Designation: A439/A439M – 18 (Reapproved 2022)

Standard Specification for Austenitic Ductile Iron Castings[1]

This standard is issued under the fixed designation A439/A439M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This specification covers austenitic ductile iron castings, which are used primarily for their resistance to heat, corrosion, and wear, and for other special purposes.

1.2 Austenitic ductile iron, also known as austenitic nodular iron or austenitic spheroidal iron, is characterized by having its graphite substantially in a spheroidal form and substantially free of flake graphite. It contains some carbides and sufficient alloy content to produce an austenitic structure.

1.3 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 *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]

A247 Test Method for Evaluating the Microstructure of Graphite in Iron Castings

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

E8/E8M Test Methods for Tension Testing of Metallic Materials

E10 Test Method for Brinell Hardness of Metallic Materials

E30 Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron (Withdrawn 1995)[3]

E59 Practice for Sampling Steel and Iron for Determination of Chemical Composition (Withdrawn 1996)[3]

E351 Test Methods for Chemical Analysis of Cast Iron—All Types

3. Ordering Information

3.1 Orders for material to this specification shall include the following information:

3.1.1 ASTM designation,

3.1.2 Type of austenitic ductile iron required (see 6.1),

3.1.3 Heat treatment options (see 4.3 – 4.6),

3.1.4 If repair of castings is permitted (see 4.7),

3.1.5 Size and number of test bars required (see 9.1 – 9.4 and 10.1),

3.1.6 Special tests, if required (see 12.1),

3.1.7 Certification, if required (see 14.1), and

3.1.8 Different preparation for delivery requirements, if needed (see 15.1).

4. Manufacture

4.1 Melting may be done in any furnaces that produce castings meeting the chemical and mechanical requirements outlined in this specification. These include cupolas, air furnaces, electric furnaces, crucible furnaces, and so forth. Nodularizing and inoculation practice shall be optional with the foundry to produce a microstructure in accordance with 1.2 and Test Method A247.

4.2 Austenitic ductile iron castings may be supplied in either the as-cast or the heat-treated condition.

4.3 By agreement between the manufacturer and the purchaser, the castings may be stress relieved by heating to 1150 to 1200 °F [620 to 650 °C] for not less than 1 h and not for more than 2 h per inch [25 mm] of thickness in the thickest section. Heating and cooling shall be uniform and shall not be more than 400 °F/h [220 °C/h] for castings less than 1 in. [25 mm] in maximum thickness and shall be not more than

[1] This specification is under the jurisdiction of ASTM Committee A04 on Iron Castings and is the direct responsibility of Subcommittee A04.02 on Malleable and Ductile Iron Castings.

Current edition approved Oct. 1, 2022. Published October 2022. Originally approved in 1960. Last previous edition approved in 2018 as A439/A439M – 18. DOI: 10.1520/A0439_A0439M-18R22.

[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.

400 °F/h [220 °C/h] divided by the maximum section thickness in inches [25 mm] for thicker castings. During the cooling cycle, castings may be cooled in still air after the temperature has dropped to 600 °F [310 °C].

4.4 By agreement between the manufacturer and the purchaser, the castings may be in-mold stress relieved by allowing castings to cool slowly in the mold at a rate not exceeding 400 °F/h [220 °C/h]. Once the temperature has dropped below 600 °F [310 °C], castings can be removed from the mold and cooled in still air.

4.5 Whenever dimensional changes in high-temperature service are a problem, by agreement between the manufacturer and the purchaser, the castings may be stabilized by heating at 1600 °F [870 °C] for a period of 1 h per inch [25 mm] of section, with a minimum period of 1 h, followed by uniform cooling, preferably in still air. Otherwise, the austenite, which is super saturated with respect to carbon, can reject carbon during service and produce dimensional changes.

4.6 By agreement between the manufacturer and the purchaser, castings with chilled edges or excessive carbides may be annealed at 1750 to 1900 °F [960 to 1040 °C] for 0.5 h to 5 h followed by uniform cooling, preferably in still air.

4.7 Repair by welding, plugging, or other approved methods may be done only with written permission from the purchaser.

5. Magnetic Properties

5.1 In the event that nonmagnetic castings are specified, the magnetic permeability test shall be used. The maximum magnetic permeability value shall be agreed upon between the manufacturer and the purchaser.

NOTE 1—A convenient shop test for differentiating the various types of austenitic ductile iron is based on the fact that a ground face of either the test bar or the castings of Types D-2 and D-2C does not attract a small steel horseshoe-type magnet which is normally attracted to steel (Alnico magnet should not be used). Types D-3, D-3A, D-5, and D-5B are attracted, and types D-2B, D-2S, D-4, and D-5S are slightly attracted. This nonmagnetic test is a convenient qualitative test only for Types D-2 and D-2C, and shall not be used as a basis for acceptance.

6. Chemical Requirements

6.1 Many combinations of alloys can be used to obtain an austenitic ductile iron. This specification includes ten general types defined by the composition limits in Table 1.

6.2 Samples taken from test coupons, broken test specimens, or castings shall conform to the requirements as to chemical composition prescribed in Table 1. Sampling shall be conducted in accordance with Practice E59 and chemical analyses in accordance with Test Methods E351 and E30. Test Methods E30 should only be used for analyzing those elements for which specific coverage is not provided for in Test Methods E351.

6.3 Spectrometric techniques may also be used for analysis, but should a dispute arise concerning chemical composition, Test Methods E351 and E30 shall be used for referee methods.

6.4 The chemical analysis for total carbon shall be made on either chilled cast pencil-type specimens or thin wafers approximately 1/32 in. [1.0 mm] thick cut from test coupons. Drillings shall not be used because of attendant loss of graphite.

7. Mechanical Requirements

7.1 Test specimens of austenitic ductile iron made according to this specification shall meet the test requirements prescribed in Table 2.

7.2 The yield strength shall be determined in accordance with Test Methods E8/E8M, using one of the following procedures: the 0.2 % offset method or the extension-under-load method may be used, by agreement between the purchaser and the manufacturer.

7.3 Brinell hardness shall be determined as HBW 10/3000 in accordance with Test Method E10.

8. Workmanship, Finish, and Appearance

8.1 The castings shall conform substantially to the dimensions on the drawings furnished by the purchaser, or if no drawing has been provided, to the dimensions predicated by the pattern supplied by the purchaser. The castings shall be free of injurious defects. Surfaces of the castings shall be free of burnt-on sand and shall be reasonably smooth. Runners, risers, fins, and other cast-on pieces shall be removed. In other respects, the castings shall conform to whatever points are specifically agreed upon between the manufacturer and the purchaser.

TABLE 1 Chemical Requirements

Element	Type									
	D-2[A]	D-2B	D-2C	D-2S	D-3[A]	D-3A	D-4	D-5	D-5B	D-5S
	Composition, %									
Total carbon, max	3.00	3.00	2.90	2.6	2.60	2.60	2.60	2.40	2.40	2.30
Silicon	1.50–3.00	1.50–3.00	1.00–3.00	4.80–5.80	1.00–2.80	1.00–2.80	5.00–6.00	1.00–2.80	1.00–2.80	4.90–5.50
Manganese	0.70–1.25	0.70–1.25	1.80–2.40	1.00 max	1.00 max[B]	1.00 max[B]	1.00 max[B]	1.00 max[B]	1.00 max[B]	1.00 max
Phosphorus, max	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Nickel	18.00–22.00	18.00–22.00	21.00–24.00	24.00–28.00	28.00–32.00	28.00–32.00	28.00–32.00	34.00–36.00	34.00–36.00	34.00–37.00
Chromium	1.75–2.75	2.75–4.00	0.50 max[B]	1.75–2.25	2.50–3.50	1.00–1.50	4.50–5.50	0.10 max	2.00–3.00	1.75–2.25

[A] Additions of 0.7 to 1.0 % of molybdenum can increase the mechanical properties above 800 °F [425 °C].
[B] Not intentionally added.

TABLE 2 Mechanical Requirements

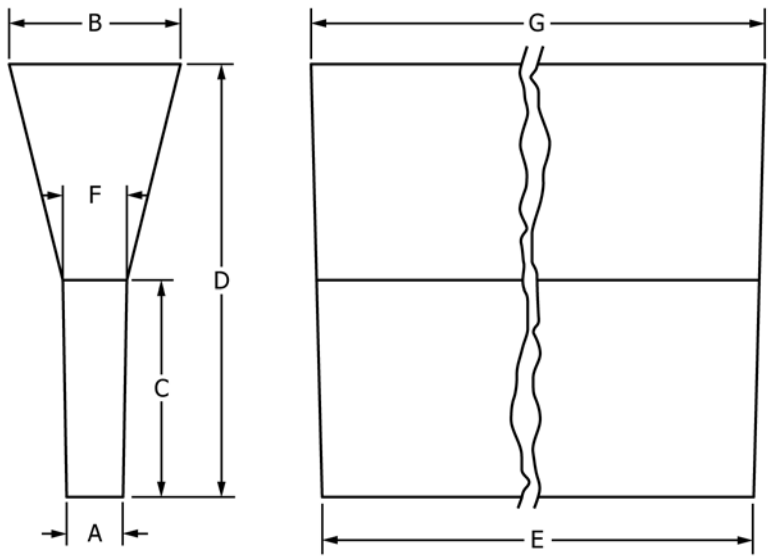
Element	Inch-Pound Grades									
	Type									
	D-2	D-2B	D-2C	D-2S	D-3	D-3A	D-4	D-5	D-5B	D-5S
	Properties									
Tensile strength, min, ksi	58	58	58	55	55	55	60	55	55	55
Yield strength (0.2 % offset), min, ksi	30	30	28	30	30	30	. . .	30	30	30
Elongation in 2 in., min, %	8.0	7.0	20.0	10.0	6.0	10.0	. . .	20.0	6.0	10.0
Brinell hardness (3000 kg)	139–202	148–211	121–171	131–193	139–202	131–193	202–273	131–185	139–193	131–193
	Metric Grade									
Element	Type									
	D-2	D-2B	D-2C	D-2S	D-3	D-3A	D-4	D-5	D-5B	D-5S
	Properties									
Tensile strength, min, MPa	400	400	400	380	380	380	415	380	380	380
Yield strength (0.2 % offset), min, MPa	210	210	195	210	210	210	. . .	210	210	210
Elongation in 50 mm, min, %	8.0	7.0	20.0	10.0	6.0	10.0	. . .	20.0	6.0	10.0
Brinell hardness (3000 kg)	139–202	148–211	121–171	131–193	139–202	131–193	202–273	131–185	139–193	131–193

9. Test Bars

9.1 The standard test bars shall be the 1 in. [25 mm] "Y" block and 1 in. [25 mm] keel block as shown in Figs. 1 and 2, respectively. A modified keel block cast from the mold shown in Fig. 3 may be substituted for the 1 in. [25 mm] "Y" block or the 1 in. [25 mm] keel block.

9.2 Whenever the section size of the castings is considerably less or greater than 1 in. [25 mm], and by agreement between the purchaser and the manufacturer, the ½ in. [13 mm] or 3 in. [75 mm] "Y" blocks shown in Fig. 1 may be used.

9.3 The test bars shall be cast in open molds made of a suitable core sand with a minimum of 1½ in. [38 mm] of sand



Dimensions	"Y" Block Size					
	For Castings of Thickness Less Than ½ in. [13 mm]		For Castings of Thickness ½ in. [13 mm] to 1½ in. [38 mm]		For Castings of Thickness 1½ in. [38 mm] and Over	
	in.	mm	in.	mm	in.	mm
A	½	13	1	25	3	75
B	1⅝	40	2⅛	54	5	125
C	2	50	3	75	4	100
D	4	100	6	150	8	200
E	7 approx	175 approx	7 approx	175 approx	7 approx	175 approx
F	9/16	15	1 1/16	28	3 1/16	80
G	7⅛ approx	180 approx	7⅛ approx	180 approx	7⅛ approx	180 approx

FIG. 1 "Y" Blocks for Test Coupons