John Deere Standard

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JDM B14
Specification for Austempered Ductile (Spheroidal Graphite) Cast Iron

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1. SCOPE

1.1 JDM B14 specifies requirements of molded ductile (spheroidal graphite) cast irons that have been heat treated by the austempering process. Property and performance requirements are those in actual castings or in test bars that are separately cast from the same iron and heat treated in the same process cycle as the castings.

1.2 JDM B14 cast iron grades are specified for applications which require higher mechanical properties and improved wear resistance compared to JDM B8 as-cast or heat treated grades. Austempered ductile iron castings are always in the fully heat treated condition.

2. DESIGNATIONS

2.1 DESIGNATION SYSTEM. JDM B14 austempered ductile cast iron (ADI) grades are designated by minimum required tensile strength. Designations of JDM B14 austempered ductile cast iron grades are shown in Table 1. Each designation is composed of a three-letter combination, followed by a hyphen and a three or four digit number. The letters "ADI" designate the grade as austempered ductile iron. The number represents the minimum tensile strength level in a test bar, expressed in MPa. JDM B14 designations correspond to specific ADI grades defined by ASTM A897M, except that JDM grades also require determination of T/H ratio and that conformance to JDM B14 specification requirements for T/H ratio, tensile strength, yield strength, and elongation is determined statistically (see Clause 3).

TABLE 1. DESIGNATIONS AND DESCRIPTIONS OF JDM B14 AUSTEMPERED DUCTILE IRON GRADES

JDM B14 Grade	Description	ASTM A897M Grade
ADI-850	Austempered ductile iron with ≥850 MPa tensile strength, ≥550 MPa yield strength, and ≥10% elongation test bar properties. Lowest strength, highest ductility, highest toughness of JDM B14 grades.	850/550/10
ADI-1050	Austempered ductile iron with ≥1050 MPa tensile strength, ≥700 MPa yield strength, and ≥7% elongation test bar properties. Strength, ductility, and toughness intermediate between ADI-850 and ADI-1200.	1050/700/7
ADI-1200	Austempered ductile iron with ≥1200 MPa tensile strength, ≥850 MPa yield strength, and ≥4% elongation test bar properties. Strength, ductility, and toughness intermediate between ADI-1050 and ADI-1400.	1200/850/4
ADI-1400	Austempered ductile iron with ≥1400 MPa tensile strength, ≥1100 MPa yield strength, and ≥1% elongation test bar properties. Highest strength, lowest ductility, lowest toughness of JDM B14 grades.	1400/1100/1

2.2 OTHER STANDARD GRADES. Prior to publication of JDM B14, ASTM A897M, and ASTM A897 (a companion specification in the inch-pound system of units), an informal designation system was used. Table 2 provides a cross reference between this informal designation system and the current designation systems in JDM B14 and ASTM A897M. JDM B14 grades may be substituted for the corresponding grades in either the former informal designation system or ASTM A897M. ASTM A897M and former informal ADI grades shall not be substituted for JDM B14 grades.

TABLE 2. CROSS REFERENCE BETWEEN JOHN DEERE AND OTHER STANDARD AUSTEMPERED DUCTILE CAST IRON GRADES

JDM B14 Grade	ASTM A897M Grades	Former Informal Grade
ADI-850	850/550/10	ADI 1
ADI-1050	1050/700/7	ADI 2
ADI-1200	1200/850/4	ADI 3
ADI-1400	1400/1100/1	ADI 4

Note to Table 2:

- JDM B14 grades may be substituted for the corresponding grades from other standards as shown. Ductile cast iron grades from other standards shall not be substituted for JDM B14 grades.

2.3 DRAWING CALLOUT. The drawing callout shall include the standard number and the material designation (grade).

Examples:
JDM B14 ADI-850
JDM B14 ADI-1050
JDM B14 ADI-1200
JDM B14 ADI-1400

3. MECHANICAL PROPERTY REQUIREMENTS

Mechanical property requirements of JDM B14 austempered ductile cast iron grades are shown in Table 3. Except for impact strength and Brinell hardness, mechanical property requirements in Table 3 are statistical limits determined by interval tolerancing methods of analysis per JDQ 83 (see Clause 7.3 and the Notes to Table 3).

TABLE 3. MECHANICAL PROPERTY REQUIREMENTS OF JDM B14 AUSTEMPERED DUCTILE CAST IRON

JDM B14 Grade	Test Bar Properties						
		Tensile Strength	Yield Strength	Elongation	Impact Strength	Brinell Hardness	
	T/H Ratio	MPa	MPa	%	J	kg/mm^2 (HB)	MPa
ADI-850	≥0.300	≥850	≥550	≥10	≥100	≥269 ≤321	≥2600 ≤3150
ADI-1050	≥0.300	≥1050	≥700	≥7	≥80	≥302 ≤363	≥3000 ≤3600
ADI-1200	≥0.300	≥1200	≥850	≥4	≥60	≥341 ≤444	≥3300 ≤4350
ADI-1400	≥0.300	≥1400	≥1100	≥1	≥35	≥387 ≤477	≥3800 ≤4700

Notes to Table 3:

- All properties are determined after austempering heat treatment of test bars heat treated in the same process cycle as the castings. See Clause 8 and Table 4 for test methods applicable to the determination of properties.
- Calculate T/H ratio as tensile strength of the test bar (in MPa) divided by Brinell hardness of the test bar (in MPa): T/H ratio = $T_{(MPa)}/H_{(MPa)}$. T/H ratio is affected by the degree of nodularity in the microstructure. T/H ratios <0.300 in as-cast ductile iron generally indicate microstructures with less than 90 percent nodularity.
- For T/H ratio, tensile strength, and yield strength: Calculate population lower limits for 99 percent of the population with 75 percent confidence (P = 0.99, C = 0.75) per JDQ 83B.
- For elongation: Calculate population lower limits for 95 percent of the population with 90 percent confidence (P = 0.95, C = 0.90) per JDQ 83B.
- Impact strength is determined by testing four unnotched charpy bars at 22 ± 4°C. Impact strength is calculated as the average of the highest three of the four test specimens All four test specimens shall be taken from the same Y-block or test casting.
- Brinell hardness ranges are typical, not a specification requirement. As described in ASTM A897M, hardness cannot be used as a gauge for other mechanical properties, except T/H ratio.
- T/H ratio shall be rounded and reported to the nearest 0.001. Tensile strength and yield strength shall be rounded and reported to the nearest 1 MPa. Elongation shall be rounded and reported to the nearest 0.1%. Impact strength shall be rounded and reported to the nearest 1 J. Brinell casting hardness shall be rounded and reported to the nearest 10 MPa or 1 kg/mm^2 (HB). Follow the rounding method of ASTM E29.

4. TEST BAR (Y-BLOCK) REQUIREMENTS

4.1 STANDARD TEST BARS. Test bar properties shall be determined only after austempering heat treatment. Test specimens shall be machined from standard 25 mm Y-blocks that have been cast in silica sand molds in conformance to ASTM A897M or technically equivalent standard and subjected to austempering heat treatment with the castings they represent. Y-block castings shall be left in the mold until they have cooled to ≤480°C. Y-blocks shall have the same chemical composition as the iron used for production castings. Test specimens shall be machined only from the 25 mm section of the Y-block.

4.2 PROPERTY REQUIREMENTS. Tensile strength, yield strength, elongation, and tensile strength to Brinell hardness ratio in the test bar shall be within the limits specified in Table 3 when tested in conformance to the test methods listed in Table 4. Test bar hardness tests required to determine the T/H ratio shall be performed in conformance to the test method listed in Table 4 and reported in MPa. The frequency of casting of Y-blocks and austempering heat treatment of test bars in production shall be sufficient to assure statistical conformance to specification requirements as indicated in the Notes to Table 3.

5. CASTING REQUIREMENTS

5.1 TENSILE AND IMPACT PROPERTIES. For castings with sufficient wall thickness, test specimens may be machined from the actual castings. Because separately cast Y-block test bars are produced from the same iron and heat treated with the castings, however, using test specimens cut from castings is seldom necessary.

5.2 BRINELL CASTING HARDNESS. In austempered structures, hardness is not a good predictor of properties in the casting. Hardness should be used only as a rough guide and is not a specification requirement.

5.3 MICROSTRUCTURE. Castings shall be free of all chill (white or mottled iron) as defined in ASTM A644. Graphite shall be essentially spheroidal with ≥90 percent nodularity.

5.4 HEAT TREATMENT. Salvage heat treatment, defined as a repetition of the complete austempering heat treatment process, is permitted only with prior approval of the purchaser. No other salvage heat treatment is permitted.

5.5 OTHER REQUIREMENTS. Unless otherwise covered in this standard or specified on the part drawing, casting quality shall conform to the requirements of JDM B15 (or to JDM B11 for parts adopted before 1 July 1994), or, if not covered by JDM B15 or JDM B11, to the requirements of ASTM A897M. Austempering may induce some heat treatment distortion. Allowable levels of distortion from the original casting dimensions shall be specified by the purchaser.

6. CHEMICAL COMPOSITION

Chemical composition requirements may be agreed upon between the supplier and purchaser, but chemical composition is not specified by JDM B14. The same principles of hardenability apply to the austempering of ductile iron as to the austempering of steel. The producer shall establish and maintain a chemical composition, including alloying elements, that will provide the necessary hardening response in the ductile iron castings and meet the specified mechanical property requirements for each JDM B14 grade produced. No matter what chemical composition is used, the requirements defined in Clauses 3 through 5 must be met.

7. QUALITY ASSURANCE

7.1 RESPONSIBILITY. The organization that accepts an order for ADI castings per JDM B14 shall coordinate all steps in the manufacturing process (including casting, heat treatment, inspection, and testing) to assure that parts and test specimens conform to the specified requirements.

7.2 DOCUMENTATION. The producing foundry and austempering heat treatment facility shall document all testing with dated records of the test results to be retained for a period of four years, and as otherwise required by local regulation. Records shall include the results of all chemical analyses, tensile and hardness tests on test bars, impact tests on test bars, and hardness tests on castings. The records and test facilities shall be available for inspection by the purchaser.

7.3 STATISTICAL ANALYSIS OF DATA. Interval tolerancing methods of statistical analysis (JDQ 83) shall be used to determine conformance of mechanical properties to the requirements shown in Table 3. The calculated limits shall be within the limits shown in Table 3 for each grade designation to conform to the requirements of this standard.

7.4 PRODUCT APPROVAL. A minimum of 20 austempered test bars obtained over a period of at least one month must be analyzed to demonstrate process capability prior to approval of a foundry or heat treatment facility and shipment of austempered ductile iron castings.

7.5 CERTIFICATION OF QUALITY. Individual Deere units may require additional measures of quality assurance, which may include official supplier quality certification. The decision to require such certification, as well as the details of any certification program, are the responsibility of the purchasing Deere unit. However, the requirements of JDM B14 shall not be lessened or negated by unit certification programs.

8. TEST METHODS

8.1 IDENTIFICATION OF TEST METHODS. Properties of JDM B14 austempered ductile cast iron shall be determined by the test methods listed in Table 4 or by technically equivalent test methods.

TABLE 4. STANDARD TEST METHODS

Property	Test Method
Tensile Strength	ISO 6892
Yield Strength	ISO 6892 using 2% offset method
Elongation	ISO 6892
Impact Strength	ASTM A327M modified per ASTM A897M
Brinell Hardness	ISO 6506 modified per JDM B14, Clause 8.2

8.2 BRINELL HARDNESS TEST. Test bar hardness shall be taken at a point representative of the tensile fracture area. Brinell hardness of test bars shall be determined using a 10 mm diameter steel ball and either a 3000 kg or a 30 kN load. The same test conditions are preferred, but not required, for determination of casting hardness.

8.3 CHEMICAL ANALYSIS. Determination of chemical composition may be performed using any recognized analytical method, including X-ray fluorescence, optical emission, and atomic absorption spectroscopy. Reference methods shall conform to appropriate ISO or ASTM standards.

9. REFERENCES

ASTM A327M	Test Methods for Impact Testing of Cast Irons [Metric]
ASTM A644	Definitions of Terms Relating to Iron Castings
ASTM A897	Specification for Austempered Ductile Iron Castings
ASTM A897M	Specification for Austempered Ductile Iron Castings [Metric]
ASTM E29	Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
ISO 6506	Metallic materials -- Hardness test -- Brinell test
ISO 6892	Metallic materials -- Tensile testing
JDM B11	General Requirements for Iron Castings
JDQ 83	Interval Tolerancing Method of Statistical Analysis