



Designation: **F2215–08 F2215 – 15**

# Standard Specification for Balls, Bearings, Ferrous and Nonferrous for Use in Bearings, Valves, and Bearing Applications<sup>1</sup>

This standard is issued under the fixed designation F2215; 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.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 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 ~~Annex A2 through Annex A9~~MS sheet standards. In the event of any conflict between requirements of this specification and the ~~Annex A2 through Annex A9~~MS sheet standards, the latter shall govern.

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.

1.4 This specification contains many of the requirements of MIL-B-1083, which was originally developed by the Department of Defense and maintained by the Defense Supply Center Richmond. ~~The following government activity codes may be found in the Department of Defense, Standardization Directory SD-1.~~

Preparing Activity  
DLA-GS

Custodians  
Army-AF  
Navy-OS  
Air Force-99

Review Activities  
Army-AV, EA, AR, MI  
Navy-SH  
Air Force-11, 84

1.5 *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:<sup>2</sup>

- A108 Specification for Steel Bar, Carbon and Alloy, Cold-Finished
- A276 Specification for Stainless Steel Bars and Shapes
- A295 Specification for High-Carbon Anti-Friction Bearing Steel
- B21/B21M Specification for Naval Brass Rod, Bar, and Shapes
- B124/B124M Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes
- B276 Test Method for Apparent Porosity in Cemented Carbides
- B283 Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed)
- D3951 Practice for Commercial Packaging
- E18 Test Methods for Rockwell Hardness of Metallic Materials
- E112 Test Methods for Determining Average Grain Size
- E381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings
- E384 Test Method for Knoop and Vickers Hardness of Materials

### 2.2 ASTM Adjunct:<sup>3</sup>

- ADJE0381 ASTM Adjuncts: Photographs for Rating Macroetched Steels (3 Plates) Plate I, Plate II, and Plate III

<sup>1</sup> 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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<sup>2</sup> 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.

<sup>3</sup> Available from ASTM International Headquarters. Order Adjunct No. ADJE0381

2.3 *ABMA Standard:*<sup>4</sup>

[ABMA-STD-10 Metal Balls \(Inactive Specification\)](#)

2.4 *ANSI Standards:*<sup>5</sup>

[ANSI B46.1 Surface Texture \(Surface Roughness, Waviness and Lay\)](#)

[ANSI B89.3.1 Sampling Procedures and Tables for Inspection by Attributes](#)

[ANSI/ASQC Z1.4 Sampling Procedures and Tables for Inspection by Attributes](#)

2.5 *Federal Standards:*<sup>6</sup>

[FED-STD-151 Metals, Test Methods](#)

[QQ-N-286 Specification for Nickel-Copper Aluminum Alloy, Wrought](#)

2.6 *ISO Standard:*<sup>5</sup>

[ISO 3290 Rolling Bearings, Bearing Parts, Balls for Rolling Bearings](#)

2.7 *Military Standards:*<sup>6</sup>

[MIL-B-1083 Military Specification: Balls, Bearing, Ferrous and Non-Ferrous \(for Use in Bearings, Valves And Bearing Applications\) General Specification for](#)

[MIL-DTL-197 Packaging of Bearings, Associated Parts and Subassemblies](#)

[MIL-STD-129 Marking for Shipment and Storage](#)

~~[MS 3224 Balls, Bearing, Aircraft Quality Steel](#)~~

~~[MS 3226 Balls, Bearing, Grade 10, Aircraft Quality Steel](#)~~

~~[MS 19059 Balls, Bearing, Chrome Alloy Steel](#)~~

~~[MS 19060 Balls, Bearing, Corrosion Resistant Steel](#)~~

~~[MS 19061 Balls, Bearing, Carbon Steel](#)~~

~~[MS 19062 Balls, Bearing, Non-Ferrous Brass](#)~~

~~[MS 19063 Balls, Bearing, Bronze](#)~~

~~[MS 19064 Balls, Bearing, Nickel-Copper Alloy \(K Monel\)](#)~~

2.8 *NAS Standard:*<sup>7</sup>

[NAS 410 Certification and Qualification of Nondestructive Test Personnel](#)

2.9 *SAE Standards:*<sup>8</sup>

[AMS 5618 Steel, Corrosion Resistant Bars, Wire and Forgings](#)

[AMS 5630 Steel, Corrosion Resistant Bars, Wire and Forgings](#)

[AMS 5749 Steel, Corrosion Resistant Bars, Wire and Forging and Tubing Premium Aircraft Quality for Bearing Applications](#)

[AMS 5880 Steel, Corrosion Resistant Bars, Wire and Forging for Bearing Applications](#)

[AMS 6440 Specification for Steel Bars, Forgings and Tubing 1.45Cr \(0.98-1.10C\) \(SAE 52100\) for Bearing Applications](#)

[AMS 6444 Specification for Steel Bars, Forgings and Tubing Premium Aircraft Quality for Bearing Applications](#)

[AMS 6490 Specification for Steel Bars, Forgings and Tubing](#)

[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](#)

### 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *ball gage deviation* ( $\Delta S$ )—difference between the lot mean diameter and the sum of the nominal diameter and the ball gage.

3.1.2 *basic diameter*—diameter size of the balls, in inches.

3.1.3 *basic diameter tolerance*—maximum allowable deviation from the specified basic diameter for the indicated grade.

3.1.4 *case depth*—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* ( $\Delta R_w$ )—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* ( $G$ )—indicates the allowable out-of-roundness expressed in millionths of an inch.

3.1.7 *lot*—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.

<sup>4</sup> Available from the Anti-Friction Bearing Manufacturers' Association, Inc., 1101 Connecticut Ave., N.W., Suite 700, Washington, DC 20036.

<sup>5</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

<sup>6</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://assist.daps.dla.mil/quicksearch/>—DLA Document Services Building 4/D 700 Robbins Avenue Philadelphia, PA 19111-5094 <http://quicksearch.dla.mil/>

<sup>7</sup> Available from Global Engineering Documents, 15 Inverness Way, East Englewood, CO 80112-5704, <http://www.global.ihs.com>.

<sup>8</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

3.1.8 *marking increments*—standard unit steps to express the specific diameter.

3.1.9 *nominal size (D<sub>w</sub>)*—basic diameter, in inches, that is used for the purpose of general identification (for example, 1/16, 1/8, and so forth).

3.1.10 *out-of-roundness*—difference between the largest diameter and the smallest diameter measured on the same ball.

3.1.11 *passivation*—treatment for corrosion-resistant steel to eliminate corrodible surface impurities and provide a protective film.

3.1.12 *specific diameter*—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*—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 Acronyms:

3.2.1 *CEVM*—consumable electrode vacuum melted.

3.2.2 *VIMVAR*—vacuum induction melt-vacuum arc remelt.

## 4. Classification

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

**TABLE 1 Classification of Balls**

Composition Number	Composition
1	chrome alloy steel (52100)
2	corrosion-resistant hardened steel
2	corrosion-resistant hardenable steel (400 series)
3	carbon steel
4	silicon molybdenum steel
5	brass
5	Brass
6	bronze
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)
14	corrosion-resisting unhardened steel
14	corrosion resistant austenitic steel (300 series)
15	premium aircraft quality chrome alloy steel (52100 CEVM)
16	premium aircraft quality corrosion resistant alloy steel (440C VIMVAR)

**TABLE 2 Classification of Defects**

Category	Defect	Testing Method
<b>Major:</b>		
101	presence of more than one nonmetallic inclusions 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, <sup>A</sup> and indications of soft spots	visual
106	balls (bronze) not free from alloy segregation	visual
107	hardness of balls less than required limits	measure
<b>Minor:</b>		
201	packaging, packing and marking not in accordance with requirements	visual

<sup>A</sup> For Composition 13 balls, in lieu of being free of pits, scratches, nicks, dents, and indentations exceeding the tolerances of [Table 8](#) are classified as major defects for Category 105 defects.

## 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 [ISO 3290](#) and [ABMA-STD-10](#), [ISO 3290](#)),

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 balls, traceability [Note 1](#)): 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,

~~5.1.11.1 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;~~

5.1.11.1 Material identification records, when required,

5.1.11.2 Eddy current inspection records, when required, and

5.1.11.3 Ultrasonic inspection record for bar stock material, when required.

~~NOTE 1—The contract or purchase order should specify the data required in each record, and that the Composition 13 material traceability and identification, 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 three working days. For military purposes, the following applicable Data Item Descriptions shall be cited in the contract or purchase order when the above records or certificates of conformance are specified: Certificate of Conformance DI-MISC-81020, Material Identification record DI-QCIC-80451, Eddy current inspection record DI-QCIC-80452, Ultrasonic Inspection record DI-QCIC-80453. The above DID's were current as of the date of this specification. The ASSIST database should be researched at <http://assist.daps.dla.mil/quicksearch/> or [www.dodssp.daps.mil](http://www.dodssp.daps.mil) to ensure that only current and approved DID's are cited on the DD form 1423.~~

## 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 G52986 in accordance with AMS 6440 or AMS 6444 and Specification ~~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](#).~~

~~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, UNS S32900, UNS S42000, UNS S41000, UNS S42700, or UNS S44004 in accordance with Specification [A276](#) and AMS 5618, 5630, 5749 and 5880. Chemical composition shall be tested in accordance with [11.2](#).

~~6.2.1 Material used in the 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 [A108](#). 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 have macrograph inspection in accordance with Test Methods [E381](#) and ASTM Adjunct [ADJE0381](#) Adjuncts. Tests shall be in accordance with ~~[11.15.2](#)~~[11.14.2](#).

6.4 *Composition 4*—Composition 4 balls shall be manufactured from selected silicon molybdenum steel UNS T41902 of the through-hardened type as specified in [Table 32](#). Chemical composition shall be tested in accordance with [11.2](#).

6.5 *Composition 5*—Composition 5 balls shall be manufactured from brass UNS C26000 as specified in [Table 32](#). 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 Specifications [B283](#), [B124/B124M](#), and [B21/B21M](#). Chemical composition shall be tested in accordance with [11.2](#).

6.7 *Composition 7*—Composition 7 balls shall be manufactured from aluminum bronze UNS C62400 and UNS C6300 as specified in [Table 32](#). 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 32](#). Chemical composition shall be tested in accordance with [11.2](#).

**TABLE 32 Chemical Compositions for Materials Not Assigned UNS Numbers**

Element	Chemical Compositions, weight %						
	Silicon Molybdenum Steel <sup>A</sup>	Brass <sup>B</sup>	Aluminum Bronze <sup>C</sup>	Beryllium Copper Alloy <sup>D</sup>	Nickel-Copper Alloy <sup>E</sup>	Aluminum Alloy <sup>F</sup>	Tungsten Carbide <sup>G</sup>
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 <sup>H</sup> , 0.60 max <sup>I</sup>	65-70		
Nickel			5.5 max	0.20 min, <sup>H</sup> 0.60 max	65-70		
Iron			2.10-4.00		5.0 max <sup>J</sup>	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						

<sup>A</sup> Composition 4.

<sup>B</sup> Composition 5.

<sup>C</sup> Composition 7.

<sup>D</sup> Composition 8.

<sup>E</sup> Composition 9.

<sup>F</sup> Composition 11.

<sup>G</sup> Composition 12.

<sup>H</sup> Nickel or cobalt, or both.

<sup>I</sup> Nickel plus cobalt plus iron.

<sup>J</sup> Iron plus zinc.

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6.9 *Composition 9*—Composition 9 balls shall be manufactured from nickel copper alloy (Monel) UNS N04400 as specified in [Table 32](#). 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 UNS A92017 as specified in [Table 32](#). 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 32](#). 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 or UNS T12001 in accordance with AMS 6490 or AMS 6491. Chemical composition shall be tested in accordance with [11.2](#).

6.13.1 *Ultrasonic Inspection of Bar Stock*—Bar and wire stock selected for the manufacture of Composition 13 balls shall be inspected using the ultrasonic inspection test method in [Annex A1](#). Composition 13 bar and wire 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 13 balls shall be macro-examined in accordance with [11.15.3](#) and [11.14.2](#).

6.14 *Composition 14*—Composition 14 balls shall be manufactured from corrosion-resistant unhardened steel conforming to the chemical composition of UNS S30200, UNS S30400, UNS S30500, UNS S31600, or UNS S43000 in accordance with Specification [A276](#). Chemical composition shall be tested in accordance with [11.2](#).

6.14.1 Material used in the manufacture of Composition 14 balls shall not exhibit defects as shown in [Table 2](#) when tested in accordance with [11.15.1](#).

6.15 *Composition 15*—Composition 15 balls shall be manufactured from premium quality chrome alloy steel conforming to the chemical composition of UNS G52986 in accordance with AMS 6444. Chemical composition shall be tested in accordance with [11.2](#).

6.16 *Composition 16*—Composition 2 balls shall be manufactured from corrosion-resistant steel conforming to the chemical composition of UNS S44004 in accordance with Specification A276 and AMS 5618 VIMVAR. Chemical composition shall be tested in accordance with 11.2.

**7. Other Requirements**

7.1 *Density*—Density shall be as specified in Table 43. 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 (cm<sup>3</sup>). The diameter used in computing the volume of the ball shall be determined in accordance with 11.12.1. Determine the weight of each sample ball to an accuracy of 2.205 × 10<sup>-6</sup> lbm (0.001 g) or 0.10 % of the weight, whichever is greater.

7.2 *Hardness:*

7.2.1 Hardness shall be as specified in Table 43 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 54 when tested in accordance with 11.9.

7.3 *Fracture Grain Size*—Unless otherwise specified, fracture grain size shall be in accordance with the material specification, when tested in accordance with 11.5. Fracture grain size shall not exceed the fracture grain size specified in Table 43, 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 Method B276 when tested in accordance with 11.6.

7.5 *Decarburization*—Compositions 1, 2, 3, 4, 13, 15 and 16 balls shall not exhibit decarburization when tested in accordance with 11.8.

7.6 *Inclusion Rating: 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 A295. For balls, fractured surfaces examined visually shall be considered defective if the following are 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,

7.6.1.3 Presence of porosity, pipe, or internal ruptures. Unless otherwise specified, inclusion rating requirements shall be in accordance with the material specification.

7.6.1 *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 UNS T11350 or UNS T12001. Inclusion rating for finished Composition 13 balls shall be as specified in AMS 6490 or AMS 6491.

**TABLE 43 Other Requirements**

Composition Number	Hardness <sup>A</sup>	Density, lbm/in. <sup>3</sup> (reference)	Fracture Grain Size, max, see 7.3
1	58-67 HRC <sup>B</sup>	0.283	8
2	58-65 HRC	0.277	7½
3	min 60 HRC <sup>C</sup>	0.284	...
4	52-60 HRC	0.278	...
5	75-87 HRB	0.306	...
6	75-98 HRB or 15-20 HRC <sup>D</sup>	0.304	...
7	15-20 HRC	0.273	...
8	min 38 HRC	0.300	...
9	85-95 HRB	0.318	...
10	min 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
14	25-39 HRC		
14 S43000	48-63 HRA		
15	58-67 HRC <sup>B</sup>	0.283	8
16	58-67 HRC <sup>B</sup>	0.277	7½

<sup>A</sup> Hardness equivalent to those shown are also acceptable. See Standard Hardness Conversion Tables E140.

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

<sup>C</sup> See 7.2.2.

<sup>D</sup> See 11.4.

**TABLE 54 Case Depth Requirements for Composition 3 Balls**

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

See Test Method [E384](#).

**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. The retained austenite content of Composition 2, 1, 2, 15 and 16 balls shall not exceed 7 % by volume, as determined using X-ray diffraction techniques, or other techniques as specified.

**7.8 Passivation**—Composition 2 and 16 balls. The surface of the finished balls shall be passivated and shall not exhibit visible corrosion when tested chemically cleaned or otherwise treated to be passive and free from all non stainless contamination per AMS 2700 or A976M. Test for acceptance in accordance with ~~H.11~~ the appropriate test method in the passivation specification. Samples exhibiting visible corrosion shall be cause for lot rejection.

**7.9 Eddy Current**—Composition 13 balls shall be tested in accordance with ~~H.11~~ [11.10](#).

**7.9.1 Processing After Eddy Current Testing**—Re-inspect any balls that are processed in any way following eddy current testing.

**7.10 First Article**—When specified in the purchase order or contract, a first article sample shall be provided. The first article test shall demonstrate the sample (s) shall meet the requirements of Sections 6, 7, 8, and 9. 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 [Table 65](#) and [Table 76](#) 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 in [Table 65](#) and [Table 76](#) shall be classified as a defect. Balls shall meet the acceptance quality limits (AQL) of [Table 98](#) when tested for dimensional requirements in accordance with ~~H.13~~ [11.12](#). ISO 3290 provides a listing of additional acceptable sizes.

**9. Workmanship, Finish, and Appearance**

**9.1 Visual Inspection**—Balls shall meet the acceptance quality limits (AQL) of [Table 98](#) when visually tested in accordance with ~~H.12~~ [11.11](#) for compliance with the requirements of [9.1.1](#); ~~9.1.2~~, and ~~9.1.2~~ [Table 2](#).

9.1.1 Balls shall be free from decarburization, over tempering, and indications of soft spots.

**TABLE 65 Tolerances by Grade for Individual Balls**

Grade	Allowable Ball Diameter Variation, millionths of an inch, $V_{DWS}$	Allowable Deviation from Spherical Form, millionths of an inch, $\Delta RW$
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

**TABLE 76 Tolerances by Grade for Lots of Balls**

Grade	Allowable Lot Diameter Variation, millionths of an inch, $V_{DWL}$	Basic Diameter Tolerance, millionths of an inch	Allowable Ball Gage Deviation, millionths of an inch, $\Delta s$		Container Marking Increment, millionths of an inch
			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	±200			50
100	200	±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. diameter	0.015 in. maximum dimension
Nicks, dents, and indentations on balls of ½ in. diameter or larger	0.024 in. maximum dimension

**TABLE 7 Visual Inspection Limits**

Type of Defect	Acceptable Limits	Acceptable Limits Composition 15, 16
Pits	0.0008 in maximum dimension for single pit; maximum of 3 permitted in any ¼ in. diameter circle	Allowed if not felt with a 0.005 in. radius probe
Scratches, surface non-metallic inclusions	0.001 in. wide by 0.010 in. long any number allowed as long as they do not cross.	Allowed if not felt with a 0.005 in. radius probe
Nicks, dents and indentations on ball of less than ½ in. diameter	0.015 in. maximum dimension	Allowed if not felt with a 0.005 in. radius probe
Nicks, dents and indentations on balls of ½ in. diameter or larger	0.024 in. maximum dimension	Allowed if not felt with a 0.010 in. radius probe
Seams, laps, tears, cracks, indications of corrosion, raised metal, scants, orange peel	None allowed	None allowed
Stains	0.005 in. major dimension not to exceed.	None allowed

**TABLE 98 Quality Conformance Inspection**

Test	Inspection Level	AQL (Defects Per 100 Units)
Visual		
Visual	II	1.0
Major Defects (see Table 2)	H	1.0
Minor Defects (see Table 2)	H	6.5
Dimensional Examination: (see Tables 6 and 7)		
Dimensional Examination: (see Tables 5 and 6)	II	1.0
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

9.1.2 Except as specified for Composition 13 ball surfaces, ball surfaces shall be free from scratches, nicks, pits, dents, seams, laps, tears, cracks, and corrosion when examined in accordance with ~~11.12.11.11~~ and ~~11.12.1~~. Composition 13 ball surfaces shall not exceed the tolerance limits specified in Table 87 for scratches, nicks, pits, dents, and indentation when examined in accordance with ~~11.12.2.11.11.1~~.

9.2 *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 109 for the specified grade, when tested in accordance with 11.7.

9.3 *Carbides*—Carbides on the surfaces of finished Composition 13 balls shall not protrude more than 11 µin. above the surface of the ball, when tested in accordance with ~~11.14.11.13~~.



**TABLE 109 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	

## 10. Sampling

10.1 *Sampling for Visual and Dimensional Testing of Composition 1 through ~~12 and 14~~ 12, 14, 15 and 16 Balls*—Sampling shall be done in accordance with ANSI/ASQC Z1.4 or an equivalent sampling Table from “C = 0.” 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 ANSI/ASQC Z1.4 or an equivalent sampling Table from “C = 0.” The sample quantity shall be one ball as applicable. Acceptance number shall be zero for all sample series unless otherwise specified.

~~10.3 *First Article Testing*—When a first article sample is required, five sample units shall be tested in accordance with Sections 6 through 12 and the requirements in Table 1 through Table 10.~~

## 11. Test Methods

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

11.1.1 *Temperature*—Room ambient 20 to 25°C (68 to ~~77°C~~ 77°C).

11.1.2 *Altitude*—Normal ground.

11.1.3 *Humidity*—50 % relative, maximum.

11.2 *Chemical Analysis:*

11.2.1 Chemical analysis of each lot of material shall be tested in accordance with the appropriate material specification. If any of the samples fail to comply with the material requirements, the lot shall be rejected.

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 instead of actual testing by the manufacturer.

11.3 *Density*—Reference value only. See 7.1.

11.4 *Ball Hardness*—Select samples of each composition in accordance with Section 10. Test in accordance with Test Methods ~~E18, except for Composition 6. Test Composition 6 balls in accordance with MS 19063.~~ 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 43, the lot shall be rejected.

11.5 *Fracture Grain Size*—Select samples of Composition 1, 2, ~~13, 15 and 16~~ 13, 15 and 16 balls in accordance with Section 10. Examine in accordance with Test Methods E112 or the test method appropriate to the material specification. ~~Balls having fracture grain sizes for Compositions 1, 2, and 13 that are not in accordance with the requirements of 7.3 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 B276 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~~ ANSI B46.1. Sample units not complying with requirements of 9.2 shall be cause for lot rejection.

11.8 *Decarburization*—Select Compositions 1, 2, 3, 4, ~~13, 15 and 16~~ 13, 15 and 16 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 magnification of 100 ~~diameters times~~. 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 54 shall be cause for lot rejection. See Test Method E384.

11.10 *Passivation*—Select Composition 2 balls in accordance with Section 10. Passivate in accordance with AMS-QQ-P-35 or Classification A976. Test for acceptance in accordance with the appropriate test method in the passivation specification. Use the following or equivalent test method. Immerse samples in distilled water at  $100 \pm 5^\circ\text{F}$  for 1 h, and then air dry at  $100 \pm 5^\circ\text{F}$  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 $\times$  power magnification. Samples exhibiting visible corrosion shall be cause for lot rejection.

11.10 *Eddy Current*—Eddy current inspection shall be performed on 100 % of Composition 13 balls.

11.10.1 *Personnel*—Personnel performing the eddy current testing shall meet the requirements of NAS 410.

11.10.2 *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. Calibration standards shall trip the reject signal and shall be segregated from acceptable balls.

11.10.3 *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.

11.10.4 *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.

11.10.5 *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  $\pm 10\%$  from the previously established calibration. Verify meter deflection on the calibration standard at the beginning and at the end of each inspection lot.

11.10.6 *Ball Rejection*—Reject any production balls that signal equal to or greater than the calibration level of the EDM notch in the calibration standards.

11.11 *Visual Testing*—Balls shall be inspected in accordance with 10.1 and Table 8 using the unaided eye, except balls eye. Balls having basic diameters of  $\frac{1}{8}$  in. or less may be examined by magnification not exceeding ten times when specified times.

11.12.1 *Visual Testing for Composition 1 through 12 and 14 Balls*—Sample balls in accordance with 10.1 and Table 9. Inspect balls for defects using the unaided eye (unless magnification is specified). Balls not meeting the requirements of Section 9 shall be rejected, and samples not complying with the requirements of Table 9 shall cause the lot to be rejected.

11.11.1 *Visual Testing for Composition 13 Balls*—Sample balls in accordance with 10.2.1. 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  $\frac{1}{2}$  in. diameter and larger. Use a 0.020-in. radius scribe on balls less than  $\frac{1}{2}$  in. diameter. If the defect is detectable with the scribe, or if the acceptance criteria of Table 87 are not met, the ball shall be rejected.

11.12 *Dimensional Testing*: [i/catalog/standards/sist/bef50d8c-a041-4a88-a9d0-24da28e501fb/astm-f2215-15](https://www.astm.org/catalog/standards/sist/bef50d8c-a041-4a88-a9d0-24da28e501fb/astm-f2215-15)

11.12.1 *Diameter Tolerance Per Ball and Ball and Lot Diameter Variation*—Sample in accordance with Section 10. Take a minimum of ten measurements in random orientations of each sample ball. If samples do not comply with out-of-roundness requirements, the lot shall be rejected. See Tables 65 and 76.

11.12.2 *Measurement of Deviation from Spherical Form*—Sample in accordance with Section 10. Test in accordance with Annex A10A2. If sample balls do not satisfy the requirements of Table 65, the lot shall be rejected.

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

11.12.4 *Specific Diameter Marking*—Sample in accordance with Section 10. Take a minimum of ten 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 76). Any unit container that does not comply with these requirements shall be rejected.

11.13 *Carbides on Finished Composition 13 Balls*—Inspect a five ball sample from each lot of finished Composition 13 balls at 250 times or greater magnification. Select 3 random fields per ball, approximately  $120^\circ$  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  $\mu\text{m}$ ., reject the lot.

11.14 *Macro-Examinations: Macro-Examinations*—

11.15.1 *Compositions 1, 2, and 14 Balls*—Take specimens that are  $\frac{3}{8}$  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. Conducting Macro-examinations for non-metallic inclusions for each heat of steel in the billet stage is determined to be a best practice but not a requirement of this standard, excluding Composition

3.

11.14.1 *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 Test Methods **E381**. The quality of steel as indicated by the results of the macro-examination shall be as agreed upon between the producer and the vendor. Defects exhibiting profiles of an unacceptable condition in Plates I, II, and III in Test Methods **E381** Adjuncts shall not be considered acceptable. When specified in the purchase order or contract, a certified material analysis report (certificate of conformance) submitted by the mill supplier is an acceptable alternate to the macro-examination of the material.

11.14.2 *Composition 13 Balls*—Perform macro-examination in accordance with AMS 6490 and AMS 6491.

## 12. Inspection

12.1 Inspection of the balls shall be in accordance with the requirements of Sections **6** through **11** and **Table 1** through **Table 109** and as agreed upon between the purchaser and the supplier. The supplier is responsible for performance of all testing and inspection requirements.

## 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 instead 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 *Military Packing*—Unless otherwise specified in the contract or purchase order, balls shall be cleaned, dried, preserved, and packaged in accordance with MIL-DTL-197.~~

~~14.2 *Commercial Packing*—Unless otherwise specified in the contract or purchase order, balls shall be cleaned, dried, preserved and packaged in accordance with Practice **D3951**.~~

### 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, 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 **D3951**.~~

## 13. Keywords

13.1 ball bearing; ball valve; bearing; bearing accessories; bearing rolling elements

## ANNEXES

### (Mandatory Information)

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

##### A1.1 Scope

A1.1.1 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

A1.2.1 Balls may be used in engine and gearbox bearings on rotary and fixed winged aircraft.

##### A1.3 Personnel

A1.3.1 Personnel performing the inspection shall meet the requirements of NAS 410.