



Designation: F 2215 – 02

Standard Specification for Balls, Bearings, Ferrous and Non-Ferrous for Use in Bearings, Valves, and Bearing Applications¹

This standard is issued under the fixed designation F 2215; 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.

1. Scope

1.1 This specification covers requirements for ferrous and nonferrous inch balls. The balls covered in this specification are intended for use in bearings, bearing applications, check valves, and other components using balls.

1.2 This is a general specification. The individual item requirements shall be as specified herein in accordance with the applicable MS sheet standards as listed in 2.7. In the event of any conflict between requirements of this specification and the MS sheet standards, the latter shall govern.

1.3 The values given in inch-pound units are to be regarded as standard. The values given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- A 108 Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality²
- A 276 Specification for Stainless Steel Bars and Shapes³
- A 295 Specification for High-Carbon Anti-Friction Bearing Steel²
- B 276 Test Method for Apparent Porosity in Cemented Carbides⁴
- D 3951 Practice for Commercial Packaging⁵
- E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials⁶
- E 112 Test Methods for Determining the Average Grain Size⁶

2.2 SAE Standards:⁷

- AMS 6440 Specification for Steel Bars, Forgings and Tubing 1.45Cr (0.98-1.10C) (SAE 52100) for Bearing Applications
- AMS 6449 Specification for Steel Bars, Forgings and Tubing 1.02Cr (0.98-1.10C) SAE 51100) for Bearing Applications
- AMS 6491 Specification for Steel Bars, Forgings and Tubing 4.1Cr-4.2Mo-1.0V (0.80-0.85C) Premium Aircraft-Quality for Bearing Applications, Double Vacuum Melted SAE CDA464

2.3 Federal Standards:⁸

- FED-STD-151 Metals, Test Methods
- QQ-B-637 Specification for Brass, Naval: Rod, Wire, Shapes, Forgings, and Flat Products with Finished Edges (Bar, Flat Wire, and Strip)
- QQ-N-286 Specification for Nickel-Copper-Aluminum Alloy, Wrought

2.4 Military Standards:⁸

- MIL-B-197 Specification for Bearings, Anti-Friction; Associated Parts and Subassemblies; Preparation for and Delivery of
- MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes
- MIL-STD-129 Marking for Shipment and Storage
- MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification
- MIL-STD-1459 Macrograph Standards for Steel Bars, Billets, and Blooms for Ammunition Components

2.5 AFBMA Standard:⁹

- AFBMA-STD-10 Metal Balls

2.6 ANSI Standard:¹⁰

- B46.1 Surface Texture (Surface Roughness, Waviness and Lay)

¹ This specification is under the jurisdiction of ASTM Committee F34 on Rolling Element Bearings and is the direct responsibility of Subcommittee F34.01 on Rolling Element.

Current edition approved Oct. 10, 2002. Published December 2002.

² *Annual Book of ASTM Standards*, Vol 01.05.

³ *Annual Book of ASTM Standards*, Vol 01.03.

⁴ *Annual Book of ASTM Standards*, Vol 02.05.

⁵ *Annual Book of ASTM Standards*, Vol 15.09.

⁶ *Annual Book of ASTM Standards*, Vol 03.01.

⁷ Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

⁸ Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

⁹ Available from the Anti-Friction Bearing Manufacturers' Association, Inc., 1101 Connecticut Ave., N.W., Suite 700, Washington, DC 20036.

¹⁰ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

2.7 MS Sheet Standards:⁸

- MS3224 Balls, Bearings, Aircraft Quality Steel
- MS3226 Balls, Bearing, Grade 10, Aircraft-Quality Steel
- MS19059 Balls, Bearing, Chrome Alloy Steel
- MS19060 Balls, Bearing, Corrosion Resistant Steel
- MS19061 Balls, Bearing, Carbon Steel
- MS19062 Balls, Bearing, Non-Ferrous Brass
- MS19063 Balls, Bearing, Bronze
- MS19064 Balls, Bearing, Nickel-Copper Alloy (K-Montel)

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

- 3.1.1 *ball gage deviation, n*—the difference between the lot mean diameter and the sum of the nominal diameter and the ball gage.
- 3.1.2 *basic diameter, n*—the diameter size of the balls, in inches.
- 3.1.3 *basic diameter tolerance, n*—the maximum allowable deviation from the specified basic diameter for the indicated grade.
- 3.1.4 *case depth, n*—the thickness, measured radially from the surface of the hardened case to a point where carbon content or hardness becomes the same as the ball core.
- 3.1.5 *deviation from spherical form, n*—the greatest radial distance in any radial plane between a sphere circumscribed around the ball surface and any point on the ball surface.
- 3.1.6 *grade designation, n*—indicates the allowable out-of-roundness expressed in millionths of an inch.
- 3.1.7 *lot, n*—balls from a single production run of balls that are offered for delivery at one time that are of the same dimensions, made from metal material of the same type and composition, formed and fabricated under the same manufacturing processes.
- 3.1.8 *marking increments, n*—the standard unit steps to express the specific diameter.
- 3.1.9 *nominal size, n*—the basic diameter, in inches, that is used for the purpose of general identification (for example, 1/16, 1/8).
- 3.1.10 *out-of-roundness, n*—the difference between the largest diameter and the smallest diameter measured on the same ball.
- 3.1.11 *passivation, n*—a treatment for corrosion-resistant steel to eliminate corrodible surface impurities and provide a protective film.
- 3.1.12 *specific diameter, n*—the diameter marked on the unit container and expressed in the grade standard marking increment nearest to the average diameter of the balls in that container.
- 3.1.13 *unit container, n*—a container identified as containing balls from the same manufacturing lot of the same composition, grade and basic diameter, and within the allowable diameter variation per unit container for the specified grade.

3.2 *Acronym:*

- 3.2.1 *VIMVAR, n*—vacuum induction melt–vacuum arc remelt.

4. Classification

4.1 This specification covers balls of Compositions 1 through 13 (see Table 1), and grades 3, 5, 10, 16, 24, 48, 100, 200, 500, and 1000 (see 3.1.6).

5. Ordering Information

5.1 When ordering balls in accordance with this specification, specify the following:

- 5.1.1 ASTM designation number, including year of issue;
- 5.1.2 Applicable MS sheet standard number;
- 5.1.3 Diameter of balls, whether standard or nonstandard;
- 5.1.4 Composition number required (see Table 1);
- 5.1.5 Grade required (see AFBMA-STD-10);
- 5.1.6 Whether a first article sample is required, and arrangements for testing and approval thereof;
- 5.1.7 Tests, test conditions, and sampling plans, if other than specified herein;
- 5.1.8 Quantity required;
- 5.1.9 Applicable levels of preservation and packing;
- 5.1.10 Special marking, if required; and
- 5.1.11 For Composition 13 balls (see Note 1):
 - 5.1.11.1 Traceability records for each ball, when required, including its corresponding heat treat lot, forging lot, consumable electrode remelt number, process lot number, and VIMVAR heat of steel;
 - 5.1.11.2 Material identification records, when required;
 - 5.1.11.3 Eddy current inspection records, when required; and
 - 5.1.11.4 Ultrasonic inspection record for bar stock material, when required.

NOTE 1—The contract or purchase order should specify that the Composition 13 material, eddy current and ultrasonic inspection records are to be maintained for 15 years from the date of purchase order or contract completion, and that the records are to be available for delivery to the purchaser within 3 working days.

6. Materials and Manufacture

6.1 *Composition 1*—Composition 1 balls shall be manufactured from chrome alloy steel conforming to the chemical composition of UNS G51986 in accordance with AMS 6449 or UNS G52986 in accordance with AMS 6440. Chemical composition shall be tested in accordance with 11.2.

6.1.1 Material used in manufacture of Composition 1 balls shall conform to the inclusion rating specifications given in 7.6.

TABLE 1 Classification of Balls

Composition Number	Composition
1	chrome alloy steel
2	corrosion resistant steel
3	carbon steel
4	silicon molybdenum steel
5	brass
6	bronze
7	aluminum bronze
8	beryllium copper alloy
9	nickel-copper alloy (Monel)
10	nickel-copper-aluminum alloy (K-Monel)
11	aluminum alloy
12	tungsten carbide
13	premium quality bearing steel (double vacuum melted M-50)

6.1.2 Material used in the manufacture of Composition 1 balls shall not exhibit defects as shown in Table 2 when tested in accordance with 11.15.1.

6.2 *Composition 2*—Composition 2 balls shall be manufactured from corrosion resistant steel conforming to the chemical composition of UNS S44003 or UNS S44004 in accordance with Specification A 276. Chemical composition shall be tested in accordance with 11.2.

6.2.1 Material used in manufacture of Composition 2 balls shall conform to the inclusion rating specifications given in 7.6.

6.2.2 Material used in the manufacture of Composition 2 balls shall not exhibit defects as shown in Table 2 when tested in accordance with 11.15.1.

6.3 *Composition 3*—Composition 3 balls shall be manufactured from carbon steel conforming to the chemical composition of UNS G10080 through UNS G10220 in accordance with Specification A 108. Chemical composition shall be tested in accordance with 11.2.

6.3.1 The quality of the material used in the manufacture of Composition 3 balls shall be equal to or exceed macrographs A3, B2, or C2 as specified in MIL-STD-1459 when tested in accordance with 11.15.2.

6.4 *Composition 4*—Composition 4 balls shall be manufactured from selected silicon molybdenum steel of the through-hardened type as specified in Table 3. Chemical composition shall be tested in accordance with 11.2.

6.5 *Composition 5*—Composition 5 balls shall be manufactured from brass as specified in Table 3. Chemical composition shall be tested in accordance with 11.2.

6.6 *Composition 6*—Composition 6 balls shall be manufactured from bronze conforming to the chemical composition of UNS C46400 (SAE CDA464) in accordance with QQ-B-637. Chemical composition shall be tested in accordance with 11.2.

6.7 *Composition 7*—Composition 7 balls shall be manufactured from aluminum bronze as specified in Table 3. Chemical composition shall be tested in accordance with 11.2.

6.8 *Composition 8*—Composition 8 balls shall be manufactured from beryllium copper as specified in Table 3. Chemical composition shall be tested in accordance with 11.2.

6.9 *Composition 9*—Composition 9 balls shall be manufactured from nickel copper alloy (Montel) as specified in Table 3. Chemical composition shall be tested in accordance with 11.2.

6.10 *Composition 10*—Composition 10 balls shall be manufactured from nickel-copper-aluminum alloy conforming to the chemical composition of UNS N05500 (K-Monel) in accordance with QQ-N-286. Chemical composition shall be tested in accordance with 11.2.

6.11 *Composition 11*—Composition 11 balls shall be manufactured from aluminum alloy as specified in Table 3. Chemical composition shall be tested in accordance with 11.2.

6.12 *Composition 12*—Composition 12 balls shall be manufactured from tungsten carbide material as specified in Table 3. Chemical composition shall be tested in accordance with 11.2.

6.13 *Composition 13*—Composition 13 balls shall be manufactured from aircraft-quality steel conforming to the chemical composition of UNS T11350 in accordance with AMS 6491. Chemical composition shall be tested in accordance with 11.2.

6.13.1 *Ultrasonic Inspection of Bar Stock*—Bar stock selected for the manufacture of Composition 13 balls shall be inspected using the ultrasonic inspection test method in Annex A1. Composition 13 bar stock shall be tested 100 %.

6.13.2 Material used in manufacture of Composition 13 balls shall conform to the inclusion rating specifications given in 7.6.

6.13.3 When a first article sample of Composition 13 ball material is required, chemical testing, fracture grain size and inclusion rating are required in addition to other tests.

6.13.4 Material used in the manufacture of Composition 1 balls shall be macro-examined in accordance with 11.15.3.

7. Other Requirements

7.1 *Density*—Density shall be as specified in Table 4 when tested in accordance with 11.3.

7.2 *Hardness:*

7.2.1 Hardness shall be as specified in Table 4 when tested in accordance with 11.4.

7.2.2 *Composition 3 Hardness*—Composition 3 balls shall have a minimum surface hardness of 60 HRC or equivalent when tested in accordance with 11.4. Composition 3 balls shall be case hardened to the depth specified in Table 5 when tested in accordance with 11.9.

7.3 *Fracture Grain Size*—Fracture grain size shall be as specified in Table 4, when tested in accordance with 11.5.

7.4 *Porosity*—Composition 12 balls shall not exceed the conditions for A02, B02, and C02 apparent porosity as given in Test Methods B 276 when tested in accordance with 11.6.

7.5 *Decarburization*—Compositions 1, 2, 3, 4, and 13 balls shall not exhibit decarburization when tested in accordance with 11.8.

7.6 *Inclusion Rating:*

7.6.1 *Compositions 1 and 2 Material Samples and Finished Balls*—Compositions 1 and 2 material and finished balls shall not exceed the inclusion rating specified for billets to be used for wire and rods in the manufacture of balls and rollers as specified in Specification A 295. For balls, fractured surfaces examined visually shall be considered defective if the following is found:

7.6.1.1 Presence of more than one nonmetallic inclusion between 1/16 and 1/8 in. long,

7.6.1.2 Presence of one nonmetallic inclusion over 1/8-in. long, or,

TABLE 2 Classification of Defects

Category	Defect	Testing Method
Major:		
101	presence of more than one nonmetallic inclusion 1/16 to 1/8 in. (SI) long	Measure
102	presence of one nonmetallic inclusion over 1/8 in. (SI) long	Measure
103	presence of porosity, pipe or internal ruptures	Visual
104	balls show evidence of contamination	Visual
105	balls not free from decarburization, cracks, pits and indications of soft spots	Visual
106	balls (bronze) not free from alloy segregation	Visual
Minor:		
201	hardness of balls less than required limits	Measure
202	packaging, packing and marking not in accordance with requirements	Visual

TABLE 3 Chemical Compositions for Materials Not Assigned UNS Numbers

Element	Chemical Compositions, weight %						
	Silicon Molybdenum Steel ^A	Brass ^B	Aluminum Bronze ^C	Beryllium Copper Alloy ^D	Nickel-Copper Alloy ^E	Aluminum Alloy ^F	Tungsten Carbide ^G
Carbon	0.45-0.55	...	...	...	...	...	...
Copper	...	60-70	remainder	remainder	25-30	3.5-4.5	...
Zinc	...	30-40	...	...	...	0.25 max	...
Aluminum	...	...	9-14	...	...	remainder	...
Manganese	0.30-0.60	...	1.5 max	...	...	0.40-1.0	...
Nickel	...	...	5.5 max	0.20 min ^H , 0.60 max ^I	65-70	...	...
Iron	...	...	2.10-4.00	...	5.0 max ^J	1.0 max	...
Beryllium	...	...	...	1.80-2.05	...	...	...
Silicon	0.90-1.15	...	...	...	...	0.8 max	...
Magnesium	...	...	...	...	...	0.20-0.8	...
Chromium	0.25 max	...	...	...	...	0.10 max	...
Other elements	...	0.5 max total	...	...	5.0 max total	0.15 max total,	...
0.05 max each	0.5 max total	...	...	...	...	...	...
Tungsten carbide (WC)	...	...	...	...	...	...	93.5-94.5
Cobalt	...	...	...	...	...	...	5.5-6.5
Phosphorus	0.030 max	...	...	...	...	...	...
Sulphur	0.030 max	...	...	...	...	...	...
Molybdenum	0.30-0.50	...	...	...	...	...	...

^A Composition 4.

^B Composition 5.

^C Composition 7.

^D Composition 8.

^E Composition 9.

^F Composition 11.

^G Composition 12.

^H Nickel or cobalt or both.

^I Nickel plus cobalt plus iron.

^J Iron plus zinc.

TABLE 4 Other Requirements

Composition Number	Hardness ^A	Density, lbm/in. ³ (SI)	Fracture Grain Size, max
2	58-65 HRC ^C	0.277	7½
3	...	0.284	...
4	52-60 HRC	0.278	...
5	75-87 HRB	0.306	...
6	75-98 HRB or 15-20 HRC ^D	0.304	...
7	15-20 HRC	0.273	...
8	38 HRC	0.300	...
9	85-95 HRB	0.318	...
10	27 HRC	0.306	...
11	54-72 HRB	0.101	...
12	87.5-90.4 HRA	0.539	...
13	61-64 HRC	0.279	8

^A Hardness equivalent to those shown are also acceptable.

^B The balls within any unit container shall have a uniform hardness from ball to ball within three points HRC or equivalent.

^C See 7.2.2.

^D See 11.4.

7.6.1.3 Presence of porosity, pipe or internal ruptures.

7.6.2 *Composition 13 Material Samples and Finished Balls*—Inclusion rating for Composition 13 material samples shall not exceed the inclusion rating specified for billets to be used for wire and rods in the manufacture of balls and rollers as specified in Specification A 295. Inclusion rating for finished Composition 13 balls shall be as specified in AMS 6491.

7.7 *Retained Austenite*—The retained austenite content of Composition 1 and 13 balls shall not exceed 3 % by volume, as determined using X-ray diffraction techniques or other techniques as specified.

TABLE 5 Case Depth Requirements for Composition 3 Balls

Nominal Size, in.	Minimum Case Depth, in.	
	At Least	But Not
1/64	1/16	0.005
1/16	3/32	0.015
3/32	1/8	0.020
1/8	3/16	0.025
3/16	7/32	0.030
7/32	1/4	0.035
1/4	3/8	0.045
3/8	7/16	0.055
7/16	1/2	0.065
1/2	9/16	0.070
9/16	3/4	0.075
3/4	1½	0.080

7.8 *Passivation*—Composition 2 balls shall be passivated and shall not exhibit visible corrosion when tested in accordance with 11.10.

7.9 *Eddy Current*—Composition 13 balls shall pass the eddy current test given in 11.11, by meeting the requirements given in 11.11.6.

7.10 *First Article*—When specified in the purchase order or contract, a first article sample shall be provided. The sample item shall meet the requirements of Sections 7, 8, 9, and 14. The purchaser should include specific instructions in the purchase order or contract regarding arrangements for testing and approval of the first article sample.

8. Dimensions, Mass, and Permissible Variations

8.1 The basic diameter of the balls, whether standard or nonstandard, shall be as specified in the purchase order or contract. Tolerance limits for size (diameter) variations and