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Standard Specification for Steel Castings, Carbon, Low Alloy, and Stainless Steel, Heavy-Walled for Steam Turbines[1]

This standard is issued under the fixed designation A356/A356M; 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 one grade of martensitic stainless steel and several grades of ferritic steel castings for cylinders (shells), valve chests, throttle valves, and other heavy-walled castings for steam turbine applications.

1.2 Optional supplementary requirements (S1 through S5) shall apply as selected by and specified by the purchaser.

1.3 The values stated in either ~~inch-pound~~SI units or ~~SI~~inch-pound 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~~may not be exact equivalents; therefore, each system ~~must~~shall be used independently of the other. Combining values from the two systems may result in non-conformance with the ~~specification.~~ standard.

1.3.1 Within the text, the SI units are shown in brackets.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A488/A488M Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel

E94 Guide for Radiographic Examination

E125 Reference Photographs for Magnetic Particle Indications on Ferrous Castings

E165 Practice for Liquid Penetrant Examination for General Industry

E186 Reference Radiographs for Heavy-Walled (2 to 412-in. (50.8 to 114-mm)) Steel Castings

E280 Reference Radiographs for Heavy-Walled (412 to 12-in. (114 to 305-mm)) Steel Castings

E446 Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness

E709 Guide for Magnetic Particle Testing

2.2 *Manufacturers' Standardization Society of the Valve and Fittings Industry Standard:*[3]

SP-55 Quality Standard for Steel Castings for Valves, Flanges, ~~and Fittings~~Fittings, and Other Piping Components (Visual Method)

3. Classification

3.1 The castings are furnished in the grades shown in Table 1.

4. Ordering Information

4.1 Orders for material to this specification should include the following information:

4.1.1 A description of the casting by pattern number or drawing (dimensional tolerances shall be included on the casting drawing),

4.1.2 Grade of steel,

4.1.3 Options in the specification, and

4.1.4 The supplementary requirements desired, including the standards of acceptance.

5. Melting Process

5.1 The steel shall be made by the open-hearth or electric-furnace process.

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[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 A01.18 on Castings.

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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.

[3] Available from Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), 127 Park St., NE, Vienna, VA 22180-4602, http://www.mss-hq.~~com~~rg.

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

TABLE 1 Chemical Requirements[A]

Grade/ UNS Number	Material	Composition, %												
		Carbon	Manganese	Silicon	Phosphorus, max	Sulfur, max	Molybdenum	Chromium	Nickel	Vanadium	Columbium	Nitrogen	Aluminum	Other
1 J03502	carbon steel	0.35[B] max	0.70[B] max	0.60 max	0.035	0.030	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
2 J12523	½ % molybdenum	0.25[B] max	0.70[B] max	0.60 max	0.035	0.030	0.45-0.65	. . .	. . .	. . .	. . .	. . .	. . .	. . .
5 J12540	½ % chromium, ½ % molybdenum	0.25[B] max	0.70[B] max	0.60 max	0.035	0.030	0.40-0.60	0.40-0.70	. . .	. . .	. . .	. . .	. . .	. . .
6 J12073	1¼ % chromium, ½ % molybdenum	0.20 max	0.50-0.80	0.60 max	0.035	0.030	0.45-0.65	1.00-1.50	. . .	. . .	. . .	. . .	. . .	. . .
8 J11697	1 % chromium, 1 % molybdenum, vanadium	0.20 max	0.50-0.90	0.20-0.60	0.035	0.030	0.90-1.20	1.00-1.50	. . .	0.05-0.15	. . .	. . .	. . .	. . .
9 J21610	1 % chromium, 1 % molybdenum, vanadium	0.20 max	0.50-0.90	0.20-0.60	0.035	0.030	0.90-1.20	1.00-1.50	. . .	0.20-0.35	. . .	. . .	. . .	. . .
10 J22090	2¼ % chromium, 1 % molybdenum	0.20 max	0.50-0.80	0.60 max	0.035	0.030	0.90-1.20	2.00-2.75	. . .	. . .	. . .	. . .	. . .	. . .
~~12A[C] J84090~~	~~9 % chromium, 1 % molybdenum, vanadium~~	~~0.08-0.12~~	~~0.30-0.60~~	~~0.20-0.50~~	~~0.030~~	~~0.010~~	~~0.85-1.05~~	~~8.0-9.5~~	~~0.40 max~~	~~0.18-0.25~~	~~0.060-0.10~~	~~0.030-0.070~~	~~0.02 max~~	~~titanium, 0.01 max; zirconium, 0.01 max~~
CA6NM J91540	martensic chromium nickel	0.06 max	1.00 max	1.00 max	0.040	0.030	0.4-1.0	11.5-14.0	3.5-4.5	. . .	. . .	. . .	. . .	. . .

[A] Where ellipses appear in this table, there is no requirement and the element need not be analyzed for or reported.
[B] For each 0.01 % reduction in carbon below the maximum specified, an increase of 0.04 percentage points of manganese over the maximum specified for that element will be permitted up to 1.00.
~~[C] The designation of Grade 12, formerly covered by this specification, has been changed to Grade 12A.~~

5.2 *Deoxidation Practice*:

5.2.1 Deoxidation of the carbon and low-alloy steel grades shall be by manganese and silicon. Furnace or ladle deoxidation with other agents is permissible with the approval of the purchaser.

5.2.2 The purchaser may specify that no aluminum be added.

5.2.3 Vacuum deoxidation is acceptable. The specific method shall be subject to approval by the purchaser.

6. Heat Treatment

6.1 *Preliminary Heat Treatment*—The castings may receive such preliminary heat treatment as the founder may elect to employ.

6.2 *Heat Treatment for Final Properties*:

6.2.1 *Normalizing*—~~The castings shall be heated to and held at the proper temperature for a sufficient time to affect the desired transformation and withdrawn from the furnace and allowed to cool to affect complete transformation. Grade 12A castings shall be normalized at 1900-1975°F [1040-1080°C] and withdrawn from the furnace and allowed to cool to affect complete transformation.~~ —The castings shall be heated to and held at the proper temperature for a sufficient time to effect the desired transformation and withdrawn from the furnace and allowed to cool to effect complete transformation.

6.2.2 *Tempering*—The casting shall be heated to and held at the proper temperature, which shall be below the transformation range, and then cooled under suitable conditions. The tempering temperature shall not be less than 1100°F [595°C]. ~~Grade 12A castings shall be tempered at 1350-1470°F [730-800°C].~~

6.2.3 *Stress Relieving*—The stress relieving operation shall be carried out in the same manner as tempering. The temperature shall be within 50°F [28°C], but not exceeding the final tempering temperature.

6.3 *Stainless Steel Casting*:

6.3.1 *Normalizing*—The castings shall be heated to 1850°F [1010°C] minimum, held sufficiently at that temperature to uniformly heat the castings, and air cooled to below 200°F [93°C].

6.3.2 *Tempering*—The castings shall be final tempered from 1050 to 1150°F [565 to 620°C].

6.3.3 *Stress Relieving*—The stress relieving operation shall be performed in the same manner as tempering. Temperature shall be between 1050°F [565°C] and 1150°F [620°C].

7. Chemical Composition

7.1 The steel shall conform to the requirements given in Table 1~~(Note 1)~~.

~~NOTE 1—The role of alloying elements in the development of Grade 12A has been extensively investigated. V and Cb contribute to precipitation strengthening by forming fine and coherent precipitates of M(C,N)X carbo-nitrides in the ferritic matrix. V also precipitates as VN during tempering or creep. The two elements are more effective in combination. Therefore, the addition of strong nitride-forming elements, those with a stronger affinity for nitrogen than Cb and V, as deoxidation agents during melting of this grade, interferes with these high-temperature strengthening mechanisms.~~ .

8. Tensile Requirements

8.1 Tensile properties shall conform to the requirements listed in Table 2 as determined by the test specimen set forth in Section 9.

8.2 Tension tests shall be performed in accordance with Test Methods and Definitions A370.

9. Number of Tests and Retests

9.1 One tension test shall be made from each heat in each heat-treatment charge and from each casting on which attached coupons are specified. The bar from which the test specimen is taken shall be heat treated with the casting represented.

9.2 If any test specimen shows defective machining or develops flaws, it shall be discarded and another specimen substituted from the same heat.

9.3 If the results of the mechanical tests for any lot or casting do not conform to the requirements specified, the founder may reheat treat and retest such lot or casting.

10. Test Specimen

10.1 Tension test specimens and samples for microexamination may be taken from coupons conforming substantially to the

TABLE 2 Tensile Requirements

Grade	Material	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa]	Elongation in 2 in. [50 mm] min, %	Reduction of Area, min, %
1	carbon steel	70 [485]	36 [250]	20.0	35.0
2	½ % molybdenum	65 [450]	35 [240]	22.0	35.0
5	½ % chromium, ½ % molybdenum	70 [485]	40 [275]	22.0	35.0
6	1¼ % chromium, ½ % molybdenum	70 [485]	45 [310]	22.0	35.0
8	1 % chromium, 1 % molybdenum, vanadium	80 [550]	50 [345]	18.0	45.0
9	1 % chromium, 1 % molybdenum, vanadium	85 [585]	60 [415]	15.0	45.0
10	2¼ % chromium, 1 % molybdenum	85 [585]	55 [380]	20.0	35.0
~~12A~~	~~9 % chromium, 1 % molybdenum, vanadium~~	~~85 [585]~~	~~60 [415]~~	~~20.0~~	~~...~~
CA6NM	martensitic chromium nickel	110 [760]	80 [550]	15.0	35.0