Designation: A 518/A 518M – 99 (Reapproved 2003)

# Standard Specification for Corrosion-Resistant High-Silicon Iron Castings[1]

This standard is issued under the fixed designation A 518/A 518M; 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 Department of Defense.*

## 1. Scope

1.1 This specification covers high-silicon cast iron castings intended for corrosion-resistant service.

1.2 This specification covers three grades as shown in Table 1. Selection of grade depends on the corrosive service to be experienced by the casting. All three grades are suited for application in severe corrosive environments. However, Grade 2 is particularly suited for application in strong chloride environments, and Grade 3 is recommended for impressed current anodes.

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 shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.4 The following safety hazards caveat pertains only to the test method portion, Section 9, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 438 Test Method for Transverse Testing of Gray Cast Iron

E 350 Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

E 351 Test Methods for Chemical Analysis of Cast Iron—All Types

**TABLE 1 Chemical Composition**

| Element | Composition, Weight % | | |
|---|---|---|---|
| | Grade 1 | Grade 2 | Grade 3 |
| Carbon | 0.65–1.10 | 0.75–1.15 | 0.70–1.10 |
| Manganese | 1.50, max | 1.50, max | 1.50, max |
| Silicon | 14.20–14.75 | 14.20–14.75 | 14.20–14.75 |
| Chromium | 0.50, max | 3.25–5.00 | 3.25–5.00 |
| Molybdenum | 0.50, max | 0.40–0.60 | 0.20, max |
| Copper | 0.50, max | 0.50, max | 0.50, max |

## 3. Ordering Information

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

3.1.1 ASTM designation and year of issue.

3.1.2 Grade of high-silicon cast iron (see Section 5).

3.1.3 Number of castings.

3.1.4 Approximate weight of the casting.

3.1.5 Drawing showing the size, shape, dimensions, and finishing details. The drawing should indicate any critical dimensions and should give the allowable tolerances on all dimensions and on the accumulation of dimensions. If the purchaser supplies the pattern, the dimensions of the casting shall conform to those predicted by the pattern.

3.1.6 Options in this specification, including:

3.1.6.1 The status of the heat treatment of the castings when shipped by the manufacturer (see Section 7).

3.1.6.2 If the chemical analysis and mechanical test results are to be reported to the purchaser (see Section 14).

3.1.6.3 If a transverse test is required (see 8.1).

3.1.6.4 If hydraulic testing is required, and, if required, the test pressure and the leakage permitted (see 8.2).

3.1.6.5 Any special packing, markings, etc.

## 4. Method of Manufacture

4.1 The alloy may be produced by any melting and casting process, or combination of processes, capable of meeting the chemical composition and mechanical properties specified.

[1] This specification is under the jurisdiction of ASTM Committee A04 on Iron Castings and is the direct responsibility of Subcommittee A04.01 on Grey and White 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.

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## 5. Chemical Composition

5.1 High-silicon iron castings are produced in one of three grades, as given in Table 1 of this specification.

## 6. Chemical Analysis

6.1 *Heat Analysis*—Chemical analysis of each heat (or each tap, if from a continuous melting operation) shall be made by the manufacturer to determine the percentages of the elements specified in Table 1. The analysis shall be made from a test sample cast during the pouring of the heat (or tap). The chemical composition thus determined shall conform to the requirements specified for that grade in Table 1.

6.2 *Product Analysis*—A product analysis may be made by the purchaser from material representing each heat, lot, or casting. The sample for such analysis shall be taken as desired by the purchaser. The chemical composition thus determined shall meet the requirements for the grade specified.

6.3 *Routine Analysis Methods*—Spectrometric and other instrumental methods or wet chemical laboratory methods are acceptable for routine and control determinations, but shall be standardized against and give essentially the same results as the methods specified in 6.4.

6.4 *Reference Analysis Methods*:

6.4.1 *Silicon*:

6.4.1.1 Analyze samples soluble when processed in accordance with Test Methods E 350, by that method, except as follows:

*(a) (a)* The sample weight shall be 0.3 g with a weight tolerance of ±0.1 mg.

*(b) (b)* Pulverize one or more pieces of the sample until the entire material in the piece or pieces passes through a 100-mesh screen.

*(c) (c)* Dissolve the sample in 25 mL of perchloric acid.

6.4.1.2 Analyze samples that are not soluble when processed in accordance with 6.4.1.1 in accordance with Annex A1.

6.4.2 *Molybdenum*:

6.4.2.1 Mill, lathe, or pulverize the sample to pass through a 100-mesh sieve. If the sample is soluble when processed in accordance with Test Methods E 350, use this method.

6.4.2.2 If the sample is not acid-soluble when processed in accordance with 6.4.2.1, proceed as follows:

*(a) (a)* Use the appropriate weight of sample in accordance with 6.4.2.1 instead of the weight given in A1.2.3 of Annex A1.

*(b) (b)* Fuse the sample in accordance with A1.2.1 and A1.2.2 and A1.2.4-A1.2.12 of Annex A1.

*(c) (c)* Add the amount of dissolving acid(s), specified in the sections in Molybdenum by the Photometric Method in Test Methods E 350, heat to fumes of perchloric acid. Proceed in accordance with Test Methods E 350.

6.4.3 *Carbon*—Determine carbon in accordance with sections on Carbon, Total, by the Combustion Gravimetric Method, in Test Methods E 350.

6.4.4 *Manganese*:

6.4.4.1 Mill, lathe, or pulverize the sample to pass through a 100-mesh sieve.

6.4.4.2 Determine manganese in accordance with the sections on Manganese by the Peroxydisulfate-Arsenite Titrimetric Method in Test Methods E 350. Add hydrofluoric acid as required for complete solution of the (HF) sample.

6.4.5 *Chromium*:

6.4.5.1 Mill, lathe, or pulverize the sample to pass through a 100-mesh sieve.

6.4.5.2 Determine chromium in accordance with the sections on Chromium by the Peroxydisulfate-Oxidation Titrimetric Method in Test Methods E 350, except dissolve the sample as follows:

*(a) (a)* Place the appropriate amount of weighed sample into a 600-mL Griffin beaker or 500-mL volumetric flask. Add 20 mL of nitric acid ($HNO_3$) and carefully add HF, dropwise, until the reaction ceases. A TFE-fluorocarbon beaker may be used if desired.

*(b) (b)* Add 30 mL of 1 + 1 sulfuric acid ($H_2SO_4$), 5 mL of phosphoric acid ($H_3PO_4$), and boil until light fumes of $H_2SO_4$ are present and the sample is completely dissolved.

*(c) (c)* Cool the solution, add 150 mL of water, heat to dissolve if necessary, and continue as in Test Methods E 350.

6.4.6 *Copper*:

6.4.6.1 Mill, lathe, or pulverize the sample to pass through a 100-mesh sieve.

6.4.6.2 Determine the copper in accordance with the sections on Copper by the Sulfide Precipitation-Electrodeposition Gravimetric Method in Test Methods E 350, or

6.4.6.3 Determine the copper in accordance with the sections on Copper by the Neocuproine Photometric Method, in Test Methods E 350. Add HF as required for complete solution of the sample.

## 7. Heat Treatment

7.1 High-silicon iron castings are generally used in the heat-treated (stress-relieved) condition. Small castings of simple configuration not conducive to high-residual stresses may be used in the as-cast condition. If the castings are to be supplied in the stress-relieved condition, the purchaser must so specify.

7.2 At its option, the foundry may heat treat the castings to remove stresses without the purchaser so specifying.

7.3 If used, the stress-relieving heat treatment shall be as follows:

7.3.1 Heat at a rate that will not crack the castings.

7.3.2 Hold the castings at a minimum temperature of 1600°F [870°C] for a minimum period of 1 h/in. [mm] of maximum section thickness, except that in no case shall the holding period be less than 2 h.

7.3.3 Cool the castings to 400°F [205°C] maximum at a rate not faster than 100°F [55°C]/15 min.

7.3.4 From 400°F [205°C] to ambient temperature, the castings may be cooled in still ambient air.

## 8. Mechanical Requirements

8.1 *Transverse Bend Test*:

8.1.1 When specified by the purchaser, the silicon-iron alloy shall be given a transverse bend test. The specimen tested shall meet the test requirements prescribed in Table 2.



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**TABLE 2 Transverse Bend Test Minimum Requirements**

NOTE 1—Test bars are to be tested on supports 12 in. [3.5 mm] apart.

| | |
|---|---|
| Load at center, min, lbf [N] | 930 [4090] |
| Deflection at center, min, in. [mm] | 0.026 [0.66] |

8.1.2 When transverse bend tests are specified, test bars shall be made and tested from each heat (or ladle in the case of continuous melting) from which the castings are poured.

8.1.3 The test bars shall be heat treated in the production furnaces to the same procedure as the castings.

8.1.4 Each test bar shall be permanently marked with the heat or ladle number from which it was poured. Marking shall be accomplished with cast digits, with a vibratory marking tool, or with a felt-point pen using indelible ink.

8.2 *Hydrostatic Test*—When specified by the purchaser, subject the castings for critical applications involving pressure or vacuum conditions to a hydrostatic pressure test at a minimum of 40 psig [275 kPa]. Any leak revealed by this test shall be cause for rejection of the casting.

## 9. Transverse Bend Test Method

9.1 When a requirement for transverse bend tests has been agreed upon between the purchaser and the manufacturer, the manufacturer shall test transverse bend bar(s) from each heat.

9.2 Conduct the transverse bend test in accordance with Method A 438, except as follows:

9.2.1 Do not machine the specimen.

9.2.2 The specimen shall be sufficiently smooth, round, and straight to permit testing without machining.

9.2.3 Produce the specimen in accordance with Fig. 1.

9.2.4 The specimen shall conform to the dimensions shown in Fig. 2.

9.2.5 Report the actual breaking load without use of a correction factor. The requirements of Table 2 allow for deviation due to variations in test bar diameter. In the same sense, measure and report the deflection at fracture without correction.

9.2.6 Apply the load at a rate such that a 0.025-in. [0.65-mm] deflection is produced in 50 to 70 s. Continue loading at the same head-movement rate until the specimen fractures.

## 10. Workmanship, Finish, and Appearance

10.1 The workmanship and finish shall be as agreed upon between the manufacturer and the purchaser.

## 11. Number of Tests and Retests

11.1 If a valid test specimen fails to conform to this specification, two retests shall be made. If either retest fails to

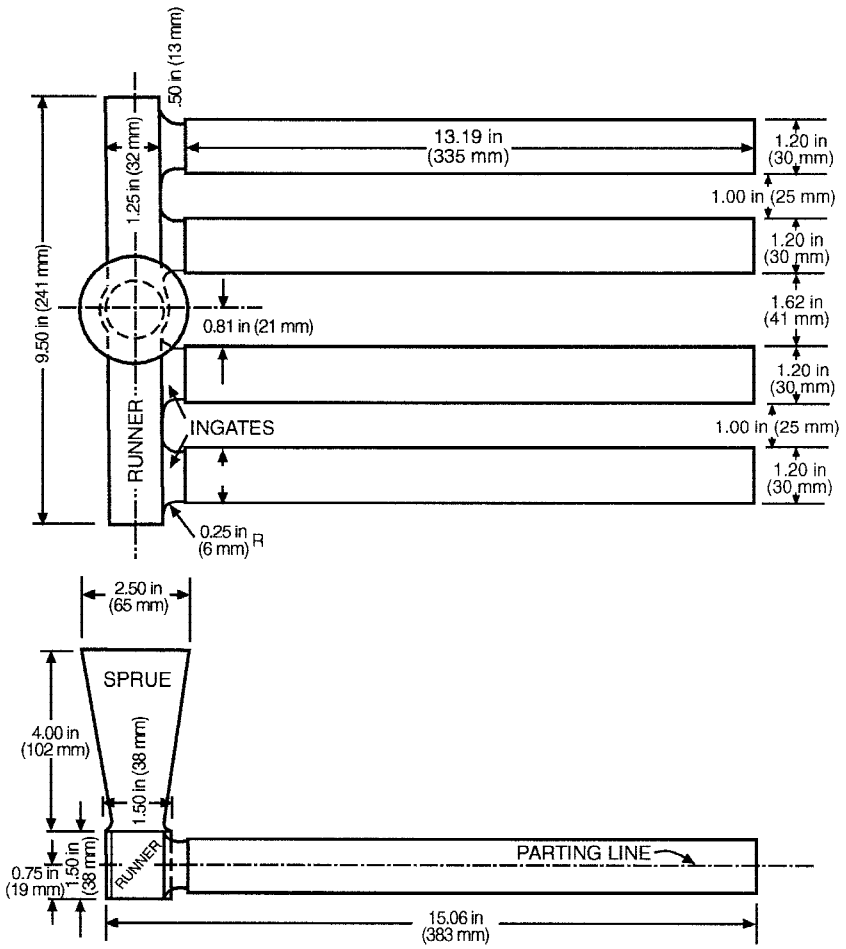


**FIG. 1 Suggested Pattern for Transverse Bend Test Bar, Cast Horizontally, 1.20 in. [30.5 mm] in Diameter**



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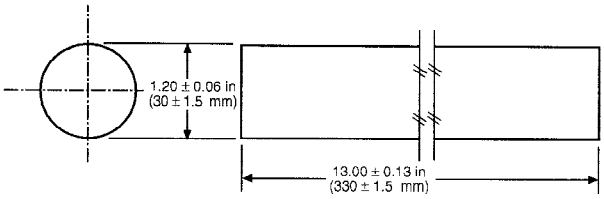


NOTE 1—It is recommended that the casting be mold-cooled to below 1000°F [540°C] before shakeout, and that the test bars be stress-relieved before transverse testing.

**FIG. 2 Transverse Bend Test Bar Dimensions**

conform to this specification, the castings represented by these test bars shall be rejected.

11.2 If after testing, a test specimen shows evidence of a defect, the results of the test may be regarded as invalid and another test made.

11.3 In the absence of further separately cast test bars, the manufacturer shall have the option of submitting test bars sectioned from an agreed-upon position in the castings.

11.4 If reheat treatment is required to meet the specification, castings and their representative test bars shall be reheat treated together. Testing will then proceed as in 11.1, 11.2, and 11.3.

## 12. Inspection

12.1 When specified in the purchase order, the inspector representing the purchaser shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples, the preparation of the test pieces, and the performance of the test(s). For such tests, the inspector shall have the right to indicate the pieces from which the samples will be taken in accordance with the provisions of this specification.

12.2 The manufacturer shall inspect the material covered by this specification prior to shipment and, upon request, shall furnish the purchaser with a certification of test(s).

## 13. Rejection and Rehearing

13.1 *Rejection*—Any rejection based on test reports shall be reported to the manufacturer within 30 days from the receipt of the test report by the purchaser. The manufacturer shall be advised within one week of purchaser's discovery of material that contains injurious defects. The purchaser shall hold the material a minimum of 30 days pending action by the manufacturer.

13.2 *Rehearing*—Samples tested in accordance with this specification that represent rejected material shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the test, the manufacturer may make a claim for a rehearing within that time.

## 14. Certification

14.1 When specified by the purchaser, the manufacturer shall provide the purchaser with a certification stating that the castings meet the specified requirements. The certification shall include the results of any chemical analyses and mechanical tests.

## 15. Product Marking

15.1 The trademark of the manufacturer shall be legibly cast on each casting.

# ANNEX

**(Mandatory Information)**

## A1. SILICON BY THE FUSION-HYDROCHLORIC ACID DEHYDRATION METHOD

A1.1 This method may be used for the referee determination of silicon in high-silicon cast irons. All reagents are to be reagent grade. All water is to be deionized or triple-distilled.

A1.2 *Procedure*:

A1.2.1 *Preparation of Sample*—Pulverize a representative portion of the sample until the entire portion will pass a No. 100 sieve.

A1.2.2 Weigh 8 g of anhydrous sodium carbonate into a 50-mL nickel crucible.

A1.2.3 Weigh 0.5 g of pulverized sample and place on top of the sodium carbonate in the nickel crucible.

A1.2.4 Weigh 4 g of sodium peroxide and place on top of the sample in the nickel crucible.

A1.2.5 Stir carefully with a glass rod until the mixture is homogeneous.

NOTE A1.1—If a delay of 5 min or more is required before fusion of the sample, place the crucible and mixture in a desiccator or on a warm (122°F) hot plate.

A1.2.6 Fuse the mixture carefully over a flame from a Meker burner as follows: Grasp the crucible with a pair of tongs, and slowly revolve the crucible around the outer edge of the flame until the contents have melted down quietly. Increase the temperature of the flame by increasing the air pressure (decreasing the fuel-to-air ratio). Gradually, to avoid spattering, raise the temperature of the flame by passing the crucible in and out of the hotter flame. As the contents become molten, rotate the crucible to stir up any unattacked particles of sample adhering to the bottom or sides. Finally, hold the crucible in the flame (continue to rotate it) until the crucible is bright red for 1 min. Use eye and skin protection for this procedure.

A1.2.6.1 *Caution*:

A1.2.7 Allow the crucible to air cool to room temperature. Invert the crucible over an 800-mL beaker and tap the sides of the crucible gently with the crucible tongs. Finally, tap the



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bottom of the crucible firmly several times until the cake falls into the beaker. Cover the beaker with a watch glass.

A1.2.8 Fill the crucible with hot (50°C) water. Carefully, in small increments, add the rinse to the beaker. Keep the beaker partially covered, because the fusion cake effervesce as the water contacts it. Rinse the crucible with a stream of hot water (~5 mL) from a wash bottle, transferring particles of fusion cake to the beaker.

A1.2.9 Fill the crucible to above the cake line with HCl (1 + 3) and warm on the hot plate at about 70°C until all particles adhering to the crucible have loosened or dissolved. Transfer the rinse solution to the beaker, again guarding against excessive effervescence. Wash the crucible twice more with 5-mL portions of hot water from a wash bottle and add the rinsings to the beaker.

A1.2.10 Add 100 mL of HCl (1 + 1) to the 800-mL beaker. Cover with a ribbed watch glass and heat gently until all of the melt has dissolved (about 30 min). If undissolved sample remains, as indicated by effervescing particles, the fusion must be repeated.

A1.2.11 Add 2 mL of nitric acid ($HNO_3$) and evaporate the solution to dryness. As the volume is reduced, lower the temperature to approximately 70°C to avoid spattering.

A1.2.12 Cool the beaker and dry the residue to room temperature. Add 20 mL of HCl and warm gently (~70°C). Break up hard lumps with a glass rod. Add 200 mL of hot water and digest 3 to 5 min until salts have dissolved.

A1.2.13 Filter the solution into a 12.5-cm quantitative ashless general-purpose filter paper containing paper pulp. Collect the filtrate in an 800-mL beaker. Transfer the precipitate to the filter, and scrub the beaker thoroughly with a rubber policeman. With a stream of hot (50°C) water from a wash bottle, rinse the sides of the beaker and wash any remaining precipitate into the filter paper. Wash the precipitate alternately with 5-mL portions of hot HCl (1 + 19) and hot water, ten times each. Finally, wash three times with 5-mL portions of hot water. Reserve the precipitate and the filtrate.

A1.2.14 Stir the filtrate and again evaporate to dryness. When dry, continue to heat the residue for 30 min at a temperature not exceeding 110°C. Prolonged heating or heating at higher temperatures may result in insoluble oxides of iron.

A1.2.15 Cool the beaker to room temperature. Add 20 mL HCl and warm gently in accordance with A1.2.12. Break up lumps, add 200 mL hot water, and digest 3 to 5 min until salts have dissolved.

A1.2.16 Filter through an 11-cm quantitative ashless general-purpose filter paper containing paper pulp. Scrub the beaker thoroughly with a rubber policeman, then wash traces of precipitate into filter with a stream of hot water from a wash bottle. Wash the filter and precipitate alternately with 5-mL portions of hot HCl (1 + 19) and hot water, ten times each. Finally, wash the paper three times with hot water. Discard the filtrate (or reserve for determination of other elements).

A1.2.17 Transfer the 11-cm filter paper and precipitate into the 12.5-cm paper. Fold the two papers together and transfer to a platinum crucible.

A1.2.18 Char the papers at approximately 250°C in a muffle furnace. Gradually increase the temperature to 600°C, completely charring the paper without flaming. Heat at 600°C until all of the black carbon is removed. (This may require 3 h or more.) Ignite at 1100 to 1150°C for at least 50 min, or to constant weight. Cool in a desiccator and weigh to the nearest 0.1 mg.

A1.2.19 Moisten the precipitate with 1 to 2 ml of sulfuric acid ($H_2SO_4$) (1 + 1) and add 3 to 5 mL of HF. Heat gently until silica is dissolved and the solution is evaporated to dryness. Increase the temperature until fumes of $H_2SO_4$ are removed. Ignite at 1100 to 1150°C for 15 min. Cool in a desiccator and weigh to the nearest 0.1 mg.

A1.3 *Calculations*:

A1.3.1 Calculate the percentage of silicon as follows:

$$\text{Silicon, \%} = \frac{(A - B) \times 0.4675 \times 100}{C} \qquad \text{(A1.1)}$$

where:

$A$ = initial weight of crucible and impure silica, g,
$B$ = final weight of crucible and residue, g, and
$C$ = grams of sample used.

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