Designation: A159 – 83 (Reapproved 2020)

# Standard Specification for Automotive Gray Iron Castings[1]

This standard is issued under the fixed designation A159; 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.*
*This specification replaces Federal specification AA-I-653A.*

## 1. Scope

1.1 This specification applies to gray iron castings, cast in sand molds, used in the products of the automobile, truck, tractor, and allied industries.

1.2 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *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 The following documents of the issue in effect on the date of material procurement form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*[2]
A247 Test Method for Evaluating the Microstructure of Graphite in Iron Castings
E10 Test Method for Brinell Hardness of Metallic Materials
2.3 *Military Standard:*[3]
MIL-STD-129 Marking for Shipment and Storage
2.4 *Federal Standard:*[3]
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

## 3. Grades

3.1 The specified grades, hardness ranges, and metallurgical description are shown in Tables 1 and 2 and in Section 9.

## 4. Ordering Information

4.1 Orders for materials under this specification shall include the following information:
4.1.1 ASTM designation,
4.1.2 Grade designation of gray iron required (3.1),
4.1.3 If special heat treatment is required (see Section 6),
4.1.4 If special microstructure requirements are needed (see Section 7),
4.1.5 Surface where hardness test is to be performed (see 9.4),
4.1.6 Depth and surface hardness of case required (see 9.6),
4.1.7 Inspection lot and sampling plan required (see Section 10),
4.1.8 If additional requirements are needed (see 11.3), and
4.1.9 Whether special packaging and marking are required (see Section 12).

## 5. Hardness

5.1 The foundry shall exercise the necessary controls and inspection techniques to ensure compliance with the specified hardness range. Brinell hardness shall be determined in accordance with Test Method E10, after sufficient material has been removed from the casting surface to ensure representative hardness readings. The 10-mm ball and 3000-kg load shall be used unless otherwise agreed upon. The area or areas on the casting where hardness is to be checked shall be established by agreement between supplier and purchaser and shall be shown on the drawing.

## 6. Heat Treatment

6.1 Unless otherwise specified, castings of Grades G1800 and G2500 may be annealed in order to meet the desired hardness range.

6.2 Appropriate heat treatment for removal of residual stresses, or to improve machinability or wear resistance, may be specified by agreement between supplier and purchaser.

## 7. Microstructure

7.1 The microstructure shall consist of flake graphite in a matrix of ferrite or pearlite or mixtures thereof.

[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.

Current edition approved May 1, 2020. Published May 2020. Originally approved in 1935. Last previous edition approved in 2015 as A159 – 83 (2015). DOI: 10.1520/A0159-83R20.

[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] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

**TABLE 1 Grades of Gray Iron**

| Grade | Casting Hardness Range | Description |
|---|---|---|
| G1800 | HB 187 max<br>4.4 BID min or as agreed[A] | ferritic-pearlitic |
| G2500 | HB 170–229<br>4.6–4.0 BID or as agreed[A] | pearlitic-ferritic |
| G3000 | HB 187–241<br>4.4–3.9 BID or as agreed[A] | pearlitic |
| G3500 | HB 207–255<br>4.2–3.8 BID or as agreed[A] | pearlitic |
| G4000 | HB 217–269<br>4.1–3.7 BID or as agreed[A] | pearlitic |

[A] Brinell impression diameter (BID) is the diameter in millimetres of the impression of a 10-mm ball at 3000-kg load.

7.2 As graphite size and shape somewhat affect hardness-strength ratio and other properties, the type size and distribution of the graphite flakes at a designated location on the casting may be specified by agreement between supplier and purchaser in accordance with Test Method A247.

7.3 Unless otherwise specified, the matrix microstructure of castings covered by this specification shall be substantially free of primary cementite. Castings in Grades G1800 and G2500 may have a matrix of ferrite or pearlite, or both. Grades G3000, G3500, and G4000 shall be substantially pearlite in matrix structure.

## 8. Heavy-Duty Brake Drums and Clutch Plates

8.1 These castings are considered as special cases and are covered in Table 2.

## 9. Alloy Gray Iron Automotive Camshafts

9.1 These castings are considered as special cases.

9.2 *Grade Designation*—G4000d.

9.3 *Chemistry*—Alloy gray iron camshafts shall contain alloys within the following range or as agreed upon between supplier and purchaser.

| | |
|---|---|
| Chromium | 0.85–1.25 % |
| Molybdenum | 0.40–0.60 % |
| Nickel | as agreed |

9.4 *Casting Hardness*—HB 241–321 determined on a bearing surface as agreed by supplier and purchaser.

9.5 *Microstructure*—Extending 45° on both sides of the centerline of the cam nose and to a minimum depth of ⅛ in. (3.2 mm), the surface shall consist of primary carbides (of acicular or cellular form or a mixture thereof) and graphite in a fine pearlitic matrix. The graphite shall be Type VII A and E distribution, 4 to 7 flake size in accordance with Test Method A247. The amount of primary carbides and location at which the structure is checked shall be a matter of agreement between the supplier and the purchaser.

9.6 *Selective Hardening*—The cam areas of camshaft casting are usually selectively hardened by flame or induction hardening by the supplier. The depth and surface hardness of the hardened case shall be as agreed upon between supplier and purchaser.

## 10. Quality Assurance Provisions

10.1 *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and tests requirements specified in this specification. Except as otherwise specified in the contract or purchase order, the producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser. The purchaser shall have the right to perform any of the inspection and tests set for in this specification where such inspections are deemed necessary to ensure that material conform to prescribed requirements.

10.2 *Lot*—For the purpose of inspection, lot and sampling plans shall be agreed upon between the purchaser and the producer.

## 11. General

11.1 Castings furnished to this specification shall be representative of good foundry practice and shall conform to dimensions and tolerances specified on the casting drawing.

11.2 Minor imperfections usually not associated with the structural function may occur in castings. These are often repairable but repairs shall be made only where allowed by the purchaser and only by approved methods.

11.3 Additional casting requirements may be agreed upon by purchaser and supplier. These should appear as product specifications on the casting or part drawing.

## 12. Preparation for Delivery

12.1 Unless otherwise specified in the contract or purchase order, castings shall be cleaned, preserved, and packaged in accordance with supplier's standard commercial practice.

12.2 *Government Procurement*—When specified for government procurement, castings shall be marked for shipment in accordance with MIL-STD-129 for military procurement and Fed. Std. No. 123 for civil agency procurement.

**TABLE 2 Brake Drums and Clutch Plates for Special Service**

| Grade | Carbon min, %[A] | Casting Hardness | Microstructure | |
|---|---|---|---|---|
| | | | Graphite | Matrix |
| G2500a | 3.40 | HB 170–229<br>4.6–4.0 BID or as agreed | Type VII, size 2–4[B]<br>A distribution | lamellar pearlite<br>ferrite if present not to exceed 15% |
| G3500b | 3.40[C] | HB 207–255<br>4.2–3.8 BID or as agreed | Type VII, size 3–5[B]<br>A distribution | lamellar pearlite<br>ferrite or carbide if present not to exceed 5% |
| G3500c | 3.50[C] | HB 207–255<br>4.2–3.8 BID or as agreed | Type VII, size 3–5[B]<br>A distribution | lamellar pearlite<br>ferrite or carbide, if present not to exceed 5% |

[A] The chemical analysis for total carbon shall be made on chilled pencil-type specimens or from thin wafers approximately 1/32 in. (0.8 mm) thick cut from test coupons. Drillings are not reliable because of the probable loss of graphite.
[B] See Test Method A247.
[C] Grades G3500b and G3500c normally require alloying to obtain the specified hardness at the high carbon levels specified.

# APPENDIX

## (Nonmandatory Information)

## X1. GRAY IRON

### X1.1 Definition

X1.1.1 *gray iron*—a cast iron in which the graphite is present as flakes instead of temper carbon nodules as in malleable iron or small spherulites as in ductile iron.

### X1.2 Chemical Composition

X1.2.1 The ranges in composition generally employed in producing the various grades of most automotive gray iron castings are shown in Table X1.1. The composition ranges for such special applications as heavy-duty brake drums and clutch plates and camshafts are shown in Table X1.2 and Table X1.3, respectively. The contents of certain elements for these applications are critical in terms of service requirements and the ranges are specified in the standard.

X1.2.2 The specific composition range for a given grade may vary according to the prevailing or governing section of the castings being produced.

X1.2.3 Alloying elements such as chromium, copper, nickel, tin, molybdenum, or other elements may be employed to meet the specified hardness or microstructural requirements or to provide the properties needed for particular service conditions.

**TABLE X1.2 Usual Composition of Brake Drums and Clutch Plates for Special Service**

| Chemical Composition, % | Grade G2500a | Grade G3500b | Grade G3500c |
|---|---|---|---|
| Carbon, total (mandatory) | 3.40 min | 3.40 min | 3.50 min |
| Silicon (as required) | 1.60–2.10 | 1.30–1.80 | 1.30–1.80 |
| Manganese (as required) | 0.60–0.90 | 0.60–0.90 | 0.60–0.90 |
| Sulfur, max | 0.12 | 0.12 | 0.12 |
| Phosphorus, max | 0.15 | 0.15 | 0.15 |
| Alloys | as required | as required | as required |

**TABLE X1.3 Usual Chemical Composition of Alloy Gray Iron Automotive Camshafts**

| | Grade G4000d, % |
|---|---|
| Total carbon | 3.10–3.60 |
| Silicon | 1.95–2.40 |
| Manganese | 0.60–0.90 |
| Phosphorus | 0.10 max |
| Sulfur | 0.15 max |
| Chromium | 0.85–1.25 |
| Molybdenum | 0.40–0.60 |
| Nickel | 0.20–0.45 optional |
| Copper | residual |

### X1.3 Microstructure

X1.3.1 The microstructure of the various grades of gray iron are generally a mixture of flake graphite in a matrix of ferrite, pearlite, or tempered pearlite. The relative amounts of each of these constituents depends on the analysis of the iron, casting design, and foundry techniques as they affect solidification and subsequent cooling rate and heat treatments, if any.

X1.3.2 The distribution and size of graphite flakes like the matrix structure of gray iron depends greatly on the solidification rate and cooling rate of the casting. If a section solidifies very rapidly, an appreciable amount of carbide causing a

**TABLE X1.1 Typical Base Compositions, %**

| Grade | Carbon | Silicon | Manganese | Sulfur, max | Phosphorus, max | Approximate Carbon Equivalent |
|---|---|---|---|---|---|---|
| G1800 | 3.40–3.70 | 2.30–2.80 | 0.50–0.80 | 0.15 | 0.25 | 4.25–4.5 |
| G2500 | 3.20–3.50 | 2.00–2.40 | 0.60–0.90 | 0.15 | 0.20 | 4.0–4.25 |
| G3000 | 3.10–3.40 | 1.90–2.30 | 0.60–0.90 | 0.15 | 0.15 | 3.9–4.15 |
| G3500 | 3.00–3.30 | 1.80–2.20 | 0.60–0.90 | 0.15 | 0.12 | 3.7–3.9 |
| G4000 | 3.00–3.30 | 1.80–2.10 | 0.70–1.00 | 0.15 | 0.10 | 3.7–3.9 (usually alloyed) |