Designation: F 2215 – 02

Standard Specification for Balls, Bearings, Ferrous and Non-Ferrous for Use in Bearings, Valves, and Bearing Applications[1]

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 Quality[2]

A 276 Specification for Stainless Steel Bars and Shapes[3]

A 295 Specification for High-Carbon Anti-Friction Bearing Steel[2]

B 276 Test Method for Apparent Porosity in Cemented Carbides[4]

D 3951 Practice for Commercial Packaging[5]

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials[6]

E 112 Test Methods for Determining the Average Grain Size[6]

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)

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[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.

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[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.

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

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 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
1	60-67 HRC[B]	0.283	8
2	58-65 HRC	0.277	7½
3	[C]	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.

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

7.6.1.3 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.

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

spherical form variations shall be in accordance with Tables 6 and 7 and the applicable MS sheet standards (see 2.7) for the respective metallic compositions and grades. Dimensions not within the tolerances specified on the applicable MS sheet standard and Tables 6 and 7 shall be classified as a defect. Balls shall be tested for dimensional requirements in accordance with 11.13.

9. Workmanship, Finish and Appearance

9.1 Balls shall be free from decarburization, overtempering, and indication of soft spots.

9.2 All surfaces shall be free of scratches, nicks, pits, dents, seams, laps, tears, cracks, and corrosion when examined with an unaided eye. Balls having basic diameters of ⅛ in. or less may be examined by magnification not exceeding 10×.

9.3 Tolerance limits for scratches, pits, nicks, and dents on Composition 13 balls shall be in accordance with Table 8. Surface defects not within the tolerance of acceptable limits specified in Table 8 shall be cause for rejection.

9.4 *Visual and Dimensional Testing*—Balls shall meet the requirements of Table 9. Composition 13 balls shall be visually tested in accordance with 11.12.

9.5 *Surface Roughness*—The surface roughness of the balls shall not exceed the value specified in the applicable MS sheet standard (see 2.7) or Table 10 for the specified grade, when tested in accordance with 11.7.

9.6 *Carbides*—Carbides on the surfaces of finished Composition 13 balls shall not protrude more than 11 in. above the surface of the ball, when tested in accordance with 11.14.

10. Sampling

10.1 *Sampling for Visual and Dimensional Testing of Composition 1 through 12 Balls*—Sampling shall be done in accordance with MIL-STD-105. The unit of product for sampling purposes shall be one ball as applicable. Acceptance number shall be zero for all sample series unless otherwise specified.

10.2 *Sampling for Examination of Composition 13 Balls*:

10.2.1 *Visual Examination*—Composition 13 balls shall be inspected 100 %.

10.2.2 *Dimensional Examination*—Sampling for dimensional examination of Composition 13 balls shall be in accordance with MIL-STD-105.

10.2.3 *Eddy Current Inspection*—Composition 13 balls shall be inspected 100 %.

TABLE 6 Tolerances by Grade for Individual Balls

Grade	Allowable Ball Diameter Variation, V_D, millionths of an in.	Allowable Deviation from Spherical Form, *W*, millionths of an in.
3	3	3
5	5	5
10	10	10
16	16	16
24	24	24
48	48	48
100	100	100
200	200	200
500	500	500
1000	1000	1000

10.3 *First Article Testing*—When a first article sample is required, five sample units shall be tested.

11. Test Methods

11.1 *Test Conditions*—Unless otherwise specified, perform all tests under the following conditions:

11.1.1 *Temperature*—Room ambient, 68 to 70°F (20 to 25°C),

11.1.2 *Altitude*—Normal ground, and

11.1.3 *Humidity*—50 % relative, maximum.

11.2 *Chemical Analysis*:

11.2.1 Determine the chemical analysis of each lot of material. Select the samples for analysis from the billets, rods or wires used in the manufacture of the balls. Determine the chemical composition by spectrochemical analysis Method 112.2, chemical analysis Method 111.2 in accordance with FED-STD-151 or by other analytical test methods as approved by the purchaser.

11.2.2 When specified in contract or purchase order, certification of chemical analysis (conformance) from the supplier of the specified material may be considered acceptable in lieu of actual testing by the manufacturer.

11.3 *Density*—Select samples of each Composition in accordance with Section 10. Weigh the balls in air and divide the weight of each sample ball by the computed volume of the ball. The diameter used in computing the volume of the ball shall be determined in accordance with 11.13.1. Determine the weight of each sample ball to an accuracy of 2.205×10^{-6} lb_m or 10 % of the weight, whichever is greater. Samples failing to comply with the density test requirements given in Table 4 shall be cause for lot rejection.

11.4 *Ball Hardness*—Select samples of each composition in accordance with Section 10. Test in accordance with Test Methods E 18, except for Composition 6. Test Composition 6 balls in accordance with MS 10963. Refer to tests made on parallel flats for hardness readings. If any of the samples fail to comply with the ball hardness requirement given in Table 4, the lot shall be rejected.

11.5 *Fracture Grain Size*—Select samples of Composition 1, 2, and 13 balls in accordance with Section 10. Examine in accordance with Test Methods E 112. Balls having fracture grain sizes for Compositions 1, 2, and 13 that are not in accordance with the requirements of Table 4 shall be cause for rejection.

11.6 *Porosity Test*—Select Composition 12 balls in accordance with Section 10. Prepare and examine the balls in accordance with Test Method B 276, or other test method as approved by the purchaser. Sample units exceeding the conditions for A02, B02, and C02 apparent porosity shall be cause for lot rejection.

11.7 *Surface Roughness*—Select samples in accordance with Section 10. Test in accordance with ANSI B46.1. Sample units not complying with requirements of 9.5 shall be cause for lot rejection.

11.8 *Decarburization*—Select Compositions 1, 2, 3, 4, and 13 balls in accordance with Section 10. Examine balls for surface decarburization. Polish and microetch transverse sections through the center of sample balls, and examine at a

TABLE 7 Tolerances by Grade for Lots of Balls

Grade	Allowable Lot Diameter Variation, millionths of an in.	Basic Diameter Tolerance, millionths of an in.	Allowable Ball Gage Deviation, millionths of an in.		Container Marking Increment, millionths of an in.
			High	Low	
3	5	±30	+30	-30	10
5	10	±50	+50	-40	10
10	20	±100	+50	-40	10
16	32	±100	+50	-40	10
24	48	±100	+100	-100	10
48	96 (SI)	±200	. . .	. . .	50
100	200 (SI)	±500	. . .	. . .	. . .
200	400	±1000	. . .	. . .	. . .
500	1000	±2000	. . .	. . .	. . .
1000	2000	±5000	. . .	. . .	. . .

TABLE 8 Visual Inspection Limits for Composition 13 Balls

Type of Defect	Acceptable Limits
Pits	0.008 in. maximum dimension for single pit; maximum of 3 permitted in any ¼-in. diameter circle
Scratches	0.006 in. width; maximum of 1 per ball up to 50 % of circumference, any number up to 25 % of circumference; no cross-scratches permitted.
Nicks, dents, and indentations on balls of less than ½-in. (SI) diameter	0.015 in. maximum dimension
Nicks, dents, and indentations on balls of ½-in. diameter or larger	0.024 in. maximum dimension

TABLE 9 Visual and Dimensional Testing

Test	Inspection Level	AQL (Defects Per 100 Units)
Visual		
Major Defects	II	1.0
Minor Defects	II	6.5
Dimensional Examination:		
Diameter tolerance per ball	S-1	2.5
Ball diameter variation	S-1	2.5
Measurement of deviation from spherical form	S-1	2.5
Tolerances by grade for lots of balls	S-1	2.5
Specific diameter marking	S-1	2.5

TABLE 10 Surface Roughness by Grade for Individual Balls

Grade	Maximum Surface Roughness Arithmetical Average, $\times 10^{-6}$ in.
3	0.5
5	0.8
10	1.0
16	1.0
24	2.0
48	3.0
100	5.0
200	8.0
500	. . .
1000	. . .

magnification of 100 diameters. Test specimens exhibiting surface decarburization shall be cause for lot rejection.

11.9 *Case Depth*—Select Composition 3 balls in accordance with Section 10. Polish and microetch transverse sections through the center of sample balls, and examine using appropriate measuring devices or instruments. Test specimens not complying with case depth requirements shown in Table 5 shall be cause for lot rejection.

11.10 *Passivation*—Select Composition 2 balls in accordance with Section 10. Immerse samples in distilled water at 100 ± 5°F for 1 h, and then air dry at 100 ± 5°F for 1 h. Repeat this cycle for a total of 24 h. At the end of the 24-h test period, examine the sample balls for surface corrosion, using a 10× power magnification. Samples exhibiting visible corrosion shall be cause for lot rejection.

11.11 *Eddy Current*:

11.11.1 *Personnel*—Personnel performing the eddy current testing shall meet the requirements of MIL-STD-410.

11.11.2 *Calibration Standard*—The calibration standard shall be a ball of the same material, heat treat condition and grade as the ball being tested. The diameter of the calibration standard shall be the same as the nominal diameter of the ball being tested. The calibration standard shall have an electrical discharge machining (EDM) notch on its surface that is between 0.030 and 0.032 in. by 0.004 in. maximum wide and 0.004 in. maximum deep. Measure and record notch dimensions.

11.11.3 *Residual Magnetism*—Check the calibration standard and balls for residual magnetism prior to testing. All parts shall have less than 0.50 gauss before testing.

11.11.4 *Scanning Coverage*—Scanning increments shall be no greater than the diameter of the coil being used for the test. Continuously scan the entire periphery of the ball surface. Use the same scanning speeds for testing and calibration. Verify full scanning of parts being tested at the beginning and at the end of each inspection lot. If fixturing requires adjustment, reinspect all parts inspected since previous check.

11.11.5 *Signal and Noise*—Set up test equipment so that calibration standards produce a signal of 50 % of the screen height. Do not change sensitivity adjustments during testing to compensate for drift within the machine; do not adjust sensitivity greater than ±10 % from the previously established calibration. Verify meter deflection on the calibration standard at the beginning and at the end of each inspection lot.

11.11.6 *Ball Rejection*—Calibration standards trip the reject signal; segregate them from acceptable balls. Reject any production balls that signal equal to or greater than the calibration level of the EDM notch in the calibration standards. Segregate any rejected balls.

11.11.7 *Processing After Eddy Current Testing*—Reinspect any balls that are processed in any way following eddy current testing.

11.12 *Visual Testing for Composition 13 Balls*—Sample balls in accordance with 10.2. Inspect balls for defects using the unaided eye (unless magnification is specified). Use a radius scribe as the initial determination of acceptability for defects. Use a 0.030-in. radius on balls ½ in. diameter and larger. Use a 0.020-in. radius scribe on balls less than ½ in. diameter. If the defect is detectable with the scribe, or if the acceptance criteria of Table 7 are not met, the ball shall be rejected.

11.13 *Dimensional Testing*:

11.13.1 *Diameter Tolerance Per Ball and Ball and Lot Diameter Variation*—Sample in accordance with Section 10. Take a minimum of 10 measurements in random orientations of each sample ball. If samples do not comply with out-of-roundness requirements, the lot shall be rejected.

11.13.2 *Measurement of Deviation from Spherical Form*—Sample in accordance with Section 10. Test in accordance with the roundness measuring equipment procedures and Vee block examination procedures described in AFBMA-STD-10. If sample balls do not satisfy the requirements of AFBMA-STD-10, the lot shall be rejected.

11.13.3 *Tolerances by Grade for Lots of Balls*—Sample lots of balls in accordance with Section 10. Take a minimum of 10 measurements in random orientations of each sample ball. If sample packages do not comply with the requirements of 8.1, they shall be rejected.

11.13.4 *Specific Diameter Marking*—Sample in accordance with Section 10. Take a minimum of 10 measurements in random orientations of each sample ball. Marking shall be within one marking increment of the average diameter of the balls in the unit container (see Table 7). Any unit package that does not comply with these requirements shall be rejected.

11.14 *Carbides on Finished Composition 13 Balls*—Inspect a five-ball sample from each lap load of finished Composition 13 balls at 250× or greater magnification. Select three random fields per ball, approximately 120° apart. Measure raised carbides using an optical interferometer or other suitable device. If a ball contains a raised carbide with a height above the ball surface in excess of 11 in., reject the lap load.

11.15 *Macro-Examinations*:

11.15.1 *Compositions 1 and 2 Balls*—Take specimens that are ⅜ in. thick (and representative of the cross section of 4-in. square rolled billets) for forged sections that are 4 in. square (used for forging and re-rolling into coils, tube rounds and bars) from the top and bottom areas of the first, middle, and last of usable ingots of a heat. Normalize, anneal, harden, and fracture these specimens. Ensure that the specimens do not have external indentations sufficient to guide the fracture during the examination. Examine fractured surfaces for the defects listed in Table 2.

11.15.2 *Composition 3 Balls*—Select samples for examination from the billets for the wire or rods used in the manufacture of the balls, in accordance with Method 321 of FED-STD-151. Conduct macro-examination of each heat of steel in accordance with MIL-STD-1459. The quality of steel as indicated by the results of the macro-examination shall be equal to or exceed macrographs A3, B2, or C2 as specified in MIL-STD-1459. Defects exhibiting profiles of D1 through D8 of MIL-STD-1459 shall not be considered acceptable. When specified in the purchase order or contract, a certified chemical analysis report (certificate of conformance) submitted by the mill supplier is an acceptable alternate to the macro-examination of the material.

11.15.3 *Composition 13 Balls*—Perform macro-examination in accordance with AMS 6491.

12. Inspection

12.1 Inspection of the balls shall be agreed upon between the purchaser and the supplier as part of the purchase order or contract.

13. Certification

13.1 Unless otherwise specified in the contract or purchase order, the supplier is responsible for performance of all testing and inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the supplier may use his own or any other facility suitable for the performance of such tests or inspections, or both, unless disapproved by the purchaser.

13.2 When specified in the contract or purchase order, certificates of quality (conformance) supplied by the manufacturer of the metal balls may be furnished in lieu of actual performance of such testing by the supplier, provided that lot identity has been maintained and can be demonstrated to the purchaser. The certificate shall include the name of the purchaser, contract number, name of the manufacturer or supplier, NSN, item identification, name of the material, lot number, lot size, sample size, date of testing, test method, individual test results, and the specification requirements.

14. Packaging and Package Marking

14.1 The balls shall be cleaned, dried, preserved, and packaged in accordance with MIL-B-197. The level of packaging shall be A or industrial, as specified in the purchase order or contract.

14.1.1 The industrial preservation shall be in accordance with Practice D 3951.

14.2 Packing shall be level A, B, or industrial, as specified in the purchase order or contract. The number of balls per unit container shall be in accordance with the contract or purchase order. The balls shall be packaged in accordance with MIL-B-197.

14.3 *Marking*:

14.3.1 *Military*—In addition to any special or other identification marking required by the contract or purchase order, each unit pack and intermediate and exterior container shall be marked in accordance with MIL-STD-129.

14.3.2 *Industrial*—Industrial marking shall be in accordance with Practice D 3951.

15. Keywords

15.1 ball bearing; ball valve; bearing; bearing accessories; bearing rolling elements

ANNEX

(Mandatory Information)

A1. TEST METHOD FOR ULTRASONIC TESTING OF COMPOSITION 13 BAR STOCK

A1.1 Scope

This annex covers the procedure for ultrasonic testing of Composition 13 bar stock selected for the manufacture of bearing balls.

A1.2 Significance and Use

Balls may be used in engine and gearbox bearings on rotary and fixed winged aircraft.

A1.3 Personnel

Personnel performing the inspection shall meet the requirements of MIL-STD-410.

A1.4 Sampling

Sampling shall be done in accordance with 10.3.

A1.5 Calibration and Standardization

A1.5.1 *Calibration Standard*—Reference pieces for calibration shall be of the same material, metal travel distance, surface finish and ultrasonic response as the bar stock being tested.

A1.5.2 *Reference Test Pieces*:

A1.5.2.1 *For Bar Stock ⅝ to 1½ in. Diameter*—The reference test piece shall be a bar of at least 3 ft in length. For near zone testing, metal travel shall be 4/10 the diameter and 9/10 the diameter of the test piece to flat bottom holes (FBHs) 0.020 in. in diameter. For far zone testing, metal travel shall be 6/10 the diameter and 1/10 the diameter of the test piece to FBHs 0.020 in. in diameter. For angle scanning, a shear notch 0.0070 ± 0.0005 in. deep, axially oriented, and located at least 8 in. from the end of the bar shall be used. The notch shall be produced from a 1-in. end mill with a 0.0002-in. maximum radius. Ultrasonic reflectors shall be spaced a minimum of 2 in. apart.

A1.5.2.2 *For Bar Stock ½ to ⅝in. in Diameter*—The reference test piece shall have all the requirements of A1.5.1 and A1.5.2.1, except for the following: for near zone testing, metal travel of 9/10 the test piece diameter shall be replaced with metal travel to a 0.020-in. diameter FBH of 0.062 in. depth. For far zone testing, metal travel of 1/10 the test piece diameter shall be replaced with metal travel of 0.06 in. to a 0.020-in. FBH.

A1.5.2.3 *For Bar Stock Less Than ½ in. Diameter*—For bar stock less than 0.500 in. diameter, only one FBH providing ½ diameter travel is required in addition to the shear notch of A1.5.2.1.

A1.6 Procedure

A1.6.1 *Longitudinal Scan*—While maintaining correct water path, obtain a 2-in. signal from the highest attenuated 2-in. FBH. Adjust sensitivity and distance amplitude control to bring near and far FBHs within ±10 % of a 2-in. amplitude indication. Establish compatibility between reference block and the material to be tested by comparing the first unsaturated back reflection from the block with the corresponding back reflection from the material to be tested. Gain shall be set to give an 80 % of screen signal from the FBH with depth of 6/10 the diameter of the test piece. Check compatibility in at least three well-separated areas on the material to be tested. Set the gate width for near zone testing to include response from FBH with depth of 1/10 (or 0.062-in. holes) and 6/10 test piece diameter. Set the gate width for far zone testing to include response from FBH with depth of 4/10 and 9/10 test piece diameter. Set the alarm sensitivity to assure 100 % of a 0.020-in. diameter FBH inspection level. Use a maximum surface scanning speed of 15 in./s. Hash or ultrasonic noise exceeding 50 % of the response from a FBH is not acceptable.

A1.6.2 *Loss of Backface*—Set instrument so the first backface reflection from the full round reference block is 80 % of screen saturation. Gate the first backface reflection and set alarm at 50 % or less of loss in backface signal. Observe scanning speed, noise level, and indexing requirement listed under longitudinal scan. Inspect and evaluate loss of backface areas.

A1.6.3 *Angle Scan Test*—Position transducer over angle reference notch area for maximum response. Rotate reference standard so center of standard block and notch are on a horizontal plane. Adjust gain to obtain a 2-in. signal and adjust flaw alarm for a 1-in. signal. Set gate width to include the area at which the signal from the reference notch is detected. Ensure that scan speed, acceptable noise level, and indexing are as established under longitudinal scan.

A1.7 Interpretation of Results

A1.7.1 *Longitudinal Scan*—Discontinuities in excess of the response from a 0.020-in. diameter FBH at the estimated discontinuity depth shall not be acceptable.

A1.7.2 *Loss of Back Reflection*—Any loss of back reflection in excess of 50 % of full saturation of the screen shall be considered unacceptable with the instrument set so the first back reflection from the correct test block is at 80 % of the screen adjusted for nonlinearity.

A1.7.3 *Angle Scan*—Discontinuities in excess of 50 % of the response from the axially oriented notch shall not be acceptable.

A1.8 Precision and Bias

All bar stock for Composition 13 balls must meet all of the requirements for UT testing as set forth in this specification.