



Designation: A909/A909M – 06

Standard Specification for Steel Forgings, Microalloy, for General Industrial Use¹

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1. Scope*

1.1 This specification covers wrought, microalloyed carbon steel forgings for industrial use. Microalloyed steels develop their properties by the addition of small amounts of microalloying elements such as vanadium, columbium, titanium, or molybdenum. The properties may be influenced also by control of the hot working process and temperature and by control of the subsequent cooling rate.

1.2 The forgings shall be furnished to chemical composition and mechanical property requirements as specified herein. Chemical composition is based on standard carbon steel grades modified to include microalloying elements. Strength level is specified based on desired mechanical properties in the forgings. Depending on the forging process, different strength classes may be attainable from a single chemical composition. Conversely, mechanical properties of a given strength class may be achieved using different chemical compositions. The manufacturer should be consulted if development of chemical composition is necessary.

1.3 For the purpose of this specification, forgings with maximum section thickness of 4 in. [100 mm] are to be considered.

1.4 Supplementary Requirements S1 to S8 are provided for use when additional controls or requirements are desired. These shall apply only when specified on the purchase order.

1.5 The values stated in either inch-pound units or SI (metric) units are to be regarded separately as standard. Within the text and tables, SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with this specification.

1.6 Unless the order specifies the applicable “M” specification designation, the material shall be furnished to the inch-pound units.

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 A01.06 on Steel Forgings and Billets.

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2. Referenced Documents

2.1 ASTM Standards:²

- A29/A29M Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for
- A275/A275M Practice for Magnetic Particle Examination of Steel Forgings
- A370 Test Methods and Definitions for Mechanical Testing of Steel Products
- A576 Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
- A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
- A788/A788M Specification for Steel Forgings, General Requirements
- A921/A921M Specification for Steel Bars, Microalloy, Hot-Wrought, Special Quality, for Subsequent Hot Forging
- E10 Test Method for Brinell Hardness of Metallic Materials
- E18 Test Methods for Rockwell Hardness of Metallic Materials
- E45 Test Methods for Determining the Inclusion Content of Steel

3. Terminology

3.1 Definitions of Terms Specific to This Standard:²

3.1.1 *microalloy forgings*—forgings from microalloyed steels produced by effectively controlling the thermomechanical components of the forging process to achieve required mechanical properties with no post-forging heat treatment.

3.1.2 *microalloy forging procedure*—the written thermomechanical processing parameters to be followed during the production of a microalloy forging. It would include, but is not limited to: starting stock size; chemical composition, including any optional microalloying additions; reheat practice; forging temperature range; method of heating; cooling methods; and lot size definition.

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.

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

4. Ordering Information

4.1 Orders for material supplied to this specification should include the information specified in 4.1 of Specification **A788/A788M**. The purchaser should refer to Specification **A788/A788M** for information not contained in this specification.

4.1.1 The type (see 6.1), grade (see 6.1), and the remainder of the chemical composition (see 6.2 to 6.5) should be included.

4.2 The information contained in 4.2 of Specification **A788/A788M** should be specified, as necessary, to adequately describe the desired material.

4.3 In addition to the requirements of 4.1 and 4.2 of Specification **A788/A788M**, the following should be included in the purchase order, as applicable:

4.3.1 From **Table 1**, strength class or method of testing, or both, including test location on the forging.

4.3.2 Definition of lot size including the number of mechanical tests to be performed per lot.

4.3.3 Any supplementary requirements.

5. Materials and Manufacture

5.1 *Melting Practice*—The steel shall be produced in accordance with the applicable methods for primary and secondary melting outlines in Specification **A788/A788M**.

5.2 The steel shall be killed.

5.3 *Hot Forging*—The forging shall be brought as close as practical to finish size by hot mechanical working. Controlled hot working and cooling practices shall be applied to develop specified mechanical properties.

5.4 *Microalloy Forge Procedure*—When requested by the purchaser, a written forge procedure shall be made available to the purchaser by the manufacturer.

6. Chemical Composition

6.1 Carbon, manganese, phosphorus, and sulfur analyses shall conform to the table on Grade Designations and Chemical Requirements of Hot-Wrought Carbon Steel Bars in Specification **A576** for the grade specified, to such other limits that may be specified using the ranges and limits in the table on Grade Designations and Chemical Requirements of Hot-Wrought Carbon Steel Bars in Specification **A576**, or to the ranges and limits set forth in **Table 1** of Specification **A921/A921M**.

NOTE 1—For improved machinability, alternative sulfur ranges may be specified by agreement between the purchaser and the producer. Additional machinability-enhancing elements such as lead, bismuth, selenium, or tellurium may also be specified by agreement.

TABLE 1 Mechanical Property Requirements

Class	Yield Strength, min		Tensile Strength, min		Elongation, min, %		Brinell Hardness, min
	ksi	MPa	ksi	MPa	in 8 in.	in 2 in.	
					[200 mm]	[50 mm]	
60	60	415	75	515	16	18	167
80	80	550	95	655	13	15	201
100	100	690	125	860	8	10	269
120	120	825	150	1030	6	8	321

6.2 Silicon analysis shall be 0.15/0.35 %. Silicon content up to 0.80 % maximum may be furnished by agreement between purchaser and producer.

6.3 Vanadium, columbium (niobium), titanium, or molybdenum may be specified singly or in combination, subject to the limits shown in **Table 2**. The elements and ranges specified shall be by agreement between the purchaser and the producer.

6.4 Nitrogen may be specified as a supplement to vanadium, columbium, or titanium. When nitrogen is specified as a supplement to vanadium, the minimum ratio of vanadium to nitrogen shall be 4 to 1. The nitrogen content shall not exceed 0.03 % and shall be reported.

6.5 Sampling for heat and product analysis shall be in accordance with the requirements of Specification **A788/A788M**. Chemical Analyses shall be in accordance with Specification **A751**.

7. Metallurgical Requirements

7.1 *Grain Size*—The steel shall conform to the fine grain size requirement of Specification **A29/A29M**. The grain refining element may be specified in accordance with one of the following types:

7.1.1 *Type A—Aluminum*—The total aluminum analysis shall be 0.020 % or greater, and shall be reported.

7.1.2 *Type B*—The grain refining element shall be specified in accordance with 5.1.2.3 of Specification **A29/A29M**.

7.2 *Microstructure*—The microstructure shall consist of a minimum of 90 % ferrite-pearlite or 90 % bainite as agreed between producer and purchaser.

8. Mechanical Properties

8.1 The mechanical properties of the forgings shall conform to the requirements listed in **Table 1** for the strength class specified.

8.2 Test specimens shall be prepared for testing from the forging in its as forged condition unless otherwise specified.

8.3 Test specimens shall be oriented parallel to the longitudinal axis of the forging and removed from a full thickness section or may be removed and produced in accordance with the requirements of Test Methods and Definitions **A370**. If conforming to Test Methods and Definitions **A370**, test specimens shall be removed from a position midway between the center and the surface of the forging.

8.4 Test specimens for shapes and flats may be machined in accordance with the requirements of Test Methods and Definitions **A370** or with both edges parallel. Test specimens for material over 1.5 in. [40 mm] in thickness or diameter may be machined to a thickness or diameter of at least ¾ in. [20 mm] for a length of at least 9 in. [230 mm], or they may conform to requirements of Test Methods and Definitions **A370**.

TABLE 2 Chemical Requirements (Microalloy Elements)

Element	Chemical Ranges and Limits, %	
	Heat Analysis	Product Analysis
	Vanadium	0.02 to 0.20
Columbium (Niobium)	0.005 to 0.07	0.004 to 0.08
Molybdenum	0.01 to 0.30	0.31 max
Titanium	0.030 max	0.040 max