Designation: A 295/A 295M – 05

Standard Specification for High-Carbon Anti-Friction Bearing Steel[1]

This standard is issued under the fixed designation A 295/A 295M; 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-carbon bearing-quality steel to be used in the manufacture of anti-friction bearings.

1.2 Supplementary requirements of an optional nature are provided and when desired shall be so stated in the order.

1.3 The values stated in either inch-pound units or SI units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 29/A 29M Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

A 892 Guide for Defining and Rating the Microstructure of High Carbon Bearing Steels

E 45 Test Methods for Determining the Inclusion Content of Steel

E 112 Test Methods for Determining Average Grain Size

E 381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings

E 1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel and in Iron, Nickel, and Cobalt Alloys

E 1077 Test Methods for Estimating the Depth of Decarburization of Steel Specimens

2.2 *Other Document:*

ISO 683, Part 17 Ball and Roller Bearing Steels[3]

3. Ordering Information

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

3.1.1 Quantity,

3.1.2 Grade identification,

3.1.3 Specification designation and year of issue,

3.1.4 Dimensions, and

3.1.5 Supplementary requirements, if included.

4. Process

4.1 The steel shall be made by a process that is capable of providing a high quality product meeting the requirements of this specification.

5. Chemical Composition and Analysis

5.1 Typical examples of chemical compositions are shown in Table 1. Other compositions may be specified.

5.2 An analysis of each heat of steel shall be made by the steel manufacturer in accordance with Test Methods A 751. The chemical composition thus determined shall conform to the requirements specified in Table 1 for the ordered grade or to other requirements agreed upon between manufacturer and purchaser.

5.3 Product analysis may be made by the purchaser in accordance with Test Methods A 751. Permissible variations in product analysis shall be in accordance with Specification A 29/A 29M.

6. Sizes, Shapes, and Dimensional Tolerances

6.1 The physical size and shape of the material shall be agreed upon between manufacturer and purchaser.

6.2 Dimensional tolerances for hot-rolled or hot-rolled and annealed bars, in straight lengths or coils, and cold-finished bars 0.500 in. [12.5 mm] and larger in diameter furnished under this specification shall conform to the requirements specified in the latest edition of Specification A 29/A 29M.

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys, and is the direct responsibility of Subcommittee A01.28 on Bearing Steels.

Current edition approved March 1, 2005. Published April 2005. Originally approved in 1946. Last previous edition approved in 1998 as A 295 – 98.

[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 International Organization for Standardization (ISO), 1 rue de Varembé, Case postale 56, CH-1211, Geneva 20, Switzerland.

***A Summary of Changes section appears at the end of this standard.**

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TABLE 1 Composition[A,B]

Name	C	Mn	P (max)	S (max)	Si	Cr	Ni (max)	Mo	Cu (max)	O (max)[C]	Al (max)[D]
52100[E]	0.93-1.05	0.25-0.45	0.025	0.015	0.15-0.35	1.35-1.60	0.25	0.10 (max)	0.30	0.0015	0.050
5195	0.90-1.03	0.75-1.00	0.025	0.015	0.15-0.35	0.70-0.90	0.25	0.10 (max)	0.30	0.0015	0.050
5090M	0.89-1.01	0.50-0.80	0.025	0.015	0.15-0.35	0.40-0.60	0.25	0.08-0.15	0.30	0.0015	0.050
1070M	0.65-0.75	0.80-1.10	0.025	0.015	0.15-0.35	0.20 (max)	0.25	0.10 (max)	0.30	0.0015	0.050
5160	0.56-0.64	0.75-1.00	0.025	0.015	0.15-0.35	0.70-0.90	0.25	0.10 (max)	0.30	0.0015	0.050

[A] Elements not quoted shall not be intentionally added to the steel without the agreement of the purchaser.
[B] Intentional additions of calcium or calcium alloys for deoxidation or inclusion shape control are not permitted unless specifically approved by the purchaser.
[C] Oxygen content applies to product analysis and shall be determined in accordance with Test Method E 1019.
[D] Total aluminum content.
[E] Specified element ranges meet the requirements of ISO 683, Part 17, Table 3, NO. B1, 100CR6.

6.3 Dimensional tolerances for cold-finished coils for ball and roller material shall be as shown in Table 2.

6.4 Coil tolerances also apply to cold-finished straight lengths under 0.500 in. [12.5 mm] in diameter.

7. Quality Tests

7.1 The supplier shall be held responsible for the quality of the material furnished and shall make the necessary tests to ensure this quality. The supplier shall be required to report results of the macroetch and micro-inclusion rating tests detailed below. Quality tests shown in 7.2-7.4 are based upon procedures established in Test Methods E 45.

7.2 *Sampling*—Samples taken in accordance with the following paragraphs shall be obtained from 4 by 4 in. [100 by 100 mm] rolled billets or forged sections. Tests may be made on smaller or larger sections by agreement between manufacturer and purchaser. A minimum 3 to 1 reduction of rolled billets or forged sections is required for strand cast products.

7.2.1 For top poured products, a minimum of six samples representing the top and bottom of the first, middle, and last usable ingots shall be examined.

7.2.2 For bottom poured products, a minimum of six samples shall be examined and they shall represent the top and bottom of three ingots. One ingot shall be taken at random from the first usable plate poured, one ingot, at random, from the usable plate poured nearest to the middle of the heat, and one ingot, at random, from the last usable plate poured. When two usable plates constitute a heat, two of the sample ingots shall be selected from the second usable plate poured. Where a single usable plate constitutes a heat, any three random ingots may be selected. Other methods of sampling shall be as agreed upon between manufacturer and purchaser.

7.2.3 For strand cast products, a minimum of six samples representing the first, middle, and last portion of the heat cast shall be examined. At least one sample shall be taken from each strand.

7.3 *Macroetch*—Specimens representative of cross sections of billets shall be macroetched and rated in accordance with Method E 381 in hydrochloric acid and water (1:1) at 160 to 180°F [70 to 80°C]. Such specimens shall not exceed S2, R2, and C2 of Method E 381.

TABLE 2 Dimensional Tolerances for Cold-Finished Coils

Size, in. [mm]	Total Tolerance, in. [mm]
Through 0.096 [2.50]	0.002 [0.05]
Over 0.096 [2.50] to 0.270 [7.00], incl	0.003 [0.08]
Over 0.270 [7.00] to 0.750 [19.0], incl	0.004 [0.10]

7.4 *Inclusion Rating*—The specimens shall be ⅜ by ¾ in. [10 by 20 mm] and shall be taken from an area halfway between the center and outside of the billet. The polished face shall be longitudinal to the direction of rolling. The scale used for rating the specimens shall be the Jernkontoret chart described in Test Methods E 45, Plate I-r. Fields with sizes or numbers of all types of inclusions intermediate between configurations shown on the chart shall be classified as the lesser of the rating number. The worst field of each inclusion type from each specimen shall be recorded as the rating for the specimen. Two thirds of all specimens and at least one from each ingot tested, or from the first, middle, and last portion of the strands tested, as well as the average of all specimens, shall not exceed the rating specified in Table 3. If specifically ordered and certified to Supplementary Requirement S4, Type A inclusion ratings shall not exceed 3.0 thin and 2.0 heavy. See S4.1.

8. Grain Size

8.1 The steels covered by this specification shall have the capability of showing a fine fracture grain size (approximately ASTM No. 8 in accordance with Test Methods E 112) when quenched from normal austenitizing temperatures not exceeding 1550°F [840°C].

9. Decarburization and Surface Imperfections

9.1 Decarburization and surface imperfections shall not exceed the limits specified in Tables 4 and 5. Decarburization shall be measured using the microscopical methods described in Test Method E 1077.

10. Microstructure

10.1 When annealing is specified in the order, the structure shall be rated and reported in accordance with Guide A 892 as follows:

10.1.1 *Carbide Size (CS)*—As the appropriate carbide size is dependent on application, the limits shall be as agreed upon between manufacturer and purchaser.

TABLE 3 Inclusion Rating

Rating Units	
Thin Series	Heavy Series
A—2½	A—1½
B—2	B—1
C—½	C—½
D—1	D—1

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TABLE 4 Decarburization and Surface Imperfections for Coils and Bars for Balls and Rollers

Size, in. [mm]	Decarburization or Surface Imperfections per Side, max, in. [mm]	
	Hot-Rolled or Hot-Rolled Annealed	Cold-Finished Annealed
Through 0.250 [6.50]	0.005 [0.13]	0.003 [0.08]
Over 0.250 [6.50] to 0.500 [12.5], incl	0.006 [0.15]	0.004 [0.10]
Over 0.500 [12.5] to 0.750 [19.0], incl	0.008 [0.20]	0.006 [0.15]
Over 0.750 [19.0] to 1.000 [25.0], incl	0.010 [0.25]	0.008 [0.20]

TABLE 5 Decarburization and Surface Imperfections for Bars and Tubes

Size, in. [mm]	Decarburization or Surface Imperfections per Side, max, in. [mm]				
	Hot-Rolled Bars	Hot-Rolled Annealed		Cold-Finished Annealed	
		Bars	Tubes	Bars	Tubes
Through 1.000 [25.0]	0.012 [0.30]	0.015 [0.38]	0.012 [0.30]	0.012 [0.30]	0.010 [0.25]
Over 1.000 [25.0] to 2.000 [50.0], incl	0.017 [0.43]	0.022 [0.56]	0.020 [0.51]	0.015 [0.38]	0.014 [0.36]
Over 2.000 [50.0] to 3.000 [75.0], incl	0.025 [0.64]	0.030 [0.76]	0.030 [0.76]	0.025 [0.64]	0.019 [0.48]
Over 3.000 [75.0] to 4.000 [100.0], incl	0.035 [0.89]	0.045 [1.14]	0.035 [0.89]		0.024 [0.61]
Over 4.000 [100.0] to 5.000 [125.0], incl	0.055 [1.40]	0.065 [1.65]	0.040 [1.02]		0.028 [0.71]

10.1.2 *Carbide Network (CN)*—As the network is influenced by section size, the limits shall be as agreed upon between manufacturer and purchaser.

10.1.3 *Lamellar Content (LC)*—52100 steels shall have a lamellar content not to exceed LC1. Lamellar content of other compositions shall be as agreed upon between manufacturer and purchaser.

10.2 The material shall be free from excessive carbide segregation.

11. Hardness

11.1 When annealing is specified in the order, the steel shall have a completely spheroidized microstructure and a hardness as specified in Table 6.

TABLE 6 Maximum Hardness for Annealed Material

Product	Condition	Maximum Hardness	
		Brinell	Rockwell B
Coils	hot-rolled, annealed	. . .	92
Bars and tubes	hot-rolled annealed	207	. . .
Coils	annealed, cold-drawn (stress-relieved)	. . .	92
Coils, bars, and tubes	annealed, cold-drawn[A]	248	. . .
Tubes	annealed, cold-rocked	331	. . .

[A] Cold-swaged material is not included.

11.2 Small sizes where Rockwell B scale hardness readings are impractical shall have a maximum tensile strength of 110 000 psi (760 MPa).

11.3 Hardness and tensile tests shall be in accordance with test methods described in Test Methods A 370.

12. Inspection

12.1 The manufacturer shall afford the purchaser's inspector all reasonable facilities necessary to satisfy him that the material is being produced and furnished in accordance with this specification. Mill inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operations. All tests and inspections shall be made at the place of manufacture, unless otherwise agreed to.

13. Certification and Reports

13.1 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment. Special requirements agreed to at the time of purchase shall be noted on the certification.

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SUPPLEMENTARY REQUIREMENTS

One or more of the supplementary requirements described below apply when included in the purchaser's order or contract. When so included, a supplementary requirement shall have the same force as if it were in the body of the specification. Supplementary requirements' details not fully described shall be agreed upon between the purchaser and the supplier, but shall not negate any of the requirements in the body of the specification.

S1. Titanium Content

S1.1 The purchaser may specify that the analysis of titanium be provided by agreement with the steel manufacturer.

S2. "SAM" Inclusion Rating System

S2.1 The purchaser may specify that the "SAM" inclusion rating system described in Method E of Test Methods E 45 be used in addition to the micro-inclusion rating system described in 7.4.

S2.2 *Sampling*—See 7.2.

S2.3 *Limits*—The "SAM" rating for B-type inclusions shall not exceed fifteen. The "SAM" rating for D-type inclusions shall not exceed ten.

S3. Magnetic Particle Method

S3.1 The purchaser may specify that the magnetic particle method described below be used in addition to the micro-inclusion rating system described in 7.4. The magnetic particle method measures bearing steel cleanliness by evaluating the total length of macro-inclusions for a stated area or per unit area. Results are expressed in millimeters per square metre.

S3.2 *Sampling*—See 7.2.

S3.3 Test specimens shall be straight cylinder quarter section samples prepared and examined in accordance with the magnetic particle method of Test Methods E 45.

S3.4 For purposes of calculation, an inclusion length shall be taken as the mean length of the length bracket into which it falls; that is, an inclusion in the 1.6 to 3.2 mm bracket shall be taken as being 2.4 mm in length. The sum of all lengths for each specimen shall be determined and expressed as total length per area inspected. The average total length per area inspected of all six specimens shall not exceed 200 mm/m^2.

S4. Sulfur Requirement for Machinability

S4.1 A sulfur content in the range of 0.015–0.030 % may be specified for improved machinability.

S4.2 When this supplementary requirement is specified, the sulfide (Type A) ratings of 7.4 shall be 3.0 thin and 2.0 heavy.

S4.3 The manufacturer's certification shall state that material was produced to this supplementary requirement when applicable.

S5. Sample Reduction Ratio

S5.1 For the sampling described in 7.2, the purchaser may specify that the reduction ratio from as-cast section to test section be provided.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A 295 - 98) that may impact the use of this standard (Approved March 1, 2005).

(*1*) SI units are to be regarded separately as standard (1.3).
(*2*) SI units throughout the specification have been rationalized.
(*3*) The titles of Test Methods E 45, E 381, and E 1019 have been updated.
(*4*) Test Methods E 112 has replaced SAE J418a for determining grain size (2.1 and 8.1).
(*5*) Table 1 has been reformatted, and the composition name "UNS K19526" has been replaced by "5090M."

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