



Designation: A 859/A 859M – 02

Standard Specification for Age-Hardening Alloy Steel Forgings for Pressure Vessel Components¹

This standard is issued under the fixed designation A 859/A 859M; 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 requirements for low-carbon age-hardening nickel-copper-chromium-molybdenum-columbium alloy steel forgings for pressure vessel components.

1.2 Forgings under this specification are available in two classes as follows:

1.2.1 *Class 1*—Normalized-and-precipitation-heat-treated, providing a minimum yield strength of 55 ksi [380 MPa] and a minimum tensile strength of 65 ksi [450 MPa].

1.2.2 *Class 2*—Quenched-and-precipitation-heat-treated, providing a minimum yield strength of 65 ksi [450 MPa] and a minimum tensile strength of 75 ksi [MPa].

1.3 Although the material is readily weldable, welding procedures are of fundamental importance and must be such as not to affect adversely the properties of the material, especially in the heat-affected zone. It is presupposed that welding procedures will be suitable for the material being welded.

1.4 Supplementary requirements are provided for use when additional testing or inspection is desired. These shall apply only when specified individually by the purchaser in the order.

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

1.6 This specification is expressed in both inch-pound and SI units. However, unless the order specifies the applicable “M” specification designation [SI units], the material shall be furnished to inch-pound units.

2. Referenced Documents

2.1 ASTM Standards:

A 275/A 275M Test Method for Magnetic Particle Examination of Steel Forgings²

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products³

A 388/A 388M Practice for Ultrasonic Examination of Heavy Steel Forgings²

A 788 Specification for Steel Forgings, General Requirements²

E 208 Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels⁴

2.2 ASME Standard:

ASME Code Section IX⁵ Boiler and Pressure Vessel Code—Section IX, Welding Qualifications

3. Ordering Information and General Requirements

3.1 In addition to the ordering information required by Specification A 788, the purchaser shall include with the inquiry and order a detailed drawing, sketch, or written description of the forging and the method of selecting test location (see 6.3). When appropriate, the areas of significant loading in the forging shall be designated.

3.2 Material supplied to this specification shall conform to the requirements of Specification A 788, which outlines additional ordering information, manufacturing requirements, testing and retesting methods and procedures, marking, certification, product analysis variations, and additional supplementary requirements.

3.3 If the requirements of this specification are in conflict with the requirements of Specification A 788, the requirements of this specification shall prevail.

4. Manufacture

4.1 *Melting Practice*—The steel shall be made to a killed, fine austenitic grain size, practice.

4.2 Heat Treatment:

4.2.1 Class 1 material shall be normalized at a temperature in the range from 1600 to 1725°F [870 to 940°C] and then precipitation heat treated in the range from 1000 to 1225°F [540 to 665°C] for a time to be determined by the material manufacturer.

³ Annual Book of ASTM Standards, Vol 01.03.

⁴ Annual Book of ASTM Standards, Vol 03.01.

⁵ Available from American Society of Mechanical Engineers, 345 E. 47th St., New York, NY 10017.

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 Annual Book of ASTM Standards, Vol 01.05.

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

4.2.2 Class 2 material shall be liquid quenched from a temperature in the range from 1600 to 1725°F [870 to 940°C] and then precipitation heat treated in the range from 1000 to 1225°F [540 to 665°C] for a time to be determined by the material manufacturer.

5. Chemical Composition

5.1 *Heat Analysis*—The heat analysis obtained from sampling in accordance with Specification A 788 shall comply with Table 1.

5.2 *Product Analysis*—The purchaser may use the product analysis provision of Specification A 788 to obtain a product analysis from a forging representing each heat or multiple heat.

6. Mechanical Requirements

6.1 *Tensile Requirements*—The forgings, as represented by the tension test specimens, shall conform to the requirements of Table 2. The largest obtainable tension test specimen as specified in Test Methods and Definitions A 370 shall be used.

6.2 Notch Toughness Requirements:

6.2.1 Unless Supplementary Requirement S6 is specified, the steel shall conform to the requirements of Table 3. One set of three specimens shall be removed from each specimen location as specified in 6.3. The supplier may select a test temperature colder than that specified in the order, but in any case, the actual test temperature shall be reported with the test results.

6.2.2 Full-size, 10 by 10 mm, Charpy V-notch specimens shall be used unless the material thickness or configuration makes it impossible to obtain full-size specimens. If the use of sub-size specimens is necessary, the largest standard sub-size specimen it is possible to obtain shall be used.

6.2.3 The acceptance values for sub-size specimens shall be reduced in direct ratio to the reduction of specimen width.

6.3 *Sampling*—The longitudinal axis and the mid-length of tension and impact test specimens shall be positioned in accordance with one of the following methods as specified by the purchaser:

6.3.1 *Method 1*—This method shall always be used when the maximum as-heat-treated thickness does not exceed 2 in. [50 mm]. Specimens shall be located in the production forging or test forging (as described in Method 4) at mid-thickness and at least 2 in. [50 mm] from other as-heat-treated surfaces.

6.3.2 *Method 2*— T by $2T$, where T is the distance from the area of significant loading (see 3.1) to the nearest as-heat-treated surface. However, the specimen shall not be nearer to one as-heat-treated surface than $\frac{3}{4}$ in. [20 mm] and not nearer

TABLE 2 Tensile Requirements

	Class 1	Class 2
Yield strength, 0.2 % offset, min, ksi [MPa]	55 [380]	65 [450]
Tensile strength, ksi [MPa]	65–85 [450–585]	75–95 [515–655]
Elongation in 2 in. or 50 mm, min, %	20	20
Reduction of area, min, %	45	45

TABLE 3 Charpy Impact Requirements

	at -50° [-45° C]
Average value of set of 3 specimens, min, ft/lb [J] ^a	20 [27]
Value of 1 specimen, min, ft/lb [J]	15 [20]

^a Not more than one specimen from a set may be below this value.

than $1\frac{1}{2}$ in. [40 mm] to a second as-heat-treated surface. When this method of testing is employed, forgings are usually manufactured in accordance with a purchaser-approved drawing showing pre-heat-treatment dimensions and the location of test specimens.

6.3.3 *Method 3*— $\frac{1}{4} T$ by T , where T is the maximum thickness of the forging as-heat-treated. When this method of testing is employed for Class 2, the maximum as-heat-treated thickness shall not exceed 8 in. [200 mm] unless otherwise agreed.

6.3.4 *Method 4*—Test specimens shall be taken from a representative separate test forging or bar made from the same heat of steel that shall receive substantially the same reduction and type of hot working as the production forgings which it represents; except that a longitudinally forged bar may be used to represent a rolled ring of similar cross section. It shall be of the same nominal thickness as the as-heat-treated production forgings and shall be heat treated in the same furnace charge and under the same conditions as the production forgings. Test specimens shall be removed using the $\frac{1}{4} T$ by T procedure referenced in Method 3 with the same limitation on forging thickness as in 6.3.3. This method shall be limited to forgings with a rough machined weight of not more than 1000 lb [455 kg].

6.4 *Metal Buffers*—The required distances from as-heat-treated surfaces may be obtained with metal buffers instead of integral extensions. Buffer material may be carbon or low-alloy steel and shall be joined to the forging with a partial penetration weld that seals the buffered surface. Specimens shall be located at least $\frac{1}{2}$ in. [13 mm] from the buffered surface of the forging. Buffers shall be removed and the welded areas subjected to magnetic particle test to ensure freedom from cracks unless the welded areas are completely removed by subsequent machining.

6.5 Samples shall be removed from forgings after heat treatment. The sample material shall be subjected to a simulated post-weld heat-treatment if Supplementary Requirement S1 is specified.

6.6 *Orientation*—For upset disk forgings, the longitudinal axis of all test specimens shall be oriented in the tangential direction. For all other forgings, the longitudinal axis of the specimens shall be oriented in the direction of maximum working of the forging unless Supplementary Requirements S11 or S14 are imposed.

TABLE 1 Chemical Requirements

Element	Composition, %
Carbon, max	0.07
Manganese	0.40–0.70
Phosphorus, max	0.025
Sulfur, max	0.025
Silicon, max	0.40
Chromium	0.60–0.90
Nickel	0.70–1.00
Molybdenum	0.15–0.25
Copper	1.00–1.30
Columbium, min	0.02