



# Standard Specification for Medium Carbon Anti-Friction Bearing Steel<sup>1</sup>

This standard is issued under the fixed designation A866; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This specification covers medium 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 inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

**A29/A29M** Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought

**A751** Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

**E45** Test Methods for Determining the Inclusion Content of Steel

**E112** Test Methods for Determining Average Grain Size

**E381** Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings

**E1019** Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques

**E1077** Test Methods for Estimating the Depth of Decarburization of Steel Specimens

### 2.2 ISO Standard:<sup>3</sup>

**ISO 683 Part 17: Ball and Roller Bearing Steels**

## 3. Ordering Information

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

<sup>1</sup> 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.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, <http://www.iso.org>.

3.1.1 Quantity (weight or pieces),

3.1.2 Grade identification,

3.1.3 ASTM designation and year of issue,

3.1.4 Dimensions, and

3.1.5 Supplementary requirements, if included.

## 4. Materials and Manufacture

### 4.1 Process:

4.1.1 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 composition 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, Practices, and Terminology **A751**. 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 the manufacturer and the purchaser.

5.3 Product analysis may be made by the purchaser in accordance with Test Methods, Practices, and Terminology **A751**. Permissible variations in product analysis shall be in accordance with Specification **A29/A29M**.

## 6. Sizes, Shapes, and Dimensional Tolerances

6.1 The physical size and shape of the material shall be agreed upon between the manufacturer and the 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. (12.7 mm) and larger in diameter furnished under this specification shall conform to the requirements specified in the latest edition of Specification **A29/A29M**.

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. 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

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

**TABLE 1 Chemical Composition<sup>A,B</sup>**

Number <sup>C</sup>	Name	C	Mn	P (max)	S (max)	Si	Cr	Mo	V	Cu (max)	O (max) <sup>D</sup>	Al (max)
...	1030	0.28 to 0.34	0.60 to 0.90	0.025	0.025	0.15 to 0.35	...	...	...	0.30	0.0020	0.050
...	1040	0.37 to 0.44	0.60 to 0.90	0.025	0.025	0.15 to 0.35	...	...	...	0.30	0.0020	0.050
...	1050	0.48 to 0.55	0.60 to 0.90	0.025	0.025	0.15 to 0.35	...	...	...	0.30	0.0020	0.050
...	1541	0.36 to 0.44	1.35 to 1.65	0.025	0.025	0.15 to 0.35	...	...	...	0.30	0.0020	0.050
...	1552	0.47 to 0.55	1.20 to 1.50	0.025	0.025	0.15 to 0.35	...	...	...	0.30	0.0020	0.050
...	4130	0.28 to 0.33	0.40 to 0.60	0.025	0.025	0.15 to 0.35	0.80 to 1.10	0.15 to 0.25	...	0.30	0.0020	0.050
...	4140	0.38 to 0.43	0.75 to 1.00	0.025	0.025	0.15 to 0.35	0.80 to 1.10	0.15 to 0.25	...	0.30	0.0020	0.050
...	4150	0.48 to 0.53	0.75 to 1.00	0.025	0.025	0.15 to 0.35	0.80 to 1.10	0.15 to 0.25	...	0.30	0.0020	0.050
...	5140	0.38 to 0.43	0.70 to 0.95	0.025	0.025	0.15 to 0.35	0.70 to 0.90	...	...	0.30	0.0020	0.050
...	5150	0.48 to 0.53	0.70 to 0.90	0.025	0.025	0.15 to 0.35	0.70 to 0.90	...	...	0.30	0.0020	0.050
...	6150	0.48 to 0.53	0.70 to 0.90	0.025	0.025	0.15 to 0.35	0.80 to 1.10	...	0.15 min	0.30	0.0020	0.050
B40	C56E2	0.52 to 0.60	0.60 to 0.90	0.025	0.015	0.40 max	...	...	...	0.30	0.0020	0.050
B41	56Mn4	0.52 to 0.60	0.90 to 1.20	0.025	0.015	0.40 max	...	...	...	0.30	0.0020	0.050
B43	43CrMo4	0.40 to 0.46	0.60 to 0.90	0.025	0.015	0.40 max	0.90 to 1.20	0.15 to 0.30	...	0.30	0.0020	0.050

<sup>A</sup> Elements not quoted shall not be intentionally added to the steel without the agreement of the purchaser.

<sup>B</sup> Intentional additions of calcium or calcium alloys for deoxidation or inclusion shape control are not permitted unless specifically approved by the purchaser.

<sup>C</sup> Steels B40, B41, and B43 meet the requirements of ISO 683, Part 17, Second Edition, Table 3.

<sup>D</sup> Oxygen content applies to product analysis and shall be determined in accordance with Test Methods E1019.

**TABLE 2 Dimensional Tolerances for Cold-Finished Coils**

Size, in. (mm)	Total Tolerance, in. (mm)
Through 0.096 (2.44)	0.002 (0.05)
Over 0.096 (2.44) to 0.270 (6.86), incl	0.003 (0.08)
Over 0.270 (6.86) to 0.750 (19.1), incl	0.004 (0.10)

ensure this quality. The supplier shall be required to report on the results of the micro-inclusion rating tests detailed below. Quality tests shown in 7.2 through 7.3 are based upon procedures established in Test Methods E45.

**7.2 Sampling**—Samples taken in accordance with the following paragraphs shall be obtained from 4 by 4 in. (102 by 102 mm) rolled billets or forged sections. Tests may be made on smaller or larger sections by agreement with the 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 by 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 Inclusion Rating**—The specimens shall be 3/8 by 3/4 in. (9.5 by 19.1 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 E45, Plate I-A. 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.

## 8. Grain Size

**8.1** The grain size shall be from 5 to 8 as defined in Test Methods E112 (see Plate 4, Austenitic Grain Size in Steels), with occasional grains as large as No. 3 permissible. Material not meeting this requirement may be normalized at 1700°F (925°C) or above, and retested.

## 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 Methods E1077.

## 10. Microstructure and Hardness

**10.1** Material may be ordered as hot rolled or thermally treated. When thermally treated, the acceptance criteria for microstructure and hardness shall be agreed upon between the manufacturer and the purchaser. No hardness limits shall apply for as-hot-rolled materials.

## 11. Inspection

**11.1** The manufacturer shall afford the purchaser's inspector all reasonable facilities necessary to satisfy him that the

**TABLE 3 Inclusion Rating**

Rating Units		
Thin Series		Heavy Series
A	2.5	A 1.5
B	2.0	B 1.0
C	0.5	C 0.5
D	1.0	D 1.0

**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 (6.35)	0.005 (0.13)	0.003 (0.08)
Over 0.250 (6.35) to 0.500 (12.7), incl	0.006 (0.15)	0.004 (0.10)
Over 0.500 (12.7) to 0.750 (19.1), incl	0.008 (0.20)	0.006 (0.15)
Over 0.750 (19.1) to 1.000 (25.4), 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 (25.4)	0.012 (0.31)	0.015 (0.38)	0.012 (0.31)	0.012 (0.31)	0.010 (0.21)
Over 1.000 (25.4) to 2.000 (50.8), incl	0.017 (0.43)	0.022 (0.56)	0.020 (0.51)	0.015 (0.38)	0.014 (0.36)
Over 2.000 (50.8) to 3.000 (76.2), incl	0.025 (0.64)	0.030 (0.76)	0.030 (0.76)	0.025 (0.64)	0.019 (0.48)
Over 3.000 (76.2) to 4.000 (101.6), incl	0.035 (0.89)	0.045 (1.14)	0.035 (0.89)		0.024 (0.61)
Over 4.000 (101.6) to 5.000 (127.0), incl	0.055 (1.40)	0.065 (1.65)	0.040 (1.02)		0.028 (0.71)

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.

tured 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 must be noted on the certification.

## 12. Certification and Reports

12.1 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufac-

## 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. Residual Elements

S2.1 The purchaser may specify that the analysis of titanium, aluminum, and/or oxygen (Test Methods **E1019**) be provided by agreement with the steel manufacturer. The number and location of samples shall be by agreement between the purchaser and the manufacturer.

### S3. "SAM" Inclusion Rating System

S3.1 The purchaser may specify that the "SAM" inclusion rating described in Method E of Test Methods **E45**, be used in addition to the micro-inclusion rating method described in **7.3**.

S3.2 *Sampling*—See **7.2**.

S3.3 *Limits*—The "SAM" rating for B-type inclusions shall not exceed fifteen. The "SAM" rating for D-type inclusions shall not exceed ten.

### S4. Magnetic Particle Method

S4.1 The purchaser may specify that the magnetic particle method described below be used in addition to the microinclusion rating system described in **7.3**. 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 commonly expressed in mm/m<sup>2</sup>.

S4.2 *Sampling*—See **7.2**.

S4.3 Test specimens shall be straight cylinder quarter section samples prepared and examined in accordance with the magnetic particle method of Test Methods **E45**.

S4.4 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 1/16 to 1/8 in. bracket shall be taken as being 3/32 in. 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<sup>2</sup> (or equivalent).

## **S5. Sulfur Requirement for Machinability**

S5.1 The sulfur content shall be 0.015–0.030 %.

S5.2 The sulfide (Type A) rating units in **Table 2** shall be 3.0 thin and 2.0 heavy.

S5.3 The manufacturer's certification shall state that material was produced to this supplementary requirement when applicable.

## **S6. Sample Reduction Ratio**

S6.1 For the sampling described in **7.2**, the purchaser may specify that the reduction ratio from as-cast section to test section be provided.

## **S7. Macroetch Testing**

S7.1 *Sampling*—See **7.2**.

S7.2 Specimens representative of the full cross section of bars, billets, or blooms shall be macroetched and rated in accordance with Method **E381** in hydrochloric acid and water (1:1) at a temperature of 160 to 180°F (71 to 82°C). Such specimens shall not exceed S2, R2, C2 of Method **E381**. Indications due to sulfur segregation (commonly referred to as Type A segregates) are not to be included in the rating. For ingot cast material only, if the size and weight of the bars, billets, or blooms prevent the full cross section from being macroetched, an oversize quarter-section may be used as an alternative. The quarter-section must meet the reduction requirement of **7.2** and contain both the surface and center of the original cross section before reduction.

## **SUMMARY OF CHANGES**

Committee A01 has identified the location of selected changes to this standard since the last issue (A866 – 09) that may impact the use of this standard. (Approved Oct. 1, 2014.)

(1) Section **7.3** Inclusion Rating. Test Method E45, Method A, now refers to Plate I-A for rating the inclusions. The previous edition of E45 referenced plate I-r.

(2) S7 Macroetch Testing. Added sampling requirements. Defined specimen to include full cross section of steel. For ingot

cast material, added oversize quarter-section as an alternative. Excluded sulfur segregation from the rating.

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