Designation: A 534 – 04

Standard Specification for Carburizing Steels for Anti-Friction Bearings[1]

This standard is issued under the fixed designation A 534; 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 the requirements for carburizing 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 the standard.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

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

A 255 Test Methods for Determining Hardenability of Steel

A 304 Specification for Carbon and Alloy Steel Bars Subject to End-Quench Hardenability Requirements

A 510 Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel

A 519 Specification for Seamless Carbon and Alloy Steel Mechanical Tubing

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

A 752 Specification for General Requirements for Wire Rods and Coarse Round Wire, Alloy Steel

E 45 Test Methods for Determining the Inclusion Content of Steel

E 112 Test Methods for Determining the 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, Oxygen, and Hydrogen in Steel and in Iron, Nickel, and Cobalt Alloys

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

2.2 *ISO Standard:*

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:

3.1.1 Quantity,

3.1.2 Alloy grade identification,

3.1.3 Specification designation and year of issue,

3.1.4 Dimensions, shape, and

3.1.5 Supplementary requirements.

4. Materials and Manufacture

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, Practices, and Terminology 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, Practices, and Terminology.

6. Dimensions, Mass, and Permissible Variations

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

6.2 Dimensional tolerances shall conform to the requirements specified in Specifications A 29/A 29M, A 510, A 519, or A 752 as appropriate for the material or as agreed between manufacturer and purchaser.

[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.

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[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.

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TABLE 1 Chemical Composition[A,B]

Number[C]	Name	C	Mn	P (max)	S (max)	Si	Cr	Ni	Mo	Cu (max)	O (max)[D]	Al (max)
. . .	4118H	0.17 - 0.23	0.60 - 1.00	0.025	0.015	0.15 - 0.35	0.30 - 0.70	. . .	0.08 - 0.15	0.30	0.0020	0.050
. . .	4320H	0.17 - 0.23	0.40 - 0.70	0.025	0.015	0.15 - 0.35	0.35 - 0.65	1.55 - 2.00	0.20 - 0.30	0.30	0.0020	0.050
. . .	4620H	0.17 - 0.23	0.35 - 0.75	0.025	0.015	0.15 - 0.35	. . .	1.55 - 2.00	0.20 - 0.30	0.30	0.0020	0.050
. . .	4720H	0.17 - 0.23	0.45 - 0.75	0.025	0.015	0.15 - 0.35	0.30 - 0.60	0.85 - 1.25	0.15 - 0.25	0.30	0.0020	0.050
. . .	4817H	0.14 - 0.20	0.30 - 0.70	0.025	0.015	0.15 - 0.35	. . .	3.20 - 3.80	0.20 - 0.30	0.30	0.0020	0.050
. . .	4820H	0.17 - 0.23	0.40 - 0.80	0.025	0.015	0.15 - 0.35	. . .	3.20 - 3.20	0.20 - 0.30	0.30	0.0020	0.050
. . .	5120H	0.17 - 0.23	0.60 - 1.00	0.025	0.015	0.15 - 0.35	0.60 - 1.00	. . .	. . .	0.30	0.0020	0.050
. . .	8617H	0.14 - 0.20	0.60 - 0.95	0.025	0.015	0.15 - 0.35	0.35 - 0.65	0.35 - 0.75	0.15 - 0.25	0.30	0.0020	0.050
. . .	8620H	0.17 - 0.23	0.60 - 0.95	0.025	0.015	0.15 - 0.35	0.35 - 0.65	0.35 - 0.75	0.15 - 0.25	0.30	0.0020	0.050
. . .	9310H	0.07 - 0.13	0.40 - 0.70	0.025	0.015	0.15 - 0.35	1.00 - 1.45	2.95 - 3.55	0.08 - 0.15	0.30	0.0020	0.050
B20	20Cr3	0.17 - 0.23	0.60 - 1.00	0.025	0.015	0.40 max	0.60 - 1.00	. . .	. . .	0.30	0.0020	0.050
B21	20Cr4	0.17 - 0.23	0.60 - 0.90	0.025	0.015	0.40 max	0.90 - 1.20	. . .	. . .	0.30	0.0020	0.050
B22	20MnCr4-2	0.17 - 0.23	0.65 - 1.10	0.025	0.015	0.40 max	0.40 - 0.75	. . .	. . .	0.30	0.0020	0.050
B23	17MnCr5	0.14 - 0.19	1.00 - 1.30	0.025	0.015	0.40 max	0.80 - 1.10	. . .	. . .	0.30	0.0020	0.050
B24	19MnCr5	0.17 - 0.22	1.10 - 1.40	0.025	0.015	0.40 max	1.00 - 1.30	. . .	. . .	0.30	0.0020	0.050
B25	15CrMo4	0.12 - 0.18	0.60 - 0.90	0.025	0.015	0.40 max	0.90 - 1.20	. . .	0.15 - 0.25	0.30	0.0020	0.050
B26	20CrMo4	0.17 - 0.23	0.60 - 0.90	0.025	0.015	0.40 max	0.90 - 1.20	. . .	0.15 - 0.25	0.30	0.0020	0.050
B27	20MnCrMo4-2	0.17 - 0.23	0.65 - 1.10	0.025	0.015	0.40 max	0.40 - 0.75	. . .	0.10 - 0.20	0.30	0.0020	0.050
B28	20NiCrMo2	0.17 - 0.23	0.60 - 0.95	0.025	0.015	0.40 max	0.35 - 0.65	0.40 - 0.70	0.15 - 0.25	0.30	0.0020	0.050
B29	20NiCrMo7	0.17 - 0.23	0.40 - 0.70	0.025	0.015	0.40 max	0.35 - 0.65	1.60 - 2.00	0.20 - 0.30	0.30	0.0020	0.050
B30	18CrNiMo7-6	0.15 - 0.21	0.50 - 0.90	0.025	0.015	0.40 max	1.50 - 1.80	1.40 - 1.70	0.25 - 0.35	0.30	0.0020	0.050
B31	18NiCrMo14-6	0.15 - 0.20	0.40 - 0.70	0.025	0.015	0.40 max	1.30 - 1.60	3.25 - 3.75	0.15 - 0.25	0.30	0.0020	0.050
B32	16NiCrMo16-5	0.14 - 0.18	0.25 - 0.55	0.025	0.015	0.40 max	1.00 - 1.40	3.80 - 4.30	0.20 - 0.30	0.30	0.0020	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] Steels B20 through B32 meet the requirements of ISO 683, Part 17, Second Edition, Table 3.
[D] Oxygen content applies to product analysis and shall be determined in accordance with Test Methods E 1019.

6.3 The dimensional tolerances for the forgings shall conform to the requirements of the engineering drawing.

7. Quality Assurance

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 on the results of the macroetch and micro-inclusion rating tests detailed below. Quality tests shown in 7.2 through 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. (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 usable portion of the heat cast shall be examined. At least one sample shall be taken from each strand.

7.3 Macroetch specimens or forged sections representative of cross sections of billets shall be macroetched and rated in accordance with Method E 381 in hydrochloric acid and water (at a ratio of 1 to 1) at 160 to 180°F (71 to 82°C). Such specimens shall not exceed S2, R2, and C2 of Method E 381.

7.4 *Inclusion Rating*—The polished face of the specimens shall be ⅜ by ¾ in. (9.5 by 19.1 mm) and shall be taken from an area halfway between the center and outside of the billet or forged sections. 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, Method A, 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 2.

8. Grain Size

8.1 The grain size shall be six or finer as defined in Test Methods E 112 (see Plate 4, austenitic grain size in steels). Material not meeting this requirement may be normalized at 1700°F (927°C) or above and retested.

TABLE 2 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 3 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
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 4 Decarburization and Surface Imperfections for Bars and Tubes

Size, in. (mm)	Decarburization and Surface Imperfections per side, max, in. (mm)				
	Hot-Rolled Bars	Annealed		Cold-Finished	
		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)

9. Hardenability

9.1 Each heat shall be tested for hardenability in accordance with Test Methods A 255. The "J" values for hardenability shall conform to limits specified in Specification A 304 or as agreed upon by manufacturer and purchaser.

10. Decarburization and Surface Imperfections

10.1 Decarburization and surface imperfections shall not exceed the limits specified in Tables 3 and 4. Decarburization shall be measured using the microscopical methods described in Test Methods E 1077.

11. Inspection

11.1 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 upon.

12. Certification and Reports

12.1 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 must be noted on the certification.

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, be provided by agreement with the steel manufacturer. The number and location of samples shall be by agreement between the purchaser and manufacturer.

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S3. "SAM" Inclusion Rating System

S3.1 The purchaser may specify that the "SAM" inclusion rating method described in Test Methods E 45, Method E, be used in addition to the micro-inclusion rating method described in 7.4.

S3.2 *Sampling*—See 7.2.

S3.3 *Limits*—The "SAM" rating for B-type inclusions shall not exceed 15. The "SAM" rating for D-type inclusions shall not exceed 10.

S4. Magnetic Particle Method

S4.1 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 commonly expressed in mm/m^2.

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 E 45.

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 be agreed upon between manufacturer and purchaser.

S5. Banding

S5.1 *Hardness Method*—The samples used may be the same as those used in 7.2. The sample shall be hardened and in the as-quenched condition. Micro-hardness measurements are to be taken using loads of 200 g or higher. After conversion to Rockwell "C" values, the hardness in the banded area shall not vary by more than five RC points.

S6. Microstructure

S6.1 A suitable microstructure may be specified by agreement between manufacturer and purchaser.

S7. Calculated Hardenability

S7.1 A calculated hardenability shall be used in lieu of the requirements in Section 9. The method used shall be agreed upon between the purchaser and the steel supplier at the time of inquiry and order.

S8. Sulfur Requirement for Machinability

S8.1 The sulfur content shall be 0.015–0.030 %.

S8.2 The sulfide (Type A) rating units in Table 2 shall be 3.0 thin and 2.0 heavy.

S8.3 The manufacturer's certification shall state that material was produced to this supplementary requirement when applicable.

S9. Sample Reduction Ratio

S9.1 For the sampling described in 7.2, the purchaser may specify that the reduction ratio from as-cast section to test section be provided.

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