



SURFACE VEHICLE STANDARD

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Automotive Austempered Ductile (Nodular) Iron Castings (ADI)

RATIONALE

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1. **Scope**

This SAE Standard covers the mechanical and physical property requirements for Austempered Ductile Iron (ADI) castings used in automotive and allied industries. Specifically covered are:

- a. Hardness
- b. Tensile Strength
- c. Yield Strength
- d. Elongation
- e. Modulus of Elasticity
- f. Impact Energy
- g. Microstructure

In this document SI units are primary and in-lb units are derived. Appendix A provides general information and related resources on the microstructural, chemical and heat treatment requirements to meet the mechanical properties needed for ADI in particular service conditions and applications.

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—Standard Test Method for Evaluating the Microstructure of Graphite in Iron Castings
ASTM A 536—Standard Specification for Ductile Iron Castings
ASTM E 10—Standard Test Method for Brinell Hardness of Metallic Materials
ASTM E 23—Standard Test Methods for Notched Bar Impact Testing of Metallic Materials
ASTM E 111—Standard Test Method for Young's Modulus, Tangent Modulus and Chord Modulus

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 ASM PUBLICATIONS

ATTN: MSC/Book Order, ASM International, PO Box 473, Novelty, OH 44072-9901.

ASM Metals Handbook, Vol. 1 Properties and Selection. Iron and Steel. Ninth Edition, ASM International 1996 Materials Park, OH 44073-0002.

ASM Specialty Handbook, Cast Irons. ASM International 1996 Materials Park, OH 44073-0002.

2.2.2 OTHER PUBLICATIONS

1st International Conference on Austempered Ductile Iron: Your Means to Improved Performance, Productivity and Cost. American Society for Metals Highway/Off-Highway Vehicles Committee Materials systems and Design Division. April 2-4, 1984 Chicago, IL. ASM International, Materials Park, OH 44073-0002.

2nd International Conference on Austempered Ductile Iron: Your Means to Improved Performance, Productivity and Cost. Sponsored by ASME – Gear Research Institute, ASME – Design Division, AMAX, Inc. March 17-19, 1986, Ann Arbor, MI. ASME – Gear Research Institute c/o Pennsylvania State University, Applied Research Laboratory, P.O. Box 30, State College, PA 16804-0030.

www.ductile.org/didata Chapter IV- Austempered Ductile Iron (Ductile Iron Society (US) website)

3. Grades

The specified grades, hardness and mechanical properties are shown in Table 1.

TABLE 1—MINIMUM MECHANICAL PROPERTIES FOR AUSTEMPERED DUCTILE IRON

Grade	Hardness HBN (dia. in mm) (MPa)	Tensile Strength (1)(2) MPa	Tensile Strength (1)(2) ksi	Yield Strength (1)(2) MPa	Yield Strength (1)(2) ksi	% Elongation Elasticity (1)(2)	Modulus of Elasticity (1)(2)(3) GPa	Modulus of Elasticity (1)(2)(3) psi	Impact Energy ⁽⁴⁾ Joules	Impact Energy ⁽⁴⁾ ft-lb
AD 750	241-302 (3.90-3.50) (2360-2960)	750	110	500	70	11	148	21.5 x 10 ⁶	110	80
AD 900	269-341 (3.70-3.30) (2640-3340)	900	130	650	90	9	148	21.5 x 10 ⁶	100	75
AD1050	302-375 (3.50-3.15) (2960 -3680)	1050	150	750	110	7	148	21.5 x 10 ⁶	80	60
AD1200	341-444 (3.30-2.90) (3340-4350)	1200	175	850	125	4	148	21.5 x 10 ⁶	60	45
AD1400	388-477 (3.10-2.80) (3800-4680)	1400	200	1100	155	2	148	21.5 x 10 ⁶	35	25
AD1600	402-512 (3.05-2.70) (3940-5020)	1600	230	1300	185	1	148	21.5 x 10 ⁶	20	15

1. Applied to equivalent thickness of up to 64 mm (2.5 in). For equivalent thickness greater than 64 mm (2.5 in), the mechanical properties will be mutually agreed upon by the manufacturer and the purchaser.
2. The property requirements in this standard are based on separately cast test bars. Casting properties and microstructure may vary due to chemistry, section size, cooling rates and other parameters. It is desired that the test bars be designed to reflect the properties of the castings they represent. The casting process for the test bars shall be agreed upon between the manufacturer and purchaser. Refer to ASTM A 536.
3. The Young's Modulus (E) was determined by the procedure defined in ASTM E 111.
4. Values obtained using unnotched Charpy bars tested at 22 °C ± 2 °C (72 °F ± 4 °F). The values in the table are the average of the three highest of four tested samples. For details of Charpy test refer to ASTM Impact Test (ASTM E 23).

4. Hardness

- 4.1 The area or areas on the castings where hardness is to be checked shall be established by agreement between the manufacturer and purchaser.
- 4.2 The foundry shall exercise the necessary controls and inspection techniques to insure compliance with the specified hardness range for the application. 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 surface to insure representative hardness readings. The 10 mm ball and 3000 kg load shall be used unless otherwise specified and agreed upon.

5. Heat treatment

- 5.1 Castings produced in accordance with this document shall be heat treated by an austempering process consisting of heating the castings to a fully austenitic condition, then holding for a time sufficient to saturate the austenite with carbon, then cooling (at a rate sufficient to avoid the formation of pearlite) to a temperature above the martensite start temperature (Ms), and isothermally transforming the matrix structure for a time sufficient to produce the desired properties. This process shall produce a microstructure that is substantially ausferrite (acicular ferrite and austenite).
 - 5.1.1 The exception to the process outlined in 5.1 is for grade AD 750. Components processed to this grade may be austenitized between the upper and lower critical temperatures prior to austempering. ADI processed to this grade will exhibit a microstructure containing some pro-eutectoid ferrite with the balance being ausferrite.
- 5.2 Appropriate heat treatment for removal of residual stresses, or to improve machinability shall be specified by agreement between the manufacturer and the purchaser.
- 5.3 Re-austempering of components or any deviation from the established heat treating process is permissible only with the expressed approval of the casting purchaser.

6. Microstructure

- 6.1 The graphite component of the microstructure shall consist of at least 85% spheroidal graphite conforming to Types I and II per ASTM A 247.
- 6.2 The cooling rate within some sections may not be sufficient to avoid the formation of pearlite or other high temperature transformation products. In such cases, the maximum acceptable quantities of these microconstituents and the location(s) within the casting may be established by agreement between the heat treater, the manufacturer and the purchaser.
- 6.3 Minor amounts of martensite may be present in the microstructure of Grades 1400 and 1600. Acceptable quantities of martensite may be established by agreement between the heat treater, the manufacturer and the purchaser.
- 6.4 The microstructure shall be substantially free of undesirable microconstituents, the details of which are agreed upon between the heat treater, the manufacturer and the purchaser.