weighing under 7000 lb [3200 kg] at the time of heat treatment. Weight at time of heat treatment excludes test prolongations.

7.2.1 Hardness testing on forgings in excess of 7000 lb [3200 kg] at the time of heat treatment may be omitted provided they meet the tensile requirements of Table 2.

7.2.2 When forgings are made in multiple as a single forging, that is, forged as one piece and divided after heat treatment, the multiple forging shall be considered as one forging and the number of tests shall be as described in 7.2.5 and 7.2.6.

7.2.3 When ordered without rough machining, hardness measurements shall be conducted on the forgings after heat treatment. Due consideration should be provided for the removal of oxidation and decarburization to ensure accuracy of hardness results when forgings which have not been rough machined are evaluated.

7.2.4 The average value of the hardness readings on each forging shall fall within the hardness ranges specified in Table 2. The permissible variation in hardness in any forging over 250 lb [110 kg] at time of heat treatment (excluding test prolongations) shall not exceed 30 Brinell Hardness for Classes A through E, 40 Brinell Hardness for Classes F through J, 50 Brinell Hardness for Classes K through N.

7.2.5 At least two hardness tests shall be taken on each flat face of disks, rings, and hollow forgings over 250 lb [110 kg] at time of heat treatment (excluding test prolongations) approximately at mid-radius for disk forgings and mid-wall for ring and hollow forgings. When it is impractical to check hardness on the face of hollow forgings these checks shall be made at each end on the OD or the ID at a distance equivalent to  $\frac{1}{2}$  the wall thickness from each end of the forging. Hardness checks shall be  $180^\circ$  apart, for example, at the 3:00 and 9:00 positions on one face, and 6:00 and 12:00 positions on the opposite face. On solid forgings over 250 lb [110 kg] at time of heat treatment (excluding test prolongations), at least four tests shall be taken on the periphery of the forging, two at each end  $180^\circ$  apart.

7.2.6 For forgings 250 lb [110 kg] at time of heat treatment (excluding test prolongations) and less, Brinell testing shall be performed on one of the following: the test material prior to machining the test specimen, the broken test specimens or the forgings themselves. Hardness tests shall be conducted on material representing the heat or heats included in each heat-treating charge, or in the case of untreated forgings (Class A), on material representing each heat. The results shall meet