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Automotive Compacted Graphite Iron Castings

RATIONALE

The technical report covers technology, products, or processes which are mature and not likely to change in the foreseeable future

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1. **Scope**

- 1.1** This SAE Standard covers the mechanical and physical requirements for Compacted Graphite Iron (CGI) castings used in automotive and allied industries. Requirements in this document include:
- a. Tensile Strength
 - b. Yield Strength
 - c. Elongation
 - d. Graphite Morphology
- 1.2** Appendix A provides general information on application of this material along with additional data on mechanical and physical properties not specified but useful as a design reference. Appendix B provides a Compacted Graphite Iron Percent Nodularity Rating Chart not specified but useful as a visual reference.

2. **References**

- 2.1 Applicable Publications**—The following publications form a part of this specification to the extent specified herein.

- 2.1.1 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 247—Test Method for Evaluating the Microstructure of Graphite in Iron Castings
ASTM E 8M—Test Methods for Tension Testing of Metallic Materials (Metric)
ASTM E 9—Test Methods of Compression Testing of Metallic Materials at Room Temperature
ASTM E 10—Test Method for Brinell Hardness of Metallic Materials
ASTM E 21—Test Methods for Elevated Temperature Tension Tests of Metallic Materials
ASTM E 132—Standard Test Method for Poisson's Ratio at Room Temperature

2.2 Related Publications—The following publications are provided for information purposes only and are not a required part of this specification.

2.2.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

I.C.H. Hughes and J. Powell, "Compacted Graphite Irons – High Quality Engineering Materials in the Cast Iron Family," SAE Paper 840772, 1984.

S. Dawson, I. Hollinger, M. Robbins, J. Daeth, U. Reuter and H. Schultz, "The Effect of Metallurgical Variables on the Machinability of Compacted graphite Iron," SAE Technical Paper Series 2001-01-0409, March 2001.

2.2.2 OTHER

E. Nechtelberger, H. Puhr, J.B. van Nesselrode and A. Nakayasu, "Cast Iron with Vermicular/Compacted Graphite – State of the Art," International Foundry Congress, Chicago, Illinois, April 1983.

D.M. Stefanescu and C.R. Loper, "Recent Progress in the Compacted/Vermicular Graphite Cast Iron Field," Giesserei-Prax., No. 5.

S. Dawson, I. Hollinger and P. Smiles, "The Mechanical and Physical properties of Compacted Graphite Iron," Global Powertrain Congress, Detroit, October 1998

3. Grades

3.1 The specified grades, minimum mechanical properties and microstructure requirements, are shown in Table 1.

**TABLE 1—MINIMUM MECHANICAL PROPERTIES AND MICROSTRUCTURE
FOR COMPACTED GRAPHITE IRON⁽¹⁾**

Grade ⁽²⁾	Typical Hardness Range	Minimum Tensile Strength MPa	Minimum Tensile Strength ksi	Minimum 0.2% Yield Strength MPa	Minimum 0.2% Yield Strength ksi	Minimum % Elongation	Typical Matrix Microstructure	Graphite Morphology % Nodularity ⁽³⁾
C250	121-179 HB	250	36.3	175	25.4	3.0	Ferritic	<20
C300HN	131-189 HB	300	43.5	175	25.4	3.0	Ferritic	20-50
C300	143-207 HB	300	43.5	210	30.5	2.5	Ferritic / Pearlitic	<20
C350	163-229 HB	350	50.8	245	35.5	2.0	Ferritic / Pearlitic	<20
C400	197-255 HB	400	58.0	280	40.6	1.5	Pearlitic / Ferritic	<20
C450	207-269 HB	450	65.3	315	45.7	1.0	Pearlitic	<20
C500HN	207-269 HB	500	72.5	315	45.7	1.5	Pearlitic	20-50

1. Refer to 7.1

2. "HN" denotes "High Nodularity". These grades are characterized by having 20 to 50% nodularity while conventional CGI is characterized by having less than 20% nodularity.

3. Refer to 6.1

4. Hardness

4.1 The hardness ranges provided in Table 1 are guidelines only.

4.2 The area or areas on the casting where hardness may be checked should be established by agreement between the manufacturer and the purchaser.

4.3 Brinell hardness shall be determined according to ASTM E 10, Test for Brinell Hardness of Metallic Materials, after sufficient material has been removed from the casting to ensure representative hardness readings. A 10 mm ball, 3000 kg load and 10 second delay time shall be used unless otherwise agreed upon.

5. Heat Treatment

- 5.1** Appropriate heat treatment to obtain minimum mechanical properties, remove residual stresses, or improve machinability may only be performed by agreement between the manufacturer and the purchaser.

6. Microstructure

- 6.1** The metallographic examination of Graphite Morphology shall be performed in the specified critical region of the casting, test lug from the casting or separately cast test coupon or cast test bar as agreed between the manufacturer and the purchaser.
- 6.2** Compacted graphite iron shall be examined metallographically for the specified graphite morphology. The microstructure shall contain the specified percentage of graphite nodules, Types I and II (reference Plate 1, Graphite Form Types of ASTM A 247). The percentage of nodular graphite can be determined by manual particle count, semiautomatic or automatic image analysis or chart comparison techniques as agreed between the manufacturer and the purchaser. The remaining graphite particles shall be in the compacted graphite shape, Type IV. Flake graphite, Type VII is not permitted.
- 6.3** The matrix microstructure shall consist of ferrite, pearlite or a combination of these and be substantially free of primary cementite.

7. Quality Assurance

- 7.1** It is the responsibility of the manufacturer to demonstrate process capability. The specimen(s) used to do so shall be of a configuration and from a location agreed upon between the manufacturer and the purchaser.
- 7.2** Sampling plans shall be agreed between the manufacturer and the purchaser. The manufacturer shall employ adequate controls to ensure that parts conform to the agreed upon requirements.
- 7.3** Non-destructive methods may be utilized to assess graphite morphology when correlation to microstructure has been established and agreed between the manufacturer and the purchaser.

8. General

- 8.1** Castings furnished to this document shall be representative of good foundry practice and shall conform to the dimensions and tolerances specified on the casting drawing.
- 8.2** Minor imperfections usually not associated with the structural functioning may occur in castings. These imperfections are often repairable, however, repairs should be made only in areas and by methods approved by the purchaser.
- 8.3** The manufacturer and the purchaser may agree upon additional casting requirements, such as manufacturer identification, other casting information and special testing. These should appear as additional product requirements on the casting drawing.

PREPARED BY THE SAE METALS TECHNICAL COMMITTEE—DIVISION 9—
AUTOMOTIVE IRON AND STEEL CASTINGS

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