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E30 Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron (Withdrawn 1995)[3]

E59 Practice for Sampling Steel and Iron for Determination of Chemical Composition (Withdrawn 1996)[3]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

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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.

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 |

| Element | Metric Grade | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 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 |

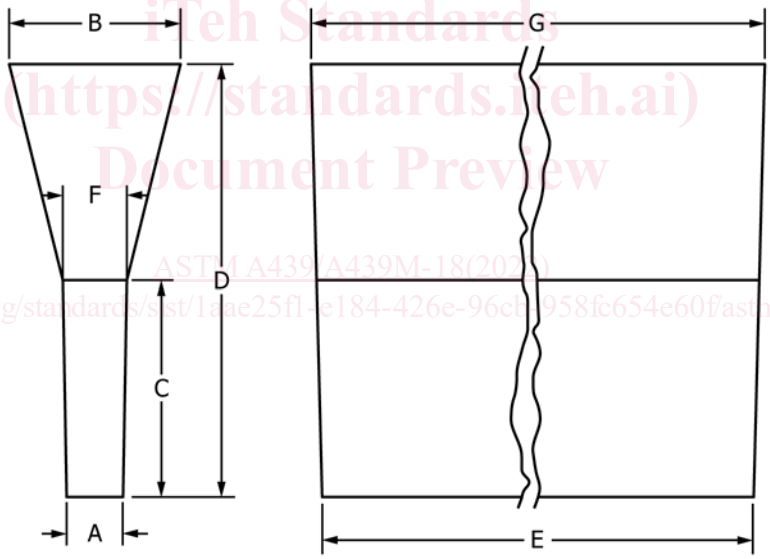
## 9. Test Bars

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.

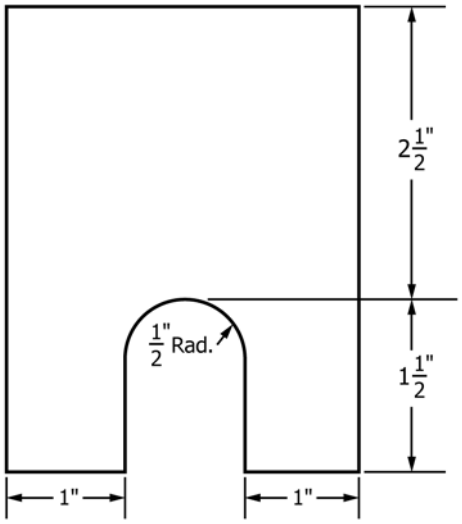
9.3 The test bars shall be cast in open molds made of a suitable core sand with a minimum of 1½ in. [38 mm] of sand






| 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**




| Metric Equivalents | | | | |
|---|---|---|---|---|
| in. | ½ | 1 | 1½ | 2½ |
| mm | 13 | 25 | 38 | 63 |

NOTE 1—The length of the keel block shall be 6 in. [150 mm].

**FIG. 2 Keel Block for Test Coupons**

on all sides and bottom of the ½ and 1 in. [13 and 25 mm] test bars and 3 in. [75 mm] of sand for the 3 in. [75 mm] test bar.

9.4 When investment castings are made to this specification, the manufacturer may use test specimens cast to size incorporated in the mold with the castings, or separately cast to size using the same type of mold and the same thermal conditions that are used to produce the castings. These test specimens shall be made to the dimensions shown in Fig. 3 and Fig. 4 of Test Methods and Definitions A370.

9.5 Test bars representing the furnace heat of iron shall be cast from the same ladle of metal as soon as practicable after the last iron is poured to produce castings, unless otherwise specified. Test bars shall be left in the mold until they have cooled to less than 930 °F [500 °C]; cooling to a black appearance is acceptable if the manufacturer has established that such black appearance corresponds to a temperature less than 930 °F [500 °C].

## 10. Number of Tests

10.1 Test bars shall be poured from each ladle treated with nodularizing agent, unless otherwise specified.

10.2 The number of test bars cast shall be agreed upon by the manufacturer and the purchaser.

10.3 One tension test shall be made from sections cut from the test bars as shown in Fig. 4. If any tension test shows obvious foundry or machining defects, another specimen shall be cut from the same test bar or from another test bar representing the same metal. If the retest specimen fails to conform to this specification, the castings they represent shall be rejected.

## 11. Tension Test Specimens

11.1 The standard round tension test specimen with 2 in. [50 mm] gauge length shown in Fig. 5 shall be used, except when the ½ in. [13 mm] "Y" block is used or when specimens are cut from castings under ¾ in. [20 mm] thickness. In these cases, either of the test specimens shown in Fig. 6 shall be satisfactory.

11.2 By agreement between the manufacturer and the purchaser, tension test specimens may be cut directly from centrifugal or other permanent mold castings. The location and orientation of such tension test specimens cut from castings shall be specified as agreed upon by the manufacturer and the purchaser.

## 12. Additional Tests

12.1 Hydrostatic tests for pressure castings, radiography standards, fracture tests, microstructure standards, or any other special tests may be set up by mutual agreement between the manufacturer and the purchaser.

## 13. Responsibility for Inspection

13.1 Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the manufacturer may use their own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the purchaser. The purchaser reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.



## 14. Certification

14.1 When agreed upon in writing by the purchaser and the supplier, a certification shall be made the basis of acceptance of the material. This shall consist of a copy of the manufacturer's test report or a statement by the supplier, accompanied by a copy of the test results that the material has been tested and inspected in accordance with the provisions of this specification. Each certification so furnished shall be signed by an authorized agent of the supplier or manufacturer.

## 15. Packaging and Package Marking

15.1 Unless otherwise specified in the contract or purchase order, preservation and packaging of casting shall be in accordance with the manufacturer's commercial practice. Packing and marking shall also be adequate to ensure acceptance and safe delivery by the carrier for the mode of transportation employed.

## 16. Keywords

16.1 austenitic; corrosion resistant; ductile iron; mechanical properties; nodular iron; tensile strength; yield strength