Designation: A 909/A 909M – 06

Standard Specification for Steel Forgings, Microalloy, for General Industrial Use[1]

This standard is issued under the fixed designation A 909/A 909M; 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.

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.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 29/A 29M Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for

A 275/A 275M Test Method for Magnetic Particle Examination of Steel Forgings

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 576 Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

A 788/A 788M Specification for Steel Forgings, General Requirements

A 921/A 921M Specification for Steel Bars, Microalloy, Hot-Wrought, Special Quality, for Subsequent Hot Forging

E 10 Test Method for Brinell Hardness of Metallic Materials

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials

E 45 Test Methods for Determining the Inclusion Content of Steel

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

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.

[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] 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.**

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4. Ordering Information

4.1 Orders for material supplied to this specification should include the information specified in 4.1 of Specification A 788/A 788M. The purchaser should refer to Specification A 788/A 788M 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 A 788/A 788M 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 A 788/A 788M, 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 A 788/A 788M.

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 A 576 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 A 576, or to the ranges and limits set forth in Table 1 of Specification A 921/A 921M.

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. [200 mm]	in 2 in. [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 A 788/A 788M. Chemical Analyses shall be in accordance with Specification A 751.

7. Metallurgical Requirements

7.1 *Grain Size*—The steel shall conform to the fine grain size requirement of Specification A 29/A 29M. 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 A 29/A 29M.

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 A 370. If conforming to Test Methods and Definitions A 370, 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 A 370 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 A 370.

TABLE 2 Chemical Requirements (Microalloy Elements)

Element	Chemical Ranges and Limits, %	
	Heat Analysis	Product Analysis
Vanadium	0.02 to 0.20	0.01 to 0.21
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

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8.5 At least two tension tests shall be made from each heat and forging lot.

8.6 If so specified by the purchaser, forgings may be specified on the basis of hardness tests alone. If this option is exercised, the class shall be identified with the letter "H," that is, "60H," "80H," and so on. Hardness testing shall be performed in accordance with Test Method E 10 or Test Methods E 18.

9. Workmanship, Finish, and Appearance

9.1 The forgings shall conform to the requirements specified on the purchaser's drawing and shall have a good, workmanlike appearance, free of any injurious imperfections.

10. Retreatment

10.1 Forgings above the specified hardness range or with ductility values below specified limits may be tempered and retested, upon approval by purchaser or in accordance with the approved forging procedure. Forgings below specified hardness minimums or tensile and yield requirements may be heat treated upon approval by the purchaser.

11. Certification and Test Reports

11.1 When specified by the purchaser, the manufacturer's certification that the material was manufactured and tested in accordance with this specification together with a report of the heat analysis for the specified elements and for copper, chromium, nickel, molybdenum, vanadium and columbium shall be furnished. When the amount of an element present is less than 0.02 %, the heat analysis may be reported as <0.02 % except for titanium and nitrogen. When specified, these elements shall be reported to three decimal places. The certification requirements of Specification A 788/A 788M shall also apply.

11.2 The report shall include the results of any mechanical tests performed in accordance with this specification, including supplementary requirements, if any.

12. Keywords

12.1 forging procedure; microalloyed; steel forgings

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall apply only when specified by the purchaser.

S1. Restricted Chemical Composition

S1.1 Restricted heat analysis limits or ranges or restricted product analysis tolerances on one or more elements shall be specified by the purchaser.

S2. Restricted Incidental Elements

S2.1 The steel shall not exceed the limits for copper, nickel, chromium, molybdenum, or other elements as shown on the purchase order.

S3. Nonmetallic Inclusions

S3.1 A microscopical examination of longitudinal sections to determine the nature and frequency of nonmetallic inclusions shall be made as prescribed in Test Methods E 45. The acceptance limits shall be specified by the purchaser.

NOTE S1—In resulfurized steels, much of the sulfur is present as sulfide inclusions. For this reason, maximum sulfide inclusion level should not be specified.

S4. Calcium Treatment

S4.1 The steel shall be calcium treated.

S5. Stress Relieving

S5.1 The steel shall be stress relieved by a cycle specified by the purchaser or selected by the manufacturer.

NOTE S2—Stress relieving may affect mechanical properties and this should be considered when specifying this requirement.

S6. Notch Toughness Tests

S6.1 Charpy V-notch tests shall be performed in sets of three. The absorbed energy requirement and the test temperature shall be agreed upon between producer and purchaser.

S6.2 Testing frequency shall be as for tension testing (see 8.5). The specimens shall be taken adjacent to the tension test specimen and shall be located as near as practicable midway between surface and center of the forging diameter or thickness and width. The longitudinal axis of specimen shall be parallel to the longitudinal axis of the forging. The length of the notch shall be perpendicular to the nearest surface of the forging. Testing procedure and acceptance criteria shall be in accordance with Test Methods and Definitions A 370.

S7. Cleaning

S7.1 The surface of the forgings shall be descaled by pickling or shot blasting or other suitable means.

S8. Magnetic Particle Testing

S8.1 Magnetic particle testing of the forgings shall be specified in accordance with Test Method A 275/A 275M. Acceptance requirements shall be as agreed upon between the purchaser and the producer.

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SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A 909 – 03) that may impact the use of this standard. (Approved Dec. 1, 2006.)

(*1*) Changed standard designation from single to dual units.
(*2*) Revised 1.3, 8.4, and Table 1 to comply with guidelines for a combined inch-pound and SI units standard.
(*3*) The heading for hardness requirements in Table 1 has been changed from "Hardness, BHN min" to "Brinell Hardness, min."

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