



Designation: ~~A608/A608M – 14 (Reapproved 2018)~~ A608/A608M – 20

Standard Specification for Centrifugally Cast Iron-Chromium-Nickel High-Alloy Tubing for Pressure Application at High Temperatures¹

This standard is issued under the fixed designation A608/A608M; 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 iron-chromium-nickel, high-alloy tubes made by the centrifugal casting process intended for use under pressure at high temperatures.

1.2 The grades of high alloys detailed in [Table 1](#) are intended for applications requiring strength and resistance to corrosion and scaling at high temperatures.

1.3 Optional Supplementary Requirements S1 to S11 are provided; these call for additional tests to be made if desired.

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

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

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

[A342/A342M Test Methods for Permeability of Weakly Magnetic Materials](#)

[A488/A488M Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel](#)

[A999/A999M Specification for General Requirements for Alloy and Stainless Steel Pipe](#)

[E8/E8M Test Methods for Tension Testing of Metallic Materials](#)

[E21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials](#)

[E94/E94M Guide for Radiographic Examination Using Industrial Radiographic Film](#)

[E139 Test Methods for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials](#)

[E142 Method for Controlling Quality of Radiographic Testing \(Withdrawn 2000\)](#)³

[E151 Recommended Practice for Tension Tests of Metallic Materials at Elevated Temperatures with Rapid Heating and Conventional or Rapid Strain Rates \(Withdrawn 1984\)](#)³

[E165/E165M Practice for Liquid Penetrant Testing for General Industry](#)

[E340 Practice for Macroetching Metals and Alloys](#)

3. Ordering Information

3.1 Orders for material to this specification should include the following, as required, to describe the desired material adequately:

3.1.1 Quantity (feet, centimeters, or number of lengths),

3.1.2 Name of material (centrifugally cast tubing),

3.1.3 Specification number and grade ([Table 1](#)),

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 The last approved version of this historical standard is referenced on www.astm.org.

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

TABLE 1 Chemical Requirements^A

Grade (UNS Number)	Composition, % (Values are maximums unless otherwise indicated.)								
	Carbon	Manganese	Silicon	Chromium	Nickel	Phosphorus	Sulfur	Molybdenum	Niobium
HC30 (J92613)	0.25–0.35	0.5–1.0	0.50–2.00	26–30	4.0	0.04	0.04	0.50	...
HD50 (J93015)	0.45–0.55	1.50	0.50–2.00	26–30	4–7	0.04	0.04	0.50	...
HE35 (J93413)	0.30–0.40	1.50	0.50–2.00	26–30	8–11	0.04	0.04	0.50	...
HF30 (J92803)	0.25–0.35	1.50	0.50–2.00	19–23	9–12	0.04	0.04	0.50	...
HH30 (J93513)	0.25–0.35	1.50	0.50–2.00	24–28	11–14	0.04	0.04	0.50	...
HH33 ^B (J93633)	0.28–0.38	1.50	0.50–2.00	24–26	12–14	0.04	0.04	0.50	...
HI35 (J94013)	0.30–0.40	1.50	0.50–2.00	26–30	14–18	0.04	0.04	0.50	...
HK30 (J94203)	0.25–0.35	1.50	0.50–2.00	23–27	19–22	0.04	0.04	0.50	...
HK40 (J94204)	0.35–0.45	1.50	0.50–2.00	23–27	19–22	0.04	0.04	0.50	...
HL30 (N08613)	0.25–0.35	1.50	0.50–2.00	28–32	18–22	0.04	0.04	0.50	...
HL40 (N08614)	0.35–0.45	1.50	0.50–2.00	28–32	18–22	0.04	0.04	0.50	...
HN40 HPNb	0.35–0.45 0.38–0.45	1.50 0.50–1.50	0.50–2.00 0.50–1.50	19–23 24–27	23–27 34–37	0.04 0.03	0.04 0.03	0.50 0.50	... 0.5–1.5
HPNbS (N28702)	0.38–0.45	0.50–1.50	1.50–2.50	24–27	34–37	0.03	0.03	0.50	0.5–1.5
HT50 (N08050)	0.40–0.60	1.50	0.50–2.00	15–19	33–37	0.04	0.04	0.50	...
HU50 (N08005)	0.40–0.60	1.50	0.50–2.00	17–21	37–41	0.04	0.04	0.50	...
HW50 (N08006)	0.40–0.60	1.50	0.50–2.00	10–14	58–62	0.04	0.04	0.50	...
HX50 (N06050)	0.40–0.60	1.50	0.50–2.00	15–19	64–68	0.04	0.04	0.50	...

TABLE 1 Chemical Requirements^A

Grade (UNS Number)	Composition, % (Values are maximums unless otherwise indicated.)								
	Carbon	Manganese	Silicon	Chromium	Nickel	Phosphorus	Sulfur	Molybdenum	Niobium ^B
HC30 (J92613)	0.25–0.35	0.5–1.0	0.50–2.00	26–30	4.0	0.04	0.04	0.50	...
HD50 (J93015)	0.45–0.55	1.50	0.50–2.00	26–30	4–7	0.04	0.04	0.50	...
HE35 (J93413)	0.30–0.40	1.50	0.50–2.00	26–30	8–11	0.04	0.04	0.50	...
HF30 (J92803)	0.25–0.35	1.50	0.50–2.00	19–23	9–12	0.04	0.04	0.50	...
HH30 (J93513)	0.25–0.35	1.50	0.50–2.00	24–28	11–14	0.04	0.04	0.50	...
HH33 ^C (J93633)	0.28–0.38	1.50	0.50–2.00	24–26	12–14	0.04	0.04	0.50	...
HI35 (J94013)	0.30–0.40	1.50	0.50–2.00	26–30	14–18	0.04	0.04	0.50	...
HK30 (J94203)	0.25–0.35	1.50	0.50–2.00	23–27	19–22	0.04	0.04	0.50	...
HK40 (J94204)	0.35–0.45	1.50	0.50–2.00	23–27	19–22	0.04	0.04	0.50	...
HL30 (N08613)	0.25–0.35	1.50	0.50–2.00	28–32	18–22	0.04	0.04	0.50	...
HL40 (N08614)	0.35–0.45	1.50	0.50–2.00	28–32	18–22	0.04	0.04	0.50	...
HN40 HP15Nb	0.35–0.45 0.05–0.25	1.50 0.50–1.60	0.50–2.00 0.50–1.50	19–23 24–27	23–27 34–38	0.04 0.030	0.04 0.030	0.50 0.50	... 0.5–1.5
HPNb (N28701)	0.38–0.45	0.50–1.50	0.50–1.50	24–27	34–37	0.03	0.03	0.50	0.5–1.5
HPNbS (N28702)	0.38–0.45	0.50–1.50	1.50–2.50	24–27	34–37	0.03	0.03	0.50	0.5–1.5
HT50 (N08050)	0.40–0.60	1.50	0.50–2.00	15–19	33–37	0.04	0.04	0.50	...
HU50 (N08005)	0.40–0.60	1.50	0.50–2.00	17–21	37–41	0.04	0.04	0.50	...
HW50	0.40–0.60	1.50	0.50–2.00	10–14	58–62	0.04	0.04	0.50	...



Grade (UNS Number)	Composition, % (Values are maximums unless otherwise indicated)								
	Carbon	Manganese	Silicon	Chromium	Nickel	Phosphorus	Sulfur	Molybdenum	Niobium ^B
(N08006)									
HX50 (N06050)	0.40–0.60	1.50	0.50–2.00	15–19	64–68	0.04	0.04	0.50	...

^A Where ellipses (...) appear in this table there is no requirement, and the element need not be analyzed or reported.

^B Columbium (Cb) and Niobium (Nb) are interchangeable names for the same Element 41.

^C Manufacturing control should ensure that this composition contains a minimal amount of ferrite. See Supplementary Requirement S5.

- 3.1.4 Size (outside or inside diameter and minimum wall thickness, see Section 8);
- 3.1.5 Condition (see Section 9, as-cast or as-cast with machining on outside or inside surfaces, or machined; see 5.1 and Sections 8 and 9),
- 3.1.6 Length (specific or random), (Permissible Variations in Length Section of Specification A999/A999M),
- 3.1.7 End finish (Ends Section of Specification A999/A999M),
- 3.1.8 Optional requirements (see 8.2.3 regarding the manufacturer's wall thickness allowance for as-cast tubing and Supplementary Requirements S1 to S11),
- 3.1.9 Test report required (see Section 13), and
- 3.1.10 Special requirements to be added to the specification.

4. General Requirements

4.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A999/A999M, unless otherwise provided herein.

5. Materials and Manufacture

- 5.1 The tubing may be supplied in the as-cast condition or as-cast with machining on the outside or inside surfaces, or machined, as agreed upon between the manufacturer and the purchaser.
- 5.2 Heat treatment of the tubing shall not be required under this specification.

6. Chemical Requirements

- 6.1 The material shall conform to the requirements as to chemical composition as prescribed in Table 1.

7. Tensile Properties

7.1 Tension tests at room temperature are not recommended as acceptance criteria under this specification since the alloys are intended for elevated temperature service, and room temperature tests do not have a dependable relationship to elevated temperature properties. (Where the design of the tubing is based on an assumption of certain minimum creep-rupture properties, one of the supplementary requirements of this specification may be stipulated on the order to ascertain the ability of the material to meet the design properties.)

8. Permissible Variation in Dimensions

8.1 *Machined Tubing (Tubing Machined on Inside and Outside):*

8.1.1 The tolerances given in Specification A999/A999M shall govern, except that the wall thickness shall not vary over the specified minimum wall thickness by more than 10 % or 1/16 in. [1.6 mm], whichever is greater. There shall be no variation under the specified minimum wall thickness.

8.2 *As-Cast Tubing (No Machining or Machined on Inside or Outside):*

8.2.1 *Outside Diameter (For for Tubes Ordered to Outside Diameter):*

8.2.1.1 Tubes machined on the outside shall meet the requirements of Specification A999/A999M.

8.2.1.2 Tubes not machined on the outside shall meet the permissible variations of Table 2.

8.2.2 *Inside Diameter (For for Tubes Ordered to Inside Diameter):*

8.2.2.1 Tubes machined on the inside shall meet the requirements of Specification A999/A999M.

8.2.2.2 Tubes not machined on the inside shall have permissible variations as agreed upon by the purchaser and the manufacturer.

8.2.3 *Wall Thickness*—The wall thickness shall not exceed the calculated minimum as-cast wall thickness by more than the limits shown in Table 3. The calculated minimum wall thickness shall be equal to the specified minimum wall thickness plus the manufacturer's allowance for "inside surface feed metal" and outside surface roughness. Upon request, the manufacturer's allowance shall be furnished to the purchaser. There shall be no variation under the calculated minimum as-cast wall thickness. For tubes over 24 up to and including 54 in. [600 to 1350 mm] in diameter, the "permissible variations over specified minimum as-cast wall thickness" shall be agreed upon by the manufacturer and the purchaser.



TABLE 2 Permissible Variations in As-Cast Outside Diameter

Specified Outside Diameter of Tubing		Permissible Plus or Minus Variations from Specified Outside Diameter	
		in.	mm
From 2 to 4	50 to 100	0.08	2.0
Over 4 to 12	100 to 300	0.10	2.5
Over 12 to 24	300 to 600	0.12	3.0
Over 24 to 36	600 to 900	0.16	4.1
Over 36 to 54	900 to 1350	0.25	6.4

TABLE 3 Permissible Variations in As-Cast Wall Thickness

Specified Outside Diameter of Tubing		Permissible Variations over Calculated Minimum As-Cast Wall Thickness	
		in.	mm
From 2 to 6	50 to 150	0.08	2.0
Over 6 to 12	150 to 300	0.10	2.5
Over 12 to 24	300 to 600	0.13	3.3

8.2.4 *Length*—If definite lengths are ordered, no length of tubing shall be under the length specified and not longer than the tolerance shown in Table 4.

9. Finish

9.1 *Machined Tubing*—All tubes shall be reasonably straight and free of rejectable indications. All visual irregularities shall be explored for depths. When the depth encroaches on the specified minimum wall thickness, such irregularities shall be considered rejectable indications.

9.2 *As-Cast Tubing:*

9.2.1 The outside surface shall be adequately cleaned (such as by shotblasting, sandblasting, wire brushing, grinding, or machining). The metal surface so revealed shall be visually inspected and shall be free of linear discontinuities or other imperfections that encroach on the specified minimum wall of the tube.

9.2.2 Various degrees of surface roughness occur on unmachined tubing. If a specific surface finish is required, it shall be a matter of agreement between the manufacturer and the purchaser.

9.3 *Surface Irregularities Not Classified as Rejectable*—Visual surface defects that have been explored and that do not encroach on the minimum sound wall thickness shall be blended either by machining or grinding the surface into the surrounding unaffected surface area of the tubing.

9.4 *Repair by Welding*—Repair of injurious defects by welding shall be permitted and major weld repairs shall be permitted only subject to the approval of the purchaser. Weld repairs shall be considered major if the depth of the cavity prepared for welding exceeds 20 % of the required minimum wall thickness or if the total surface area exceeds 10 in.² [65 cm²]. Defects shall be completely removed before welding. If defects are linear, complete removal shall be checked by liquid penetrant inspection (Practice E165/E165M). Only qualified operators and procedures in accordance with Practice A488/A488M shall be used. All weld repairs shall be subjected to the same inspection standard as the tubing.

10. Pressure Test

10.1 All tubing shall be subjected to an internal air pressure of at least 75 psi [515 kPa] for at least 1 min either while submerged in clear water or with the entire outer surface coated with sulfur-free soap suds at the discretion of the manufacturer. In the usable portion of the tube, leaks are not permitted. If the Hydrostatic Test, Supplementary Requirement S6, is invoked, the exact details of the test and testing procedure shall be clearly defined and made a part of the ordering information (3.1.8).

10.2 Leaks may be repaired by welding only if such repair is approved by the purchaser.

TABLE 4 Excess Length Tolerances for Centrifugally Cast Tubes

Outside Diameter of Tube		Permissible Excess Length	
		in.	mm
From 2 to 12	50 to 300	¼	6.4
Over 12 to 24	300 to 600	½	13
Over 24 to 54	600 to 1350	1	25

11. Flattening Test

11.1 Flattening tests are not required since material covered by this specification is not intended to be bent, flanged, or otherwise formed.

12. Mechanical Tests Required

12.1 *Air Pressure Test*—Each length of tubing shall be subjected to the pressure test described in Section 10.

13. Certification

13.1 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufactured and tested in accordance with this specification together with a report of the test results shall be furnished at the time of shipment.

14. Product Marking

14.1 In addition to the marking prescribed in Specification **A999/A999M**, the marking shall include the length, an additional symbol "S" if the tubing conforms to the supplementary requirements specified in Supplementary Requirements S1 to S11, the heat number or manufacturer's number by which the tube can be identified, and, when as cast (see 8.2), the notation "AS CAST."

15. Keywords

15.1 alloy; centrifugal casting; high temperatures; pressure containing parts; steel tube; temperature service applications

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements may become a part of the specification when specified on the inquiry or invitation to bid and purchase order or contract.

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S1. Product Analysis

S1.1 Product analysis may be made on any length of tubing. Individual lengths failing to conform to the chemical requirements shall be rejected. For product analysis, the outside surface of the tube shall be ground clean before sampling and a sample taken from this area by drilling. If drillings are taken, the drill should penetrate at least to the mid-point of the tube wall, but the inner 1/8 in. [3 mm] of the tube wall shall not be included in the sample unless the tube has been bored.

S2. Short-Time, High-Temperature Tension Test

S2.1 Short-time, high-temperature tension tests shall be made from a longitudinal or transverse section cut from the end of the tubing representing each heat or lot as agreed upon between the manufacturer and the purchaser.

S2.2 The test specimen shall conform to the dimensions shown in Fig. 7 or 9 of Test Methods **E8/E8M**, or as described in Practice **E151**. The specimen gage diameter shall not encroach on the zone of feed metal when cut from an as-cast tube.

S2.3 The specimen shall be subjected to a short-time tension test at a temperature of 1400 °F [760 °C], 1600 °F [870 °C], 1800 °F [980 °C], or 2000 °F [1095 °C], as selected by the purchaser. During the test the temperature range shall be maintained within ± 10 °F [5.5 °C] at the selected temperature. If the temperature is not specified by the purchaser, the test shall be conducted at 1600 °F [870 °C]. Processing by heat treatment to improve the hot tensile strength of the material or specimen shall not be permitted. However, the specimens may be aged for 24 h at test temperature before testing.

S2.4 The test shall be made in accordance with Test Methods **E21**, except that the speed of the head of the testing machine shall be so adjusted that the crosshead speed shall not exceed 0.05 in. [1.3 mm]/in. [25 mm]/min.

S2.5 The test specimens shall conform to properties agreed upon between the manufacturer and the purchaser. The values shown in **Table S2.1** may be used as a guide.

S3. Stress Rupture Test

S3.1 The stress rupture test shall be made from a longitudinal or transverse section cut from the end of the tubing representing each heat or lot as agreed upon between the manufacturer and the purchaser.

S3.2 The conditions of testing may be specified by the purchaser as either:

S3.2.1 1600 °F [870 °C] and an initial stress of 10 000 psi [69 000 kPa] or 8000 psi [55 000 kPa], or