



Designation: A 859/A 859M – 04

# Standard Specification for Age-Hardening Alloy Steel Forgings for Pressure Vessel Components<sup>1</sup>

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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 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 as Grades A or B. Grade A may be ordered in one or two classes as follows:

1.2.1 *Grade A 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 *Grade A 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].

1.2.3 Grade A was the original steel composition in this specification.

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, including those applicable in Specification A 788, 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.

<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.

Current edition approved March 1, 2004. Published April 2004. Originally approved in 1986. Last previous edition approved in 2002 as A 859/A 859M – 02.

## 2. Referenced Documents

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

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

A 788 Specification for Steel Forgings, General Requirements

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

E 604 Test Method for Dynamic Tear Testing of Metallic Materials

2.2 *ASME Standard*:

ASME<sup>3</sup> 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.

<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.

<sup>3</sup> Available from American Society of Mechanical Engineers, 345 E. 47th St., New York, NY 10017.

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

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.

4.1.1 Vacuum degassing in accordance with Specification A 788 is highly recommended.

##### 4.2 Heat Treatment:

4.2.1 Normalizing may, at the manufacturer’s option, precede the prescribed heat treatment cycle.

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

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

4.2.4 Grade B forgings shall be double quenched and tempered (liquid quenched twice) by austenitizing twice at a temperature in the range of 1600 to 1725°F [870 to 940°C], and then precipitation hardened at a temperature in the range of 1000 to 1300°F [540 to 700°C] for a time to be determined by the 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 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 For Grade A, Class 1 or 2 forgings, unless Supplementary Requirement S6 is specified, the Charpy impact test results 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 For Grade B forgings two sets of Charpy impact specimens shall be removed from each test specimen location as specified in 6.3 and shall conform to the requirements of Table 3.

6.2.3 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.

6.2.4 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 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.

**TABLE 1 Chemical Requirements**

Element	Composition, %	
	Grade A	Grade B
Carbon	0.07 max	0.02–0.04
Manganese	0.40–0.70	0.75–1.05
Phosphorus, max	0.025	0.015
Sulfur, max	0.025	0.002
Silicon, max	0.40	0.40
Chromium	0.60–0.90	0.45–0.75
Nickel	0.70–1.00	3.35–3.85
Molybdenum	0.15–0.25	0.55–0.65
Copper	1.00–1.30	1.15–1.75
Columbium	0.02 min	0.02–0.06
Vanadium max	...	0.008
Aluminum max	...	0.03
Titanium max	...	0.003
Tin max	...	0.03
Arsenic max	...	0.025
Antimony max	...	0.025
Nitrogen	...	report