Designation: A 447/A447M – 93 (Reapproved 2007)

Standard Specification for Steel Castings, Chromium-Nickel-Iron Alloy (25-12 Class), for High-Temperature Service[1]

This standard is issued under the fixed designation A 447/A447M; 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-base, heat-resisting alloy castings of the 25 % chromium, 12 % nickel class, intended for structural elements, containers, and supports in electric furnaces, petroleum still tube supports, and for similar applications up to 2000°F [1095°C]. The purchaser should inform the manufacturer when the service temperatures are to exceed 1800°F [980°C].

1.2 In the absence of significant proportions of elements other than those prescribed in Section 4, the two types of alloys covered by this specification may in general be distinguished as follows:

1.2.1 *Type I*—Alloys characterized by relatively low limiting creep stress at temperatures between 1500 and 2000°F [815 and 1095°C], and relatively high ductility at ordinary temperatures after aging for short periods at temperatures between 1300 and 1500°F [705 and 815°C].

1.2.2 *Type II*—Alloys having relatively high limiting creep stress but which may develop low ductility at ordinary temperatures when aged for short periods at temperatures between 1350 and 1500°F [730 and 815°C].

1.3 The values stated in either inch-pound units 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.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 781/A 781M Specification for Castings, Steel and Alloy, Common Requirements, for General Industrial Use

A 800/A 800M Practice for Steel Casting, Austenitic Alloy, Estimating Ferrite Content Thereof

E 8 Test Methods for Tension Testing of Metallic Materials

E 21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials

3. General Conditions for Delivery

3.1 Material furnished to this specification shall conform to the requirements of Specification A 781/A 781M, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A 781/A 781M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A 781/A 781M, this specification shall prevail.

4. Process

4.1 The alloy for the castings shall be made by the electric-furnace process or by any other process approved by the purchaser.

5. Heat Treatment

5.1 Except as otherwise agreed upon between the manufacturer and the purchaser, the manufacturer shall not be required to heat treat the castings.

6. Chemical Composition

6.1 The castings shall conform to the requirements of Table 1 as to chemical composition.

7. Sampling

7.1 Material for the tests specified in Sections 10, 12, and 13 may be taken from separately cast test blocks of a form such as that shown in Fig. 1, from another type of test block, from the castings, or from coupons attached to the castings, as may be agreed upon between the manufacturer and the purchaser.

7.2 Material for the magnetic permeability test specimen (Section 11) may be taken, prior to heat treatment, from the same coupon as the specimen for the tension test after aging; from suitable specimens cast as parts of separately cast test

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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.

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TABLE 1 Chemical Requirements

Element	Composition, %
Ni[A]	10.00–14.00
Cr	23.00–28.00
C	0.20–0.45
N, max	0.20
Mn, max	2.50
Si, max	1.75
P, max	0.05
S, max	0.05
Fe and other elements	as may be agreed upon between the manufacturer and the purchaser

[A] Commercial nickel usually carries a small amount of cobalt, and within the usual limits cobalt shall be counted as nickel.

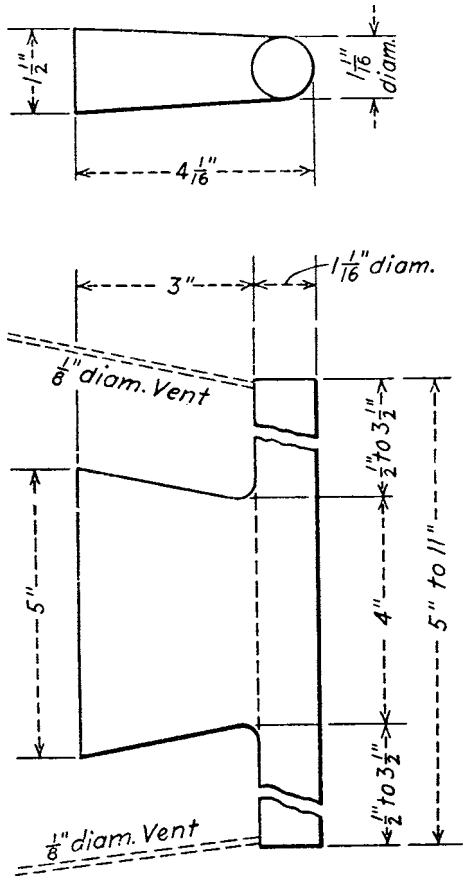

TABLE *Continued*

Metric Equivalents			
in.	[mm]	in.	[mm]
⅛	[3.2]	3½	[88.9]
½	[12.7]	4	[101.6]
1 1⁄16	[27.0]	4 1⁄16	[103.2]
1½	[38.1]	5	[127.0]
3	[76.2]	11	[279.4]

NOTE—Pour through head; cover molten head with powdered charcoal, coke dust, etc., immediately after pouring, in order to keep head fluid as long as possible.

FIG. 1 Test Block for Tension Test Specimen

blocks; or, by agreement between the manufacturer and the purchaser, from castings representing the melt.

7.3 In the case of castings for unusual or severe service, the test coupons shall be attached to the castings at convenient locations as may be agreed upon between the manufacturer and the purchaser.

7.4 In all cases, it shall be the manufacturer's duty to provide a sufficient number of samples for the specified tests.

8. Number of Tests

8.1 The purchaser shall specify not more than two tests. The tests shall be selected from the following list, with the restriction that not more than one of the tension tests at high temperature (that is, 8.1.3 or 8.1.4) may be required:

8.1.1 Tension test after aging,

8.1.2 Magnetic permeability test,

8.1.3 Stress-rupture test, and

8.1.4 Short-time high-temperature tension test.

9. Retests

9.1 *Mechanical Tests*—If any of the specimens first chosen for any of the mechanical tests agreed upon fail to conform to the specified requirements, an additional specimen from the same melt may be tested. This additional specimen shall conform to the requirements prescribed for the test in question.

9.2 *Magnetic Test*—If the magnetic permeability of the specimen first tested does not conform to the requirement prescribed in 11.1, three additional specimens from the same melt may be tested. At least two of these shall conform to the prescribed requirement.

10. Tensile Properties After Aging

10.1 The tensile properties of the material after aging shall conform to the following requirements:

	Type I	Type II
Tensile strength, min, ksi [MPa]	80 [550]	80 [550]
Elongation in 2 in. [50 mm], min, %	9	4

10.2 Samples from which the tension specimens are to be taken shall be heated for 24 h at 1400 ± 25°F [760 ± 14°C] and allowed to cool at least down to 400°F [205°C] at rates not exceeding 200°F [110°C]/h. The tension test specimens shall be machined from the heat-treated sample, and shall conform to the dimensions shown in Fig. 1 of Test Methods E 8.

10.3 The tension test shall be made in accordance with Test Methods E 8. The speed of head of the testing machine shall be so adjusted that the rate of separation of the gage marks on the test specimen shall not exceed 0.1 in. [3 mm]/min.

11. Magnetic Permeability

11.1 The magnetic permeability of the material shall conform to the following requirements:

	Magnetic Permeability, max
Type I	1.70
Type II	1.05

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NOTE 1—The magnetic permeability test gives a qualitative indication of the ferrite content for alloys falling within the range of chemical composition specified in Section 6, excluding iron and other elements as may be agreed upon. When special alloying elements are specified, the magnetic permeability test is not recommended because its significance has not yet been established for such alloys.

11.2 The specimen shall be heated in air to 2000 ± 25°F [1095 ± 14°C], held within this range for 24 h, and then quenched in water. After quenching, all scale and superficial oxidized metal shall be removed in order to avoid errors that might arise from the presence of magnetizable oxides formed during heating.

11.3 Unless otherwise agreed upon between the purchaser and the manufacturer, the magnetic permeability shall be determined in accordance with Supplementary Requirement S1 of Practice A 800/A 800M.

NOTE 2—Where the test method used measures volume percent ferrite, conversion to magnetic permeability may be accomplished using the following requirements:

Volume, Ferrite, %, max	Magnetic Permeability, max
1	1.05
8	1.70

12. Stress-Rupture Test

12.1 The following tensile stress shall be sustained for at least 16 h without rupturing the specimen:

	Tensile Stress, ksi [MPa]
Type I	5 [34]
Type II	8 [55]

12.2 The test specimen shall conform to the dimensions shown in Fig. 1 of Test Methods E 8.

12.3 The specimen in the as-cast condition shall be mounted in the testing machine and held for 1 h at 1600 ± 10°F [870 ± 5.5°C]. The specimen shall then be subjected to a steady tensile load while the temperature over the gage length is maintained at 1600 ± 10°F [870 ± 5.5°C] in an air atmosphere.

13. Short-Time, High-Temperature Tensile Properties

13.1 The short-time, high-temperature tensile properties shall conform to the following requirements:

	Tensile Strength, min, ksi [MPa]	Elongation in 2 in. [50 mm], min, %
Type I	as agreed upon between manufacturer and purchaser	as agreed upon between manufacturer and purchaser
Type II	20 [140]	8

13.2 The test specimen shall conform to the dimensions shown in Fig. 1 of Test Methods E 8.

13.3 The specimen in the as-cast condition, that is, without any heat treatment after cooling from the casting temperature, shall be subjected to a short-time tension test during which the temperature shall be maintained at 1600 ± 10°F [870 ± 5.5°C]. The specimen shall be mounted in the testing furnace and held within this range of temperature for 1 h, and the test load then applied.

13.4 The test shall be made in accordance with Practice E 21 except that the speed of head of the testing machine shall be so adjusted that the rate of separation of the gage marks on the test specimen shall not exceed 0.03 in. [0.8 mm]/min.

14. Defective Test Specimens

14.1 If any specimen shows defective machining or develops flaws, it may be discarded and another specimen from the same melt substituted.

14.2 If any part of the fracture in any of the specimens subjected to tension tests is more than ¾ in. [19.0 mm] from the center of the gage length as indicated by gage marks placed on the specimen before testing, another specimen may be substituted.

15. Repair by Welding

15.1 Weld repairs shall be inspected to the same quality standards as are used to inspect the castings.

15.2 When heat treatment is specified, the castings shall be heat treated after welding.

16. Keywords

16.1 ausenitic stainless steel; high temperature applications; stainless steel; steel castings

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall not be applied unless specified in the purchase order. A list of standardized supplementary requirements for use at the option of the purchaser is included in Specification A 781/A 781M. Those which are ordinarily considered suitable for use with the specification are given below. Others enumerated in Specification A 781/A 781M may be used with this specification upon agreement between manufacturer and purchaser.

S5. Examination of Weld Preparation

S8. Marking

S6. Certification

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APPENDIX

(Nonmandatory Information)

X1. BIBLIOGRAPHY

X1.1 The following selected bibliography is appended for use by those who may be interested in gaining some information about the complex behavior of metals under stress at elevated temperatures. The bibliography is by no means complete, but will serve as an introduction to the subject.

(1) Brophy, G. R., and Furman, D. E., "The Cyclic Temperature Acceleration of Strain in Heat Resisting Alloys," *Transactions*, TA-SEA, Am. Soc. Metals, Vol 30, No. 4, December 1942, pp. 1115–1138.

(2) Fellows, J. A., Cook, E., and Avery, H. S., "Precision in Creep Testing," *Metals Technology*, METYA, Am. Inst. Mining and Metallurgical Engrs. Technical Publication 1443, Vol 9, No. 5, August 1942, pp. 1–15.

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(5) Gow, J. T., and Harder, O. E., "Balancing the Composition of Cast 25 percent Chromium-12 percent Nickel Type Alloys," *Transactions*, TASEA, Am. Soc. Metals, Vol 30, No. 4, December 1942, pp. 855–935.

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(9) Compilation of Available High-Temperature Creep Characteristics of Metals and Alloys, Joint Research Committee on Effect of Temperature on the Properties of Metals (Joint Committee of Am. Soc. Mech. Engrs. and ASTM), March 1938. (*ASTM STP 37*, ASTTA).

(10) Manjoine, M. J., "New Machines for Creep and Creep-Rupture Tests."(Constant strain-rate tests) *Transactions*, TASEA, Am. Soc. Mech. Engrs., February 1945, pp. 111 and 116.

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